Title	The price of fear: Developing a behavioural assessment of fear-related avoidance incorporating dynamic response measures
Author(s)	Garcia-Guerrero, Santiago
Publication Date	2019-09-30
Publisher	NUI Galway
Item record	http://hdl.handle.net/10379/15712

THE PRICE OF FEAR: DEVELOPING A BEHAVIOURAL ASSESSMENT OF FEAR-RELATED AVOIDANCE INCORPORATING DYNAMIC RESPONSE MEASURES

Thesis submitted to the National University of Ireland, Galway in fulfilment of the requirements for the Degree of Doctor of Philosophy (Psychology)

Santiago Garcia Guerrero

B.A. (Hons), MSc. Psychology

School of Psychology,
National University of Ireland, Galway

September 2019

Supervised By:

Dr. Denis O'Hora

School of Psychology, National University of Ireland, Galway

Funding

The work associated with this thesis was made possible by a Hardiman Research Scholarship.

I would like to extend my most sincere gratitude to the EXPLORE award in supporting my PhobiApp project, as well as the government of Ireland for funding my intellectual and professional endeavours.

Likewise, I would like to acknowledge and thank the NUIG travel bursaries that facilitated the dissemination of the research presented in this thesis.

Table of Contents

List of Appendices

Abstract

Introduction. Fears (e.g., of spiders, or heights) are maladaptive to the extent that they can cause us to avoid opportunities that could enrich our lives. Thus, avoidance is central to fear constructs. However, the roles that avoidance motivations play in fears are complex and remain partially understood. Much research of avoidance has considered it to be the result of subjective fear and this viewpoint tends to construe avoidance exclusively as problematic behaviour. Even though avoidance can significantly impair an individual's life in extreme cases, it is a crucial component of adaptive behaviour. Early researchers understood that the balance between avoidance motivations and approach motivations was critical to identifying maladaptive behaviour and modifying it. Recently, there has been a revival of interest in developing experimental paradigms based on theories that explicitly postulate a conflict between coexisting motivations to approach and avoid stimuli. The present work connects with the early work on approach-avoidance conflict (AAC) and is informed by recent empirical developments.

Aims. The primary aims of the current research programme were to: (a) characterise the state of the art of fear measures; (b) develop novel measures of maladaptive fears using approach-avoidance paradigms; (c) explore approach-avoidance conflicts whilst responding; (d) provide a preliminary dynamical model of approach-avoidance conflict.

In accordance with the foregoing, a review of current fear measures was conducted. Next, a series of novel empirical measures of approach-avoidance conflict were developed and tested. Then, the implications of these findings were incorporated within a dynamical systems model of the dynamic interplay between approach and avoidance motivations within a context. Finally, some implications of the present work for the conceptualization of maladaptive avoidance were briefly discussed.

Methodology. *Study 1* presented a scoping review examining the strength of association between performance on exposure-based behavioural approach tasks (BATs), and two types of measures of fears/anxiety: (a) self-report scales, and (b) implicit response time tasks. The procedural consistency of BATs across studies was critically evaluated. *Experiment 1* and *2* tested two novel AAC-based measures of spider fear. Participants chose between higher or lower points rewards, when the higher points were paired with spiders. Based on how many more points were needed for participants to choose the spider option, a price was calculated as an avoidance-based index of spider fear. This price was then

compared to self-report measures of spider fear and against performance in a BAT procedure in *Experiment 2*. *Experiments 3* and *4* investigated whether AAC could be observed in movement while participants made decisions. Participants chose to win or lose varying numbers of points. In 20% of trials wining the points incurred a 20% risk of mild electrical shock. Mouse cursor movements were recorded as participants registered their decision.

Results. *Study 1* revealed that the majority of studies explored spider fear, suggesting an underrepresentation of other fears in the experimental literature. In comparison to implicit measures of fears, explicit (questionnaire) measures related more strongly to performance in BATs. Overall, there is a lack of standardization in the BAT procedures implemented in the sampled studies. *Experiments 1* and *2* report significant and non-significant correlations between the price index and self-reported fear, compromised by strong floor effects. The price index was a better predictor of performance in the BAT than self-reported fear. *Experiments 3* and *4* demonstrated that AACs are indeed visible in the response trajectories whilst deciding between the options. Moreover, conflict was highest when participants chose between equally valued response options. Finally, within-trial analyses revealed that different experimental arrangements facilitate the manifestation of motor and cognitive defaults when deciding.

Conclusions. *Study 1* suggests that the relationship between indirect (explicit/implicit) measures of fears and BATs cannot be generalised beyond arachnophobia. Developing BATs that target a wider range of phobias will contribute to the ecological representativeness of fear measures and research on maladaptive avoidance. The experimental approach-avoidance studies (*Experiments 1* to *4*) provide evidence in support of this methodology to investigate the processes underlying maladaptive avoidance, with potential ecological validity and clinical utility. Furthermore, these experiments provide evidence for the importance of considering the dynamic interplay between approach and avoidance motivations in the conceptualization of avoidance; and the role of approach contingencies in modifying maladaptive patterns of avoidance. *Experiments 3* and *4* put forth mouse-tracking as an ideal methodology to investigate the time course of competing approach-avoidance motivations during decisions. The data typified avoidance responses as more complex than approach responses, and demonstrated that response trajectories change depending on the level of conflict induced. Counterbalancing the response options of decision-making tasks across trials, instead of across trial-blocks as frequently done, helps to dissociate potential cognitive and motor defaults.

Acknowledgments

Were it not for Dr. O'Hora (and the encouragement of Prof. Dickins) I would not have pursued a PhD. It is a great privilege to work with you Denis and I feel honoured that you saw in me somebody worth working with. I cannot help thinking—even after four years!— how lucky I was that our paths crossed. I wholeheartedly thank you for your friendship, your believing in me and unflagging support throughout these years. Your mentoring made me cleverer than I was and returned a long-forgotten confidence in myself. Your unusual, but effective, way of making complicated matters sound fascinating certainly eased my journey; I hope that one day I can do that for somebody else. As a legacy, thanks to you "*the R force with me is, master*".

Special thanks to the members of my Graduate Research Committee, and all the School of Psychology staff at NUI Galway. I am particularly grateful to Declan Coogan whose friendship and unconditional assistance made me feel at home. I could not have asked for a better person to share DIY ideas—so necessary in my insatiable need to productively procrastinate—and a reliable source of tools and materials.

In the same manner, I want to express my most sincere gratitude to both of my examiners: Prof. Simon Dymond and Dr. Ian Stewart. I feel grateful indeed for having had such remarkable academics and wonderful people as part of my PhD process. I have a great admiration for you both and it humbles me to realise that you took the time and effort to go through my thesis. I appreciate every second that you devoted to my work and all the feedback provided, as well as the interesting discussions we had during my viva.

To Dr. Arkady Zgonnikov for your patience and dedication whilst teaching me to code. It is a truism to say that without you, none of my experiments would have come to be, and by extension, my PhD; that is a debt I will never be able to repay. Your friendship and lovely family fill my heart with warmth, thanks for sharing that with me.

With all my heart infinite thanks and love to my PhD comraderies. When the prospect of moving to Ireland became a reality, I never thought I would encounter such adorable and special people. I could not thank you all enough for welcoming into your lives and share the load of this endeavour. Colleagues and friends who have kept me going over the years (alphabetically): Amanda, Avril, Chris, Ciara, Corinna, Cormac, Dearbhaile, Donna, Edith, Eimear, Elaine, Emma, Eric, Grainne, Hazel, Helga, Jane, Jess, Kate, Kristin, Liam, Marita, Mark, Milou, Naomi, Owen, Páraic, Sarah, Sophi, Tom. Also, I want to thank Gary

O'Donoghue for his unconditional support, his amazing coding skills and the time spent in the PhobiApp project.

To my beautiful Princess, you are my emotional backbone. I will be forever grateful for being there when I needed you (and give me space when necessary so I could focus on finishing this!), para tí una frase de Mario Benedetti: "Y aunque no siempre he entendido mis culpas y mis fracasos, en cambio sé que, en tus brazos, el mundo tiene sentido".

Above all, gratitude is due to my parents: A mi familia, sin duda alguna, las personas a las que les debo todo. Gracias papito por tu incansable apoyo emocional y estimulación intelectual, pero sobre todo, por inculcar en mí el gusto por el conocimiento y el estudio. A mi madre, por ser un modelo de perseverancia y amor incondicional. A mi segunda familia Duran-Lopez, por todo el cariño, apoyo y amor incondicional; no hay suficiente espacio en este mundo para albergar la gratitud y amor que siento por vosotros.

Thanks are due to all the significant mentors whose dedication and relationship with me are responsible for my academic and professional training. In particular, I want to thank Prof. Tom Dickins, for believing in me from day one and being such a nice friend and mentor. A Vladimir Bernal por ser una fuente de inspiración tanto profesional como personal, haberme enseñado tanto y seguir siendo un amigo con el cual contar. Lo mismo he de decir acerca de Diana Melisa Quant, amiga cercana y compañera de luchas académicas, gracias por estar siempre disponible para una conversación interesante y lista con palabras de aliento cuando las he necesitado. También quiero agradecer a todos mis mentores que de una u otra forma contribuyeron a mi formación académica y se esforzaron por hacer de mí un psicólogo competente, especialmente Aldo Hernandez, Duilio Cruz, Patricia Hernández, Sonia Zambrano, y finalmente, Oscar Omaña—que en paz descanses.

Last, but not least, to my participants for your commitment and generosity with their time. Finally, to Roisin, for being my most deadly—quite literately—and hairy PhD companion and co-researcher; and to Dr. Michel Dugon for facilitating her adoption and being willing to help.

List of Works

Below is a list of dissemination outputs, which have stemmed (directly and indirectly) from this thesis.

Garcia-Guerrero, S., O'Hora, D., & Zgonnikov, A. (2019, June). *Tracking approach-avoidance decision conflicts*. Oral Presentation at 38th Meeting of the European Group of Process Tracing Studies (EGPROC), Dresden, Germany.

Garcia-Guerrero, S. & O'Hora, D. (2019, May). *The dynamic nature of approach-avoidance conflicts during decision-making*. Oral Presentation at the NUIG research day, NUI Galway, Ireland.

Garcia-Guerrero, S., O'Hora, D., & Zgonnikov, A. (2018, April). *Tracing fear: Hand and eye movement during approach-avoidance*. Oral Presentation at the 10th European Meeting of Human Fear Conditioning, Wales, UK.

Garcia-Guerrero, S., O'Hora, D., & Zgonnikov, A. (2018, April). *Mouse-tracking as an index of stimulus control in an approach-avoidance task*. Oral Presentation at the 12th Annual Conference of the PSI Division of Behaviour Analysis, Galway, Ireland.

Garcia-Guerrero, S., O'Hora, D., & Zgonnikov, A. (2017, July). *The Price of Fear: Developing a behavioural assessment of fear-related avoidance incorporating dynamic response measures*. Poster presented at the 39th Annual Meeting of the Cognitive Science Society, London, UK.

Garcia-Guerrero, S., O'Hora, D., & Zgonnikov, A. (2017, June). *Fear-related decision-making and dynamic avoidance: Lessons from a first attempt at developing a paradigm.* The 36th meeting of the European Group of Process Tracing Studies in Judgment and Decision Making (EGPROC), Galway, Ireland.

Garcia-Guerrero, S. & O'Hora, D. (2017, June). *Fear-related decision-making and dynamic avoidance*. Oral Presentation at the NUIG research day, NUI Galway, Ireland.

Garcia-Guerrero, S. & O'Hora, D. (2016, June). *The Price of Fear: Developing a behavioural assessment of fear-related avoidance incorporating dynamic response measures*. Oral Presentation at the 10th Annual Conference of the PSI Division of Behaviour Analysis, Maynooth, Ireland.

Garcia-Guerrero, S. & O'Hora, D. (2016, June). *The Price of Fear: Developing a behavioural assessment of fear-related avoidance incorporating dynamic response measures*. Oral Presentation at the 35th Annual Meeting of the European Group of Process Tracing Studies (EGPROC), Bonn, Germany.

Garcia-Guerrero, S. & O'Hora, D. (2016, February). *Pricing emotions in decisions: Developing a behavioural assessment of fear-related avoidance in decision-making*. Poster presented at the Hardiman Scholars event, NUI Galway, Ireland.

List of Tables

List of Figures

Chapter II

Chapter III

Chapter IV

Chapter V

List of Acronyms

Note. Some of the acronyms below might appear in the body of the document with an “s” as suffix (e.g., AACs). If typed in lower case, this indicates that the acronym is meant in the plural form.

AAC: Approach-Avoidance Conflict.

AAC-Ts: Approach-Avoidance Conflict Tasks (generic term for any experimental paradigm based on such theoretical postulates).

ASI: Anxiety Sensitivity Index (Peterson & Heilbronner, 1987).

BAT: Behavioural Approach Task (in some texts the “A” means avoidance, and the “T” stands for test. This acronym is used indiscriminately herein).

BEAQ: Brief Experiential Avoidance Questionnaire (Gámez, et al., 2014).

BIS/BAS: Behavioural Inhibition System/Behavioural Approach System, scale (Carver, & White, 1994).

CI: Confidence Interval.

DSM: Diagnostic and Statistical manual of Mental Disorders (American Psychiatric Association, 2013)

DST: Dynamical Systems Theory.

EAST: Extrinsic Affective Simond Task (De Houwer, 2003).

FPQ: Fear of Pain Questionnaire (McNeil & Rainwater, 1998).

FSQ: Fear of Spiders Questionnaire (Szymanski & O'Donohue, 1995).

GNAT: Go/No-go association task (Nosek & Banaji, 2001).

IAT: Implicit Association Test (Greenwald, McGhee, Schwartz, 1998).

IGT: Iowa Gambling Task (Bechara et al., 1994).

ISWS: Isolated Square Wave Stimulator.

IRAP: Implicit Relational Assessment Procedure (McKenna et al., 2007).

MO: Motivating Operation (Michael, 1982, 2000).

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Liberati et al., 2009).

PSE: Point of Subjective Equality.

RT: Response Time (interchangeable with “reaction time” unless otherwise clarified).

SD: Standard Deviation.

SE: Standard Error.

SPIN: Social Phobia Inventory (Connor et al., 2000).

SPQ: Spider Phobia Questionnaire (Lang, Melamed & Hart, 1970).

STAI-T: State-Trait Anxiety Inventory—trait scale (Spielberger, 1983).

TCMR: Time-Continuous Multiple Regression (Scherbaum et al., 2010)

Chapter I

General Introduction

Pathological avoidance is a key feature of many mental health conditions (Arnaudova, Kindt, Fanselow, Beckers, 2017), and it is a defining feature of anxiety disorders (Dymond, 2019). According to the 2018 health at a glance report (OECD/EU, 2018), around 25 million people (5.4% of the European population) live with anxiety disorders. In 2015, the sum of mental health related costs across EU countries are estimated to be €600 billion, with anxiety disorders being the most common. The corresponding costs for the Irish government are estimated to be around €15m in 2018 (HSE, 2018). Indeed, Ireland occupies the fourth place, out of 28 EU countries, ranking in prevalence of psychological disorders. Consistent with these figures, anxiety disorders make up almost a third of the all psychological disorders recorded in Ireland (OECD/EU, 2018).

A primary reason that anxiety disorders are debilitating is that individuals avoid potentially rewarding situations due to a fear of what might happen (e.g., avoiding meeting new people due to a fear of negative social consequences, or not taking the injections needed due to a fear of needles). In fact, even when individuals have been treated for anxiety disorders, avoidance is likely to resurge and, as a consequence, such disorders have a probability of recurrence of approximately 0.4 to 0.5 (Andersch & Hetta, 2003; Barrett, Duffy, Dadds, & Rapee, 2001; Bruce et al., 2005; Ginsburg et al., 2011; Lipsitz, Mannuzza, Klein, Ross, & Fyer, 1999; Roy-Byrne & Cowley, 1994; Yonkers, Bruce, Dyck, & Keller, 2003).

While it is appropriate to consider the role that avoidance plays in preventing some individuals living rich positive lives, some level of avoidance is essential for survival. Moreover, on many occasions avoidance may lead to consequences which, although undesirable or suboptimal, do not necessarily require clinical intervention (e.g., preferring to take medicinal tablets over injections). However, situations like this involve a compromise between the desired and undesired consequences of an action (e.g., receiving treatment vs. experiencing pain). In other words, a balance between a tendency to approach and avoid certain aspects of a situation adaptively; a characteristic seldom present in individuals with psychopathologies. Indeed, the current thesis posits that one's goal should be to calibrate our competing motivations of approach and avoidance appropriately for the current context, a stance which resonates with previous work in the area (cf. Bublatzky, Alpers, & Pittig, 2017;

Stein & Paulus, 2009). This position lends itself to the development of novel empirical paradigms to investigate approach-avoidance conflicts that will be described in due course.

In service of this position, this introduction starts with a brief overview of some traditional approaches to the study of avoidance, focusing on main shifts in the conceptualization and procedures used to measure it (see Hofmann & Hay, 2018; Krypotos, Effing, Kindt, Beckers, 2015; Vervliet, Craske, & Hermans, 2013 for more thorough reviews). Next, in order to fully appreciate and place the current work in the context of mainstream research, we address the concept of fear as an emotion (traditionally conceived as underlying avoidance) and its relation to decision-making; a brief contextualization of key related concepts is also provided within our epistemological position. Finally, the development and principles of an approach-avoidance theory are presented, including some of the experimental tasks developed within this framework.

Conceptual background

The empirical literature on avoidance has a long history. A feature of this literature is the role that has been attributed to the experience of fear or other negative emotions such as disgust or shame. These emotions have been understood as causes (e.g., Cannon, 1927), an accompaniment (e.g., Darwin, 1872/1965), and a consequence (e.g., James, 1884) of avoidance at different times by different theorists. In summarising the methodological trends in the literature, this section will highlight how the role of fear, in particular, has changed over time. It is partly due to this ambiguous nature of fear that the current thesis focuses instead on avoidance and the balance between approach and avoidance motivation.

Maladaptive avoidance is crucial in determining the clinical severity of anxiety (Barlow, 2002; Mineka & Oehlberg, 2008; Rapee & Heimberg, 1997). Nevertheless, the experience of fear has traditionally been postulated as its underlying emotion and motivation, as reflected in its presence across nosological classifications (i.e., the DSM; American Psychiatric Association, 2013). As a result, the vast majority of work in the area of anxiety conceives both fear and avoidance as two separate but integral components of anxiety-related disorders. However, scientific operationalizations of psychological constructs, such as fear, can represent methodological challenges and can sometimes diverge in terms of their ecological or clinical validity (Krypotos, Vervliet, & Engelhard, 2018; Lang, 1968;

MacCorquodale & Meehl, 1948; Scheveneels, Boddez, Vervliet, & Hermans, 2016; cf. Guion, 1980; Messick, 1980).

Psychological constructs as mediators of behaviours are usual in mainstream psychology but this was not always the case. In fact, modern research in this area could roughly be conceived as stemming from two historical periods, each characterised by different epistemological positions. The first 50 years were dominated by behaviouristic perspectives and thus an emphasis on observable behaviour (i.e., avoidance), and directly manipulable variables in the environment as locus of control (instead of subjective experiences). The next period consisted of a transition phase, initially influenced by the increasing popularity of cognitivistic perspectives. During this time, psychological constructs (such as fear) reclaimed a place in psychological science as locus of control or mediators of (avoidance) behaviour. This was quickly followed by developments in informatics and neurosciences, empirically complementing and adding complexity to some of the postulated constructs.

The first period lasted from approximately 1920 to 1970. In these early years, fear and avoidance were indistinguishable since all forms of behaviour were conceptualised to be the product of the interaction with the environment. In turn, behaviours acted or had observable effects on the environment (e.g., overt avoidance changed the stimuli available to the organism). Subjective experiences, on the other hand, were considered inaccessible to the experimenter, which meant that neither their properties nor their effects on the environment could be measured (e.g., the presence of subjective fear did not represent changes in the stimuli available to the organism).

Consistent with this perspective, the experimental investigation of avoidance involved arrangements in which aversive-neutral stimuli were paired or arrangements in which responses terminated an ongoing aversive stimulation or postponed its delivery. Pavlov (1903/1928, 1927) pioneered with his conditioning procedures demonstrating that animals, as the result of pairing stimuli spatially and temporally, could respond to previously neutral stimuli (i.e., non-eliciting with respect to the specified response) in a similar way as to stimuli which elicited a response without previous learning (e.g., a dog's abrupt withdrawal responses to non-harmful stimulation). This was followed by the infamous studies by Watson and collaborators (Watson & Morgan, 1917; Watson & Rayner, 1920) on conditioned emotional reactions, substantiating that pairing neutral stimuli with aversive stimuli gave rise to emotional reactions initially absent before the neutral stimuli.

For the early behaviourists, antecedent stimuli constituted the cause of behaviour. Skinner (1938), in contrast, extended the locus of control of behaviour to consequential stimuli. For Skinner, stimuli following the emission of a response affected behaviour by increasing or decreasing its future probability in the context of similar antecedent stimuli. That is, it was the removal of an aversive stimulus which reinforced any response that preceded it (negative reinforcement), just as any response followed by the introduction of an aversive stimulus was weakened (positive punishment). His work on operant behaviour and related experimental instruments paved the way for the study of escape and avoidance as negatively reinforced classes of behaviour (i.e., any response that served the purpose of avoidance became a member of a response class regardless of its form). Significant contributions came from many of Skinner's contemporaries, such as Solomon and Wynne (1953; Solomon, Kamin, & Wynne, 1953) on the acquisition of avoidance, and Sidman (1953) on temporal aspects maintaining it.

The knowledge gained from empirical basic research was then incorporated into therapeutic interventions, such as flooding wherein sustained exposure to the aversive stimulus weakens avoidance responses though habituation and counterconditioning (e.g., Delprato, 1973; Baum, 1970; Stampfl & Levis, 1967). The correspondence between empirically informed interventions (e.g., flooding) and the observed behavioural changes (e.g., decreased avoidance), provided a confirmation consistent with the theory and with clinical implications. For example, flooding relates to the underlying processes of avoidance since the procedure involving exposure to the aversive stimulation is done gradually (habituation) and does not permit escape responses to take place (thus, these are not—negatively—reinforced). As a consequence, techniques such as flooding, reduce the future probability of escape/avoidance responses. However, marking the end of the behavioural period, Costello (1970) provided an important criticism alluding to the discrepancy between avoidance and the phenomenology of its pathological manifestation (i.e., phobias). In particular, he pointed out that avoidance represented an advantageous copying response, and so avoidance in itself could not explain clinical phobias. That is, avoidance responses serve survival by promoting movement away from situations which may cause harm to an individual. However, avoidance can also be disproportionate and maladaptive for social and cultural contexts; which although not life-threatening, can lead to psychological distress.

Costello's words then cautioned researchers about not pathologising all manifestations of avoidance, and spurred a renewed focus on the concept of fear which coincided with a crescendo of cognitivist theories at the time (Seligman & Johnston, 1973; Rachman, 1977; Marks, 1981). A cognitive approach to study fear, involving additional processes, thus stood as a plausible alternative to overcome a seemingly simplified view of avoidance; especially since the concept of avoidance did not differentiate between clinical and non-clinical fears. Fear, defined as a multi-system construct including cognitive processing and response systems at both the physiological and behavioural level (e.g., Frijda, 1986; Gross, 2007; Lang, 1978, 1985; Lang, Bradley, & Cuthbert, 1998; Mauss & Robinson, 2009), became an integral part of mainstream research. Theoretically, for example, certain cognitive processes (e.g., catastrophization, uncertainty) could then be a distinctive feature of avoidance as clinically relevant. In line with this, exposure-based therapies continued to rely heavily on the weakening effect of repeated contact with the feared stimuli, but contemporary clinical approaches focused instead on changing the cognitive processes assumed to be conducive to avoidance (see Vervliet et al., 2013 for a state of the art).

Reconsidering variables of a subjective nature (e.g., emotions, cognitions) not only represented a conceptual shift but also a departure in terms of the methodologies used for the investigation of psychological phenomena. Self-report questionnaires, asking individuals to provide answers with respect to a variety of hypothetical—fear eliciting—scenarios, have since proliferated and dominated some areas of psychology (see Baumeister, Vohs, & Funder, 2007). This has been followed by a steady increase in the design and number of studies measuring individuals' implicit associations with respect to pathologically relevant stimuli (Roefs et al., 2011; Waechter & Stolz, 2015).

Methodological specialization in the investigation of the processes involved in avoidance, as different from behavioural outputs, continues to be reflected in the vast majority of studies that address the physiological, cognitive (e.g., representations, self-reports, expectancy) and neurological circuits involved when responding to threats (e.g., Lang et al. 1998; Mobbs et al., 2009; Onat & Büchel, 2015; Pittig, Treanor, LeBeau, & Craske, 2018; Quirk & Milad, 2012; Vervliet et al., 2013). Nonetheless, this overemphasis on cognitive/neuronal processes seem to have inadvertently neglected the behavioural component of fear, as reflected in few publications between 1980 and 2005 focusing on overt avoidance (Krypotos, Effing et al., 2015).

The present work represents an invitation to refocus on avoidance (rather than fear as traditionally conceived) and echoes some of the perceived advantages in implementing experimental tasks that differ from traditional conditioning paradigms (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013). Reconsidering avoidance as pivotal for our scientific understanding of anxiety disorders is justified on at least three fronts: First, there is a lack of correspondence between the response systems involved in emotions (Mauss & Robinson, 2009). Namely, targeting an aspect of the anxiety condition (be it behavioural, physiological or cognitive) may not necessarily lead to changes in the others (see Cacioppo, Berntson, Larsen, Poehlman, & Ito, 2000; Lang, 1968, 1988; Mandler, Mandler, Kremen, & Sholiton, 1961; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Rachman & Hodgson, 1974; Vermilyea, Boice, & Barlow, 1984). Second, avoidance is pervasive in all anxiety disorders (American Psychological Association, 2013), from avoiding problematic words in the case of stuttering to a myriad of situations as in the case of agoraphobia. Third, physically withdrawing from environments perceived as threatening not only restricts contact with potential reinforcers but also hampers processes that facilitate functional behaviour (e.g., desensitization), leading to clinically significant impairment (Barlow, 2002; Mineka & Oehlberg, 2008; Rapee & Heimberg, 1997).

In addition, conceptual work directly related to avoidance is scarce despite some recent publications on the topic (Arnaudova et al., 2017; Dymond, 2019; Hofmann & Hay, 2018). Given avoidance as a key determinant in an individual’s adjustment, this gap in the literature questions the extent to which performance in disorder-relevant contexts can be predicted (Lonsdorf & Merz, 2017; Scheveneels et al., 2016). Moreover, as pointed out by Costello (1970), it appears that the concept of avoidance, insofar as it is considered pathological, may be better defined in conjunction with an approach component in order to differentiate it from instances where individuals need to avoid danger. In this sense, the investigation of avoidance, and by extension, anxiety, could benefit from perspectives that take into account the interplay of both approach and avoidance processes.

Emotions and Decision-Making

Our lives can be conceived as a continuous stream of decisions. From mundane decisions such as choosing which clothes to wear on a daily basis or what to eat for breakfast, to situations which can have a greater impact within our lifespan, such as whether to have children or whether to undergo surgery. In the literature, emotions are viewed as having evolved to aid the appraisal of situations in a more efficient manner than that offered by cognitive processing (LeDoux, 1992). In fact, many influential conceptualizations of emotions have emphasised the role of emotions in maximising survival (Darwin, 1872/1965; Izard, 1972, 1991; Lazarus, 1991).

It is easy to acknowledge the survival value of emotions when we think of fear as a preparatory response for escape or defence, or as a cue to display behavioural signs of submission. However, the role of emotions may not be as clear when we think of many of our daily decisions that require cognitive activity. Indeed, classical approaches to how humans evaluate situations were heavily influenced by a “homo economicus” view in which people were said to calculate the pros and cons of a situation in a logical way so as to maximise the net gains—independent of emotion. Since the work of Kahneman and Tversky (1979; Tversky, Slovic, & Kahneman, 1990; Tversky, 1969), however, the role of subjective biases and emotional states in decision-making has been recognised as a crucial component. Emotions change the way we evaluate environmental events (e.g., Schwarz & Clore, 1988, 1996; Johnson & Tversky, 1983; Nygren, Isen, Taylor, & Dulin, 1996) and hence, influence the way we interact with it (Charpentier, De Neve, Li, Roiser, & Sharot, 2016).

Most theories posit that emotions provide information (decoded in positive or negative valences and usually experienced as feelings of liking and disliking) about the nature of environmental events, enhancing our ability to make advantageous decisions (e.g., Baumeister, Masicampo, & Vohs, 2011; Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, Damasio, Tranel, & Damasio, 1997; Frijda, 1986; Lazarus, 1991; Mellers, Schwartz, & Ritov, 1999; Miu, Heilman, & Houser, 2008; Pham, Lee, & Stephen, 2012; Schulreich, Gerhardt, & Heekeren, 2016; Schwarz, 1990; Schwarz, 2000; Slovic, Finucane, Peters, & MacGregor, 2007). For example, the somatic marker hypothesis, put forward by Bechara and collaborators (Bechara, Damasio et al., 1994; Bechara, Damasio, Tranel, & Damasio, 1997), was one of the first theories to provide strong empirical evidence for the role of emotions in the evaluation of rational decisions. In their seminal studies, Bechara and his team had participants complete a gambling choice task that contained both advantageous and disadvantageous options (i.e., better or worse gain/loss ratio). They compared the performance of healthy participants against that of individuals who had specific lesions in encephalic areas directly related with the circuits of emotion. The results demonstrated that healthy individuals learned which choice options yielded the better gain/loss ratio over time, whereas participants with brain injury made more risky choices, suggesting insensitivity to the negative consequences of their choices (Bechara, Damasio, Tranel, & Damasio, 1997).

Emotions are commonly defined as a system that provides organisms with energy for action and goal-relevant affordances (Lang, 2010; Cacioppo & Gardner, 1999; Elliot, 2008), and the neuronal circuits that regulate emotion are highly integrated with circuits involved in motor processes (Haber, 2003; Rolls, & Grabenhorst, 2008). In simple organisms, stimulation from a source of energy activates a limited number of responses (e.g., positive/negative phototaxy). However, in complex organisms, there is greater biological capacity to compute environmental information and more behavioural flexibility.

From an evolutionary perspective, emotions prioritize approachable and avoidable opportunities (Frijda, 1986; Lazarus, 1991; Pluchik, 1980). Thus, emotions serve as a quick appraisal system to synchronise multiple sensorial inputs and motor outputs or patterns of action in a discrete fashion (e.g., appetitive/aversive; approachable/avoidable). Thereby, the potential costs of having to rely on a systematic computation of all of the eventual features of an environment are minimised.

Youngstrom and Izard (2008) argue that the functional advantages of emotions—over cognitive processing—can be synthesized into:

1. *Specialization*. Fear and disgust can both generate avoidance responses, and anger and enthusiasm may yield comparable degrees of approach. However, all of these emotions are triggered by different environmental stimuli and manifest themselves in different behaviours (Carver, 2004; Davison, Ekman, Saron, Senulis, & Friesen, 1990; Izard, 1992).
2. *Rapid appraisal*. Sensorial inputs reach first the structures of the primitive brain involved in emotions such as brainstem, amygdala, and hypothalamus, and then reach the cortex (Panksepp, 2000), producing a discrete valuation of the environment.
3. *Rapid response*. Recruitment of the motor system based on primary discrete appraisal—as opposed to subsequent full threat assessment.

From a behavioural science perspective, e*motion*s are of interest insofar as they relate to actions[1]. In fact, some theories posit that emotions may be best defined as action tendencies (Chen & Bargh, 1999; Darwin, 1872/1965; Epstein, 1994; Frijda, 1988; Gray, 1970, 1975; Lang, 1985; Lang et al., 1997; Mowrer, 1960; see also Beatty, Cranley, Carnaby,

[1] Etymologically the word “emotion” comes from the Latin *e-* (variant of *ex* as in old word *exmovēre*) meaning “out” and *movere* which means “to move” (Hoad, 2003).

& Janelle, 2016). For example, the biphasic theory of emotion (Lang, Bradley, & Cuthbert, 1997) organises emotional responses around two basic motivational systems: appetitive and defensive, with approach and avoidance as their corresponding behavioural correlates.

The role of emotions has been recognised in the behaviour analytic literature from the beginning. Generally speaking, we can say that emotions, like motivation, tune the organism to stimuli, and reinforces likely to exert control over behaviour (Killeen, 2017), facilitating the selection of responses from an individual's repertoire (Ringen, 1993; Skinner, 1987; Staddon, 2003). In fact, the strengthening effect of reinforcement over behaviour has long been operationalised as dependent on *a state of deprivation* (Skinner, 1953). Functionally speaking, motivated behaviour is choice behaviour, since among the many potential behaviours an individual can produce only some are expressed in a given situation; that is, the one with the relatively greatest attraction for the person, and we speak of such a choice as representative of that individual's preference (Maier, 1949). Hence, within the framework adopted here, choice preference reflects an imbalance between the approach-avoidance motivations at play.

Fear and anxiety as constructs

The concept of fear has long been linked to avoidance behaviour in the literature (e.g., Darwin, 1872/1965, p. 81). However, there are different ways to talk about fear/anxiety. We can allude to their phenomenology (e.g., "I feel extremely vulnerable and in danger"), their physiology (e.g., increased heart rate, adrenaline secretion, perspiration), or their behavioural correlates (e.g., trembling, freezing, withdrawal) in relation to the conditions under which these tend to occur.

In the literature, therefore, definitions of fear and anxiety encompass a multitude of processes at the behavioural, cognitive, physiological and neurological level (Craske et al., 2009; Hofmann, 2008; Lang, 1968, 1978; LeDoux & Pine, 2016; Steimer, 2002). In addition, environmental conditions as well as differences along specific dimensions are sometimes included to differentiate the presupposed processes involved. For example, most theories propose differences between fear and anxiety in terms of time and certainty of the threat—aversive—stimuli. Fear is commonly conceived as being present-oriented (i.e., immediate) and relatively certain (i.e., the eliciting stimulus is identifiable and the perceived threat is imminent), whereas anxiety is future-oriented and relatively uncertain (Barlow, 2000;

LeDoux et al., 2016; Öhman, 2008). Therefore, the temporal characteristics of these suggest that fear is a short-lived response whereas anxiety is sustained for longer.

For ethologists, fear and anxiety include underlying physiological changes and the activation of defensive systems whose behavioural outputs protect against perceived danger (McFarland, 1987). From an evolutionary perspective, fear has long been theorised to be controlled by our mammalian brain (evolved early), whereas anxiety is controlled by cortical networks (evolved late), leading to the notion of two evolutionarily distinct processes for basic versus complex emotions (e.g., Epstein, 1994; Öhman, 1986, 2008; Lang, 2010; Lang & Bradley, 2010; LeDoux, 2012). Accordingly, many leading theories conceptualise different phases of processing that intervene between a perceived threat and avoidance (e.g., Beck & Clark, 1997; Frijda, 2017; Mathews & Mackintosh, 1998; Mobbs, Hagan, Dalgleish, Silston, & Prévost, 2015; Öhman, 1996; Lazarus, 1991; Oatley & Jenkins, 1996; Scherer, 2009). For example, Lazarus and Folkman (1984, 1987) posit a primary cognitive appraisal, where potential harms or benefits with respect to goals are assessed, and a secondary appraisal in charge of assessing potential coping mechanisms.

Many of these theories proposing different processes involved in fear and anxiety have found indirect support in neurological models (Milad & Quirk, 2012; LeDoux & Pine, 2016). However, in spite of the evidence that at the neuro-anatomical and -functional level fear and anxiety are dissociated (e.g., Davis, 1998; Davis& Shi, 1999; Walker, Toufexis, & Davis, 2003), they are confounded at the behavioural level by the fact that their neuronal circuits have common efferent connections.

The fact that many of the (cognitive, physiological, neurological) processes involved in fear-related behaviours converge at the motor level (avoidance) can represent methodological and conceptual challenges (Arnaudova et al., 2017). Empirical data has long reported that avoidance does not always correlate with the presupposed processes involved in anxiety (Beckers et al., 2013; Lang, 1968, 1988). For instance, studies with non-verbal animals have consistently demonstrated that overt avoidance, once generalised, takes place without the behavioural signs of fear. Moreover, avoidance may persist after the extinction of conditioned emotional responses (Luciano et al., 2013; Rachman, 1985; Solomon et al., 1953), and in verbally competent individuals, language could elicit physiological responses and lead to avoidance of—potentially threatening—stimuli that have never been experienced (e.g., see Augustson and Dougher 1997; Barnes and Roche 1997; Barnes-Holmes, Barnes-Holmes, Smeets, & Luciano, 2004; Dymond, Bennett, Boyle, Roche, & Schlund, 2018).

The reported discrepancy between the response systems of fear (e.g., Lang, 1968; LeDoux, Moscarello, Sears, & Campese, 2017) is, in practice, also a discrepancy between measurements across experiments. While there have been recent initiatives for ensuring consistency and replicability in fear research (e.g., Lang, McTeague, & Bradley, 2016; Lonsdorf et al., 2017), these do not emphasise the measurement of overt avoidance as an outcome measure in its own right. The exclusion of overt avoidance from attempts of this nature (aiming to integrate and standardise the methodologies used) seems to do a disservice to the area of psychopathology and clinical research (Arnaudova et al., 2017; Hofmann & Hay, 2018). This becomes of paramount importance if we are concerned about the usefulness of a measure *as a predictor of other variables*—and the inferences drawn from it—in clinical settings.

In anxiety research, there seems to be a disconnection between some widely used experimental procedures and the measurement of avoidance as measured in ecologically valid settings. For example, the probe detection task (MacLeod, Mathews, & Tata, 1986) consists of the presentation of a small dot during a short time window. People are more likely to indicate the presence of the dot, by pressing a key, if their attention is directed towards the visual space in which the dot appears. Anxious individuals are more likely to detect the dot if a threat word (i.e., related to anxiety provoking situations) had previously been presented in the same location, compared to neutral words. Faster response times correlated with the presence of threat stimuli has thus been interpreted as supporting the hypothesis of an attentional bias of threat (e.g. MacLeod et al., 1986; Mogg, Mathews, & Eysenck, 1992). This pattern of responding on the dot probe task has been replicated in clinical populations such as generalized anxiety (e.g., Mogg et al., 1992) and obsessive–compulsive disorder (e.g., Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996). Therefore, enhanced threat appraisal among anxious individuals might have some descriptive diagnostic utility, but there is little research directly exploring the effects of such threat biases on avoidance (Arnaudova et al., 2017), that is, regarding their predictive value for behaviours of clinical importance.

Despite advances in fear research and its conceptualization as an instigator of anxiety-related psychological disorders, avoidance is critical in determining fear as adaptive or maladaptive (Arnaudova et al., 2017; Barlow, 2002; Eifert & Forsyth, 2007; Hayes, Wilson, Gifford, Follette, & Strosahl, 1996; Krypotos, Effting, et al., 2015; Mineka & Oehlberg, 2008). Therefore, the focus here is on the behavioural expression of the presupposed processes of fear/anxiety: overt avoidance.

That is not to say that the concept of fear (or anxiety) has no room within the present work. Fear—insofar as we need to explicitly define it—is an emotional state. From a behavioural analytic perspective, therefore, emotions (e.g., fear, anxiety, sadness, etc.), are descriptive terms for behavioural predispositions (i.e., response classes) attributed to a certain kind of circumstance (i.e., class of stimuli) due to the likelihood of their occurrence therein. These behavioural dispositions originate in the interaction with the environment, and thereby, in the history of contacting appetitive/aversive consequences. In Skinner's (1953) terms, emotions are "a particular state of strength or weakness in one or more response induced by any one class of operations." (p. 166).

In the vernacular, when we label a person as "fearful", we are not saying that she or he is currently experiencing perspiration, hyperventilation, tachycardia, pupil dilation, and exhibiting withdrawal responses from a source of stimulation. Nor do we mean that she or he has responded in such a way in the past; although in the absence of such occurrences, it would not be valid to refer to somebody as "fearful". What is meant is that *such a way of responding is likely in certain situations*, which is *informed by* a great number of *past instances* in which such responses have occurred under certain circumstances (environments with specific characteristics). Thus, a "fearful individual" is highly likely to engage in specific behaviours (physiological, verbal and behavioural responses) *in the presence of stimuli historically paired with aversive stimulation*.

Within the theoretical context of this thesis, fear can also be conceptualised as *an imbalance, favouring avoidance, between approach-avoidance motivations*. It is important to note that from this perspective no distinction is made on whether the processes leading to avoidance are conscious[2] or not. This stands somewhat in contrast to some leading conceptualisations of fear (e.g., LeDoux & Pine, 2016; Lovibond, 2006; cf. Panksepp, Fuchs, & Iacobucci, 2011). For example, although initially the non-conscious and conscious processes involved in fear were once considered different (see LeDoux, 2014), these are now viewed as inseparable in the sense that non-conscious mechanisms involved in the perception of threat cues (present in all animals) initiate responses in the brain and body that contribute to the "feeling of fear" in humans (LeDoux & Pine, 2016).

[2] The nature of "consciousness" is a highly contended and nuanced area of research (e.g., Seth et al., 2008; Goldman, 1993) and a thorough treatment thereof would lead us stray. Thus, we consider any psychological event to be conscious insofar as the individual is able to discriminate it or respond to it (e.g., able to verbalise it).

While acknowledging the importance of the subjective experience for a full understanding of fear in humans, conceptualising fear in terms of avoidance retains the possibility to draw inter-species parallels about the basic mechanisms involved when responding to threats (e.g., Milad & Quirk, 2012; Panksepp et al., 2011). Moreover, an emphasis on avoidance (or the "behavioural products" of fear) not only reduces the inference that goes in identifying the variables responsible for changes in it (cf. Dymond & Roche, 2009), but it is also directly associated with the physical manifestation of fear as critically conducive to psychopathology; as previously mentioned, physically withdrawing from situations inadequately perceived as threatening is a critical contributor to an individual's maladaptive behaviour.

This conceptual stance widens the scientific scope of research in the area of fear and does not necessarily represent a fundamental paradigmatic shift. Just as the construct of fear can refer to a myriad of basic (non-conscious) or complex psychological processes, so can the concept of avoidance. That is, avoidance can be the result of classical conditioning, operant reinforcement, generalization or symbolic—verbal—behaviour (Dymond, Schlund, Roche, De Houwer, Freegard, 2012); the latter being especially pertinent to human research, and related to propositional models (e.g., Lovibond, 2006). Furthermore, conceiving avoidance in conjunction with approach (rather than in isolation), takes into account simultaneous contingencies and therefore the interactive nature of behavioural processes determining how an organism responds to a situation (e.g., influencing the degree of stimulus control and thus the strength of behaviour; see Miller & Murray, 1952). A definition of fear in terms of an approach-avoidance balance thus opens up new investigative avenues and can expand our understanding of both human and non-human fear processes by incorporating—approach—action tendencies (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013).

Emotional states as modifiers of motivation

Emotions have been the subject of much discussion throughout history (Elliot, Eder, & Harmon-Jones, 2013; Frijda & Scherer, 2009; Solomon, 2008). Nevertheless, they have traditionally been conceived as inherently linked to a tendency to move (Arnold, 1960; Frijda, 1986; Lang, 1984; Lazarus, 1991).

By labelling an individual's emotional state (or assuming a particular emotion), we are making use of a verbal short-cut for that individual's propensity to behave in one way or another. That is, behavioural dispositions *are effects*, not initiators or mediators of inner causes of behaviour (Moore, 2010; Rolls, 2013; Zeiler, 1992). This means that such emotions or "states", though playing a role in the current interaction with the environment (i.e., manifestation of behaviour), reside in the past interaction with it. In Killeen's (2016) words, "the state is determined by the immediate and historic context." (p. 18). Viewed in this manner, the control over behaviour exerted by such states can be tested and somewhat predicted.

Functionally speaking, emotional states are comparable to the concept of motivation in behavioural analysis (Dougher & Hackbert, 2000). Namely, they function as *motivating operations* (MOs; Michael, 1982, 1993, 2000; see also Laraway, Snycerski, Olson, Becker, & Poling, 2014 for an empirical overview to date), which alter the current effectiveness of a reinforcer/punisher thereby affecting ongoing behaviour, and can also alter the (appetitive/aversive) value of stimuli controlling future behaviour. For example, just as water deprivation increases the effectiveness of drinking as a reinforcer and make all response classes associated with its consumption more likely to occur under certain circumstances, "fear" increases the likelihood of—avoidance—behaviours that have been negatively reinforced in the past, occurring in the presence of stimuli considered threatening.

In classic analytic terms, *motivation is the measurable probability of a specific class of behaviour* (e.g., approach/avoid) *occurring under specific circumstances*. Nevertheless, we concur with Killeen (1992) when he points out that behavioural analysts have historically emphasised response rate as the fundamental datum, and this may have led to the detriment of our knowledge about other dimensions of behaviour. Accordingly, we also posit that MOs affect behaviour on a multitude of behavioural dimensions. In this regard, motivation regains its etymological meaning when Killeen (1992) asserts that "[m]otivation is nothing other than motion, or the potential for motion" (p. 437), and incentives not only move behaviour towards a consequential place, but also towards a consequential time (including acceleration) and response topography. In Killeen's physicalistic terms "[i]ncentives are attractors in behaviour space. It is the force of incentives that mediates both performance (movement along a trajectory toward an incentive) and learning (displacement of the trajectory into a more efficient one)" (Killeen, 1992, p. 437, see also Marr, 1992 for a similar perspective).

To put this into context, the effect of emotions on behaviour has traditionally been explored via interruptions in stable rates of responding, as a consequence of encountering aversive stimulation (e.g., conditioned emotional responses; Rachlin, 1935; Watson &

Rayner, 1920). The "emotion of fear", therefore, could be said to be correlated with behavioural inhibition. However, the effects of emotions can be registered in other ways such as erratic movement towards a source of reinforcement—provided that behaviour movement is continuously recorded. Skinner alluded to this phenomenon when talking about anxiety: "[a]lthough the biological advantage of avoidance is obvious, the emotional pattern of anxiety appears to serve no useful purpose. It interferes with the normal behaviour of the individual and may even *disorganize avoidance behaviour* [emphasis added] which would otherwise be effective in dealing with the circumstances." (Skinner, 1953, pp. 178-179).

Although Skinner did not theorise about the processes behind this manifestation of anxiety, from an approach-avoidance conflict perspective, such disorganization of behaviour would be a function of the conflict generated when both the motivation to approach and avoid exert similar influences over behaviour. As alluded to later (see Chapter IV), registering this disorganization—or conflict—on responding requires expanding the available scientific tools to other dimensions of behaviour, beyond response rate/allocation.

An approach-avoidance framework

The ability to move without direct external force is a defining characteristic of an organism. Inbuilt mechanisms for motion, hence, appear an obvious feature in order for living organisms to travel and obtain sources of energy wherever these are to be found. However, being able to move through space is not sufficient. Mechanisms to detect and distinguish between approachable stimuli (e.g., sources of energy, pleasurable stimulation) and avoidable stimuli (e.g., threats, noxious stimulation) are also necessary (Dolan, 2002). Indeed, these mechanisms are so fundamental that they are found both in unicellular organisms, such as the amoeba, as well as highly complex multicellular organisms such as humans (Elliot, 2008; Schneirla, 1959; Zanjonc, 1984). The evolutionary value of these basic mechanisms seems clear: approach facilitates thriving and avoidance facilitates surviving (Elliot, 2008, Kenrick & Shiota, 2008).

Approach-avoidance mechanisms become more nuanced the more complex an organism is, shifting from stereotyped all-or-nothing forms of response to more variability depending on environmental and organismic variables. For example, bacteria will reliably flagellate away from acid (avoidance), whereas maggots will approach light in order to reach food, but once fed, will systematically turn their heads away from (avoid) sources of light and migrate towards the dark (Hinde, 1966). Likewise, slightly more complex animals can react dynamically to changes in the environment, but sometimes stereotypic behaviour can be triggered under specific circumstances (e.g., courtship behaviour of birds, such as the “moonwalk” of the red-capped manakin), described by ethologists as *fixed (or modal) action patterns* (Burghardt, 1985; but see Pellis, 1985). An organism’s biological affordance will determine the form of these approach-avoidance mechanisms (e.g., crawling, running, swimming, flying) as well as constrict its manifestation along response dimensions (strength, duration, spatiality, etc.). Stimuli with survival value are said to have positive valence and instigate approach, whereas stimuli with negative valence instigate avoidance (Laham, Kashima, Dix, & Wheeler, 2015; Lewin, 1935; Seibt, Neumann, Nussinson, & Strack, 2008).

In humans and other complex animals, various hierarchical levels of approach and avoidance have been proposed to operate. These include not only basic reactions to stimuli of survival value, but also emotions as moderators and, in humans in particular, goals as a regulatory (and evaluative) process providing precise direction and efficiency of approach-avoidance behaviours (Cacioppo & Berntson, 1994; Elliot & Church, 1997). In other words, the degree of approach/avoidance is influenced by the characteristics of the environment, how these characteristics are assessed (e.g., dangerous/safe), as well as the state of the organism (e.g., deprived/satiated; Lang et al., 1998; Mobbs, Hagan et al., 2015).

While there are diverging academic perspectives, the interplay between approach and avoidance tendencies has historically been conceived of as inherent to human behaviour in general (Elliot & Covington, 2001). For example, Miller (1944) considered conflict between approach and avoidance motivations to be at the root of psychopathology. According to him, competition between incompatible responses generated conflict, even though eventually one response would become dominant and therefore manifest. An approach-avoidance conflict (henceforth AAC), therefore, was when an individual experienced both an attraction towards and a repulsion from a situation (Elliot, 2006; Hovland & Sears, 1937; Miller, 1944; McNaughton, DeYoung, & Corr, 2016); the more equal the tendency to both approach and avoid a situation, the stronger the conflict experienced.

Unlike dominant interpretative views before his time, Miller developed a theory of approach-avoidance motivation that lent itself to scientific scrutiny. In his theory, Miller (1944) postulates four fundamental principles acting during AACs:

1. An *approach gradient* relates the strength of the tendency to approach an event to the organism's proximity to it.
2. An *avoidance gradient* relates the strength of the tendency to withdraw from an event to the organism's proximity to it.
3. The gradient of avoidance increases more rapidly (is steeper) than that of approach.
4. The strength of both gradients depends on the "drive upon which they are based" (p. 434), raising or lowering the entire gradient in response to greater or lesser motivation.

Miller's (1944) conceptualization of how these approach and avoidance motivations interact to determine behaviour allow predictions to be tested (e.g., Boyd, Robinson, & Fetterman, 2011; Townsend & Busemeyer, 1989). More importantly, it provides a framework that incorporates hypothetical changes in ongoing behaviour as a function of the relative strengths of competing consequential stimuli in the environment.

For example, let us assume that a given individual sees a bulk of money (the goal) lying at the end of a corridor. As this person has found this stimulus to be reinforcing, he then starts to approach it. His motivation to approach the money will become stronger the closer he is to the money (first principle); if he had to travel a great distance to get it he would not be as motivated. However, as he gets closer, he now notices that there is a spider crawling onto the bulk of money. Assuming that his motivation to avoid spiders ("fear") is low relative to his motivation to approach the money, he will continue to approach the (conflicted) goal. Yet, the closer he gets to the goal, the greater the repulsion (avoidance motivation) he gets from the spider (second principle). The counter effect of the motivation to avoid the spider, might manifest in a drastic deceleration in the locomotion towards the goal (third principle), until the person comes to a halt, where both approach and avoidance gradients cross (i.e., the point of greatest conflict). Alternatively, if the individual continues to move forwards, past the point where the gradients cross, the strength of avoidance would now be greater than that of approach and the individual is thereby expected to move backwards—such ambivalence is typical in anxiogenic situations. However, assuming that this person receives some form of encouragement from a witness (fourth principle), he might indeed end up grasping the money; or moving farther away if his motivation to avoid is increased by seeing somebody else's fear reactions to it (see Appendix A for an illustration of Miller's model).

This formulation resonates with Costello's (1970) point of view. For Costello, the distinctive aspect of phobic behaviour was the fact that such an avoidance was in conflict with approach behaviours: "[r]esponses learned in the usual avoidance procedure are adaptive because they enable the animals simply to avoid a noxious stimulus. If this were true also of the consequences of phobic behaviours, they could not be considered maladaptive and would not come to the attention of clinicians. But phobias are maladaptive because they prevent the occurrence of behaviours desired by the individual (e.g., the claustrophobic person cannot sit in a lecture theatre or a cinema) and/or desired by society (as in the case of a child with a school phobia)." (p. 251).

As a cognitivist, for Costello the factors affecting an individual's motivation could be subjective. However, from a traditional behavioural perspective, contingencies of reinforcement or punishment are the factors influencing motivations. Accordingly, Hayes (1976) followed Costello's argument by positing that if approach contingencies played a role in the manifestation of avoidance, this should become evident in different predictions when experimentally controlling for them. Namely, an increase in the value of approach contingencies should reduce avoidance behaviour for a phobia of a given strength. Accordingly, Hayes, Lattal, and Myerson (1979) trained rats to nose-poke at a high rate for food. The experimenters then divided the sample into two groups and manipulated the levels of deprivation, so these differed in terms of their motivation to approach (i.e., one group was kept at 70% of the rats' ad lib body weight, and the other at 90%). In addition, nose-poking was now accompanied by an aversive consequence such as an electric shock. As the result of this arrangement, the rats with a stronger motivation to approach (70% weight) produced higher rates of responding, and thereby received more shocks, than the "less motivated" comparison group (90% weight). The results supported the suggestion that pathological avoidance (i.e., in the face of contradictory contingencies) could indeed be a function of both avoidance and approach contingencies. Arguably, maldaptive behaviour occurs when approach and avoidance tendencies neither interact with each other nor do they correspond with environmental demands. Presumably for humans, avoidance may be considered pathological if this behaviour is insensitive to strong approach contingencies (implying greater benefits in approaching than in avoiding a situation), and such a pattern is stable over time.

The recognition that approach and avoidance motivations interact, as demonstrated by Hayes et al. (1976; see also Bugelski & Miller, 1938; Brown 1948) suggests that avoidance is of clinical relevance insofar as it is in conflict with approach tendencies as pointed out by Costello (1970); surprisingly, an aspect that has not received due attention in fear conditioning research (Beckers et al., 2013; cf. Gannon, Roche, Kanter, Forsyth, & Linehan, 2011; Pittig & Dehler, 2019; Pittig, Treanor et al., 2018). Since many real-life situations entail a benefit/risk trade off characteristic of AACs, it can be argued that studying confounded approach-avoidance responses is more ecologically and clinically representative than exploring these responses in isolation (Kashdan, Elhai, & Breen, 2008). For example, people sometimes expose themselves to avoidable aversive consequences in the face of competing rewards (e.g., Geller & Seifter, 1960; Pittig, Hengen, Bublatzky, & Alpers, 2018) as in the case of addictions, or to avoid other consequences perceived as more aversive (e.g., enduring a visit to the dentist to avoid toothache later).

Furthermore, the fact that AACs require not only an assessment of the pros and cons of a situation, but also their relative value and their probability, makes this kind of processing highly cognitively demanding (see Kim et al., 2010), hence, akin to the way people evaluate meaningful decisions. Moreover, the inhibition present in approach-avoidance conflicts has been found to involve neural activity distinct from that of simple approach or avoidance behaviour (Gray & McNaughton, 2000; Hare, Camerer, & Rangel, 2009; Ito & Lee, 2016; Praamstra & Seiss, 2005; Luttrell, Stillman, Hasinski, & Cunningham, 2016; Rolls & Grabenhorst, 2008), and recent research indicates that individuals' behaviour is sensitive to competing rewards, which can promote a switch from avoidance to approach (Bublatzky, Alpers, & Pittig, 2017; Dibbets & Fonteyne, 2015; Krypotos, Arnaudova, Effting, Kindt, & Beckers, 2015; Pittig, Hengen et al., 2018; Schlund et al., 2017; cf. Vervliet & Indekeu, 2015).

Recently, a variety of approach-avoidance conflict tasks (henceforth AAC-Ts) have been developed following this framework (e.g., Aupperle, Sullivan, Melrose, Paulus, & Stein, 2011; Bublatzky et al., 2017; Meulders, Franssen, Fonteyne, & Vlaeyen, 2016; Rattel, Miedl, Blechert, & Wilhelm 2017; Sierra-Mercado et al., 2015), as illustrated in the following three experimental paradigms. Aupperle and her team (2011) devised a task to induce different levels of conflict by simultaneously changing the probability and magnitude of both the appetitive and aversive stimuli. Using a keyboard, the task consists of moving an avatar along a horizontal track to either the left or right, in the direction of a positive or negative cue (i.e., a sunshine or rain cloud). The avatar can be placed along nine possible positions between the extremes cuing the positive or negative consequence (i.e., pleasant or unpleasant visual and auditory stimulus). Underneath each position of the track, a number indicates the relative probability of receiving either consequence. For example, the position at the very centre of the track indicates that there is an equal (50%) probability of being exposed to the pleasant or unpleasant consequence, whereas the most off-centre position indicates the greatest (90%) probability of experiencing whichever consequence is the closest; so if the avatar is moved towards the positive consequence and placed two places away from it, there will be 70% probability of being exposed to the pleasant stimulus and a 30% probability of being exposed to the unpleasant stimulus. In addition, next to each positive/negative cue, a bar is used to indicate the magnitude of the reward corresponding to each consequence. By varying the initial position of the avatar, as well as the reward magnitude of each consequence, researchers can explore, not only how participants respond to the trade-offs between the reward and threat magnitudes, but also to the additional response cost, say, if the avatar appears farther from the desired consequence. The findings from this study demonstrated that the extent to which participants approached each consequence correlated with the self-reported motivation to approach and avoid the positive and negative consequences respectively, and that greater reward induced more approach behaviour. It is worth noting that each decision in this task always involves a probability of contacting the aversive consequence; analogous to many real-life situations in which avoidance does not guarantee absolute absence of the aversive consequence.

Another paradigm is the Avoidance–Reward Conflict (ARC) Task, developed by Sierra-Mercado et al. (2015). The ARC task is feasible for translational research on AACs as it can be used with both human and non-human animals. In this task, subjects decide between two options depending on both the magnitude of the available reward (e.g., money, juice) and the probability of receiving an aversive stimulation (e.g., air puff in the eye). On each trial, the response options consist of two circles on each side of the screen, each of a different colour and outline thickness. Choosing the white circle (always with a thin outline) results in no aversive stimulation and a smaller reward relative to any response alternative. Choosing the non-white option results in low, medium or high probability of the aversive consequences depending on whether the circle is blue, yellow or red respectively. The corresponding small, medium or large magnitude of the reward is determined by the thickness of the circle being thin, medium, or thick. Using this task, Sierra-Mercado and collaborators were able to investigate how reward and aversion interact in the context of decision making. They demonstrated that subjects distinguish between varying amounts of aversion and reward, and observed that humans and monkeys had similar behavioural patterns. Namely, the probability of choosing an option was a function of its reward magnitude, especially when the aversive stimulation was high. However, there were no significant differences between medium and high reward in terms of response probability. In addition, human subjects did not respond differentially when the intensity of the aversive stimulus was medium or high.

The third example of an AAC paradigm, developed by Meulders and her team (2016), consists of a task in which avoidance is pitted against response effort. During their task, using a robotic arm to capture motion and add resistance force, participants had to take a “ball” from a starting point at the lower left area of the computer screen to a final location at the upper left of the screen. To achieve this, participants could take one of three possible paths (through the left, middle or right hand-side of the computer screen) that implied different degrees of deviation from the straightest route to the goal. For example, participants could take a direct, resistance-free, upwards trajectory (left path), but this option was always accompanied by an electric shock. Diverging from the direct response path reduced the probability of receiving the shock but increased the effort required. That is, if participants took the path following the middle of the screen, they risked shock 50% of the time and experienced moderate resistance when moving the robotic arm; choosing the longest path on the right was shock-free but it involved strong resistance, requiring great biomechanical force to move the robotic arm. As a consequence of this arrangement, the researchers found a positive relationship between participants’ fear of shock-related pain and degree of divergence in the response trajectory. There was also a greater tendency for pain-afraid participants to avoid (i.e., choose an indirect path) in comparison to controls (whose task did not include shock).

The methodological sophistication of the previous AAC-Ts permit the investigation of more complex behaviour in comparison to traditional avoidance tasks (that involve responses to one stimulus at a time) and traditional decision-making tasks (of an hypothetical abstract nature). First, approach-avoidance paradigms tend to implement aversive stimuli known to elicit avoidance responses, such as noxious physical stimulation or stimuli established as phobic. Second, the fact that each response option has both positive (approachable) and negative (avoidable) aspects adds a more realistic level of complexity to the processes of interest, making it more akin to everyday decisions in which we trade off the pros and cons of a course of action. Third, since participants are usually presented with options that vary with respect to their degree of appetitiveness and aversiveness, these tasks allow for variability and complexity in decision-making. Fourth, approach-avoidance tasks could be considered a methodological step closer to establishing a link between cognitive dispositions and emitted responses.

Thus, implementing AAC-Ts in which people have to decide between two options at a given time, each involving both appetitive and aversive consequences, can represent a scientifically useful strategy to investigate the underlying motivations of pathological avoidance (Beckers, Krypotos et al., 2013; Gannon et al., 2011; Krypotos, Effting et al., 2015; Pittig, Treanor et al., 2018). The degree of approach or avoidance, in response to varying (appetitive/aversive) characteristics of the choice outcomes, thus becomes a means to estimate the relative motivating value of a preferred choice. For example, an approach response would imply that the appetitiveness of such a choice at the time was greater than its aversiveness.

In this sense, individual differences in how people calibrate these motivations to approach and avoid a situation can become an indicator of an individual's "fear". Moreover, the extent to which these motivations balance each other, that is, the degree to which their relative strength is significantly different or equal, can be of predictive utility in determining the extent to which an individual would physically avoid a situation. In so doing, the following paradigms might represent an improvement and complement the scarce empirical literature from an AAC perspective, which thus far has focused on describing group differences in AAC-Ts performance.

Up to this point we have briefly mentioned key paradigmatic transitions in the scientific enquiry of avoidance (and its assumed connection with psychological components of anxiety-related disorders: fear). We then discussed some concepts of relevance to the area of research in terms of the stance currently adopted. The rationale and main principles behind an approach-avoidance framework were introduced. We ended this introduction putting forward such a framework as a scientifically viable approach to further our understanding of the processes involved in maladaptive avoidance. This reasoning guided the studies conducted as part of this thesis, and the interplay between approach-avoidance motivations is thereby advocated as the process of interest. Thus, the present research programme offers a methodological approach that, in integrating co-existing motivations and their dynamic interaction, contributes to a re-conceptualization of clinical fear and provides a new measure thereof based on behavioural processes. In addition, it lays the foundations for the scientific exploration of the dynamic processes present in AACs during decision-making.

Outline of empirical chapters

The literature abounds with studies that examine the relationship between implicitly measured constructs and self-reports (e.g., Nosek, 2005), and between implicit anxiety-related constructs and clinical conditions (e.g., Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). The relationship between indirect measures of this kind and overt avoidance, however, has not been the focus of research thus far. In the published literature, the relationships between these measures and avoidance are often only included as ancillary, and it is unclear the strength of their relationship across experiments. *Study 1* (Chapter II), assesses and compares the strength of the relationship between explicit and implicit measures of fear with that of overt avoidance. In addition, the procedural characteristics of the protocols used to assess overt avoidance are critically examined.

The development of approach-avoidance conflict tasks (AAC-Ts) is quite incipient. Thus, additional systematic manipulations of experimental variables potentially tapping on different processes involved in AACs are warranted to further the theory. Moreover, there are few experimental attempts examining the power of these tasks to predict behaviour "outside the computer screen". The aim of *Experiment 1* and *2* (Chapter III) is to develop decision-making tasks whereby different levels of avoidance can occur as a function of variable approachable consequences. *Experiment 2* builds on exploring the relation between performance in the (approach-avoidance) computer task and a realistic behavioural exercise.

Lastly, although some approach-avoidance tasks have appeared in recent years, none of these permit the continuous measurement of behaviour. The ability to synchronise behaviour with continuous changes in the environment is critical for survival (e.g., changes in a prey's locomotion precedes the adjustment of a predator's trajectory, weather changes are followed by shelter seeking or hoarding behaviours, and approaching a high rank member of the group requires constant assessment and optimal behavioural regulation: submission, escape, fight). Therefore, defence mechanisms (e.g., avoidance) are expected to be dynamic. Yet, very few AAC paradigms exist to study avoidance in this manner. In addition, most of the current data ensuing from AAC-Ts has been interpreted based on response times as the only index of conflict considered thus far. The focus of *Experiment 3* and *4* (Chapter IV) is to explore the dynamic nature of AACs. Additionally, the theorised conflict/competition generated through our AAC-T is empirically tested using process-tracking measures (i.e., mouse-tracking).

Chapter V offers a general overview of the present work, with a brief discussion about the potential implications for the conceptual and clinical domains. These implications revolve around conceiving avoidance as a dynamic process, and the ecological representativeness and potential practical utility of developing measurements in line with the present work.

Chapter II

Study 1 — Arachnophobia-philia: A scoping review and initial meta-analysis of the relationships between fear measures and behavioural avoidance.

Many fears[1] are adaptive, keeping us safe from dangerous situations (Dymond & Roche, 2009; Krypotos, Effting, Kindt, & Beckers, 2015; Öhman, 1986). The ability to learn about novel dangerous situations without direct experience allows us to remain safe from deadly situations (e.g., unprotected electricity cables) in which experiential learning would be impossible, and from future threats that require early intervention (e.g., climate change). However, fears also potentially insulate us from appetitive consequences or important learning opportunities (Campbell-Sills & Barlow, 2007; Kazdin & Kagan, 1994; Mineka & Oehlberg, 2008). For example, turning down social activities or escaping social interactions due to social anxiety removes access to social reinforcement and inhibits the development of social skills that might facilitate access in the future and prevent generalized social anxiety. Even though pathological fears can be distinguished from non-pathological fears on many grounds (e.g., greater intensity, duration, frequency of emotional responses), it is often their behavioural manifestation in the form of avoidance that is of greatest clinical relevance (Barlow, 2002; Beckers & Craske, 2017). Avoidance is a stronger and more stable predictor of treatment outcome and future functioning than self-reported fear (Castriotta, 2013). The current paper provides a scoping review of the literature base that informs our estimates of the strength of the relationship between fears (e.g., spider fear), measured (a) explicitly via self-reports, (b) implicitly via response time measures, and overt behavioural avoidance (e.g., physically avoiding spiders).

For the purposes of the current scoping review, we focused on behavioural approach tasks (henceforth BATs) as a measure of behavioural avoidance. The direct format of BATs arguably make them an ecologically valid measure of avoidance (Bellack & Hersen, 1988; cf. Krypotos, Vervliet, & Engelhard, 2018; Vervliet & Raes, 2013). In a typical BAT, participants are provided with an opportunity to approach an exemplar of the feared class of

[1] As with many familiar terms, "fear" is deceptively complex. The term "fear" is used to describe the quality of emotional responses ("I feel fear"), and to describe the strength of our aversion to a stimulus, experience or state of affairs ("I tremble at the sight of spiders"). The current review is concerned with the latter usage of the term "fear", and to underline this usage, we employ the plural term "fears", since this usage makes it more difficult to misconstrue it as alluding to an experience; the focus of the current paper is on *response to a perceived threatening stimulus*.

stimuli or context—the threat. For instance, in a spider BAT, spider-afraid individuals might be asked to move as close as they feel comfortable to a real spider (e.g., Lang & Lazovik, 1963). The degree to which participants approach the threat constitutes the dependent variable. This can be operationalized as the eventual distance between the participant and the threat (which will positively correlate with fear), the speed of approaching the threat, or number of steps towards the threat (which will negatively correlate with fear).

In order to estimate the relationship between fears and avoidance, we incorporated two means of estimating fears: self-report questionnaires and implicit measures of fears. Undoubtedly the most widely employed tool to gauge an individual's level of a fear consists of psychometric questionnaires, of which a broad range have been developed. Generic self-report measures of fears or anxiety include the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988). Other measures address particular threats, such as snakes (e.g., Klorman, Weerts, Hastings, Melamed, & Lang, 1974), heights (e.g., Cohen, 1977), and social situations (e.g., Liebowitz, 1987).

Self-report measures of fears are sometimes termed explicit measures, since it is clear to the respondent that their fear is being assessed when they are completing the questionnaire. In recent years, there has been a growing interest in developing implicit measures of attitudes and emotions, including fear, to avoid effects of social desirability (see Edwards, 1957; Schwarz, 1999; Schwarz & Oyserman, 2001) and other potential biases on the estimates obtained. De Houwer, Teige-Mocigemba, Spruyt, and Moors (2009) define an implicit measure as "a measurement outcome that is causally produced by the to-be-measured attribute in the absence of certain goals, awareness, substantial cognitive resources, or substantial time" (p. 350). Implicit processes have traditionally been equated with automaticity and unconsciousness (e.g., De Houwer, 2006; Eder, Rothermund, & Proctor, 2010; Greenwald & Banaji, 1995; cf. Hahn, Judd, Hirsh, & Blair, 2014; McNally, 1995). As a consequence, a common feature of implicit tasks is that they require quick responding (i.e., within 300-3000 ms), as responses of greater duration might indicate deliberation and planning.

Even though implicit measures of fears share a dependency on response-time differences to infer discriminated processing of threat and non-threat stimuli, these measures differ in their design and theoretical background. In the Implicit Association Task (IAT; Greenwald, McGhee, & Schwartz, 1998), a commonly employed implicit measure, participants are required to sort a set of stimuli (words or images) according to concepts (e.g., spiders; flowers) or emotional valence (e.g., pleasant; unpleasant). In the critical trial blocks, participants sort the stimuli using the same response for one half of the concept-pair and one half of the valence-pair (e.g., press the left button for spiders and pleasant words; press the right button for butterflies and unpleasant words). The concept-valence alignment can be construed as consistent with an individual's experiences ("congruent") or not ("incongruent"). When this alignment is congruent, participants are expected to respond more quickly than when the alignment is incongruent. In the general population, the "spider" concept and the "unpleasant" valence are congruent and, in line with expectations, faster responses are observed when stimuli in these categories are classified as such using the same response (de Jong, van den Hout, Rietbroek, & Huijding, 2003). To assess individual differences in the strength of association between the "spider" concept and the "unpleasant" valence, one compares the response time differences (i.e., incongruent – congruent) of spider-fearful participants and control participants (for a more comprehensive review of implicit measures and their characteristics see De Houwer, 2006; 2009).

A number of other implicit measures of fears have been employed in the literature. These include the Extrinsic Affective Simon Task (EAST; De Houwer, 2003), the Implicit Relational Assessment Procedure (IRAP; Barnes-Holmes, Barnes-Holmes, Stewart, & Boles, 2010; Barnes-Holmes, Hayden, Barnes-Holmes, & Stewart, 2008), the Approach-Avoidance Task (AAT; Rinck & Becker, 2007) and the Go/No-go association task (GNAT; Nosek, & Banaji, 2001). There are important differences in these paradigms in terms of the assumed processes upon which they depend and controls for potential confounds within the various experimental protocols. However, for the purposes of the current meta-analysis, we are concerned with the power of such measures to predict overt behavioural avoidance. With this in mind, as our predictor variable, we selected the outcome value of each task as reported by the researchers. Methodological similarities of these tasks, and the fact that the outcome values from all of the implicit measures included are based primarily on response-time (RT) differences across participants, lead us to categorize these measures together.

A large meta-analysis (126 studies; Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005) estimated a significant mean population correlation of .24 between IAT measures and explicit measures of shared constructs. Nosek (2005) conducted a study with a large sample of participants (n = 6836) on 57 different topics where an average correlation of .36 between implicit and explicit evaluations was found. Yet, there was considerable variability in the correlations depending on the topic, ranging from .10 (Thin–Fat people) and .70 (pro-choice–pro-life). It is worth noting that the vast majority of studies that have gathered and synthetized data on the relationship between implicit and explicit measures have focused exclusively on the IAT, leaving other implicit measures underrepresented. The relative predictive validity of implicit and explicit measures has also been assessed and the relative strengths of the approaches varies across domains. Greenwald, Poehlman, Uhlmann, and Banaji (2009) found an average correlation of .27 for prediction of behavioural, judgment, and physiological measures by IAT measures, in comparison to .36 for explicit measures. However, to our knowledge, there are as yet no systematic reviews or meta-analyses that have estimated the relationship between implicit measures of fear and overt behavioural avoidance specifically.

Recent procedural innovations are re-invigorating interest in avoidance (e.g., Aupperle, Sullivan, Melrose, Paulus, & Stein, 2011; Buetti, Juan, Rinck, & Kerzel, 2012; Garcia-Guerrero, Dickins, & Dickins, 2014; Rattel, Miedl, Blechert, & Wilhelm, 2017; Rinck & Becker, 2007; Schlund et al., 2017; Vervliet, Lange, & Milad, 2017). In addition to highlighting salient features of the literature, we conducted an initial meta-analysis to estimate the extent to which self-reports and implicit measures of fears/anxiety correlate with overt behavioural avoidance. Furthermore, this review documents the implementation and systematization of BATs to date.

Method

The present scoping review was conducted and structured following the PRISMA statement (Liberati et al., 2009), and no preregistration was undertaken.

Eligibility Criteria

We categorized measures of fears/anxiety into two groups: (a) implicit response-time associative tasks (e.g., Simon Task; De Houwer, Crombez, Baeyens, & Hermans, 2001), and (b) explicit self-report questionnaires (e.g., FSQ; Szymanski & O'Donohue, 1995). Tasks in which participants were exposed to real threats, and parameters of physical proximity (e.g., distance) or graded exposure to these (e.g., time), constituted our measure of avoidance; we refer to these as behavioural approach tasks (BATs).

Thus, we selected experimental studies that: (a) measured responses related to anxiety diagnostic categories[2]; (b) implemented a self-report or implicit measure *and* a BAT; (c) were written in English, available in full-text format, published in peer-reviewed journals or fully available PhD theses, and whose analyses were based on primary data; (d) reported a correlational relation (i.e., Pearson) between the self-report/implicit and BAT measures (or other analyses from which it could be calculated); (e) did not measure the outcome variable of interest after an intervention or other experimental manipulation affecting the eliciting/anxiogenic quality of the stimuli; (f) included only human participants.

Information Sources

Studies were identified by searching electronic databases, hand-picking references cited in highly relevant papers, references suggested by researchers in the field, as well as open searches on Google Scholar. The searched databases were: *Scopus, Embase, PsychINFO (1806), Cochrane (Wiley Online Library), Web of Science, ProQuest (Dissertations)*; all searches were conducted from each database's default starting year. These databases were initially reviewed on 9th of October 2016 and the search was refreshed on the 10th of November, 2018.

We contacted 16 authors asking them for any unreported correlational data from published studies and data from any work in preparation. We also attempted contacting 12 authors requesting unobtainable full-text theses from databases. Eight authors replied with data from published work (out of 16) from these attempts; no unpublished work was provided.

Search. The search concepts were: Fear, approach-avoidance, and behavioural task. Pertinent synonymous and key words were concatenated per each string. Appropriate truncation and wild cards were applied to these key-word concepts (e.g., fear*, anxi*, approach*, avoid*).

[2] We excluded studies with samples that also included symptoms identified as belonging to other—diagnostically differentiated—condition (e.g., psychotic disorders). This was done in an attempt to keep the dependent measures as close as possible to responses characteristic of anxiety. Having said that, most studies did not specifically control for potential comorbidity and sample classification was mostly done using psychometric questionnaires.

The search strategy was generated following Bramer and de Jonge's (2015) guidelines on search standardization. This was adapted to each of the databases (when possible, the search command included a filter for human subjects, see Table 2.1):

Table 2.1

Search commands used for each of the databases

database	Search string strategy / command line
Scopus	(TITLE-ABS-KEY(fear* OR phobia OR anxi* OR emotion* OR motivation*) AND TITLE-ABS-KEY(approach avoidance OR {overt avoidance} OR (overt W/2 avoid*) OR (overt W/2 behavio?r) OR (approach* W/3 conflict) OR (avoid* W/3 conflict) OR {approach-avoidance task} OR {approach-avoidance paradigm})AND TITLE-ABS-KEY(behavio* task)) AND (LIMIT-TO(EXACTKEYWORD,"Human"))
Embase	(fear* OR phobia OR anxi* OR emotion* OR motivation*:ab,ti) AND (approach avoidance OR "overt avoidance" OR (overt NEAR/2 (avoid* OR behavio?r)) OR (conflict NEAR/3 (approach* OR avoid*)) OR "approach-avoidance task" OR "approach-avoidance paradigm":ab,ti) AND (behavio* task:ab,ti) AND "human"/de
PsychINFO	((fear* OR phobia OR anxiety OR emotion* OR motivation*) AND (approach avoidance OR "overt avoidance" OR "overt avoidance" OR "overt behavio*r" OR "approach-avoidance conflict" OR "approach-avoidance task" OR "approach-avoidance paradigm") AND (behavio* task)).ab,ti. NOT (animals NOT humans).sh.
Cochrane	((fear* or phobia or anxi* or emotion* or motivation*) and (approach avoidance or "overt avoidance" or (overt near/2 (avoid* or behavio?r)) or (conflict near/3 (approach* or avoid*)) or "approach-avoidance task" or "approach-avoidance paradigm") and (behavio* task)):ti,ab,kw
Web of Science	ts = ((fear* OR phobia OR anxi* OR emotion* OR motivation*) AND (approach avoidance OR "overt avoidance" OR (overt near/2 (avoid* OR behavio?r)) OR (conflict near/3 (approach* OR avoid*)) OR "approach-avoidance task" OR "approach-avoidance paradigm") AND (behavio* task))
ProQuest	TI,AB,SU((fear* OR phobia OR anxiety OR emotion* OR motivation*) AND (approach avoidance OR "overt avoidance" OR (overt NEAR/2 (avoid* OR behavio?r)) OR (conflict NEAR/3 (approach* OR avoid*)) OR "approach-avoidance task" OR "approach-avoidance paradigm") AND (behavio* task))

Study Selection

Eligibility assessment was performed independently in an unblinded standardized manner by two reviewers in accordance with the inclusion criteria. Disagreements between reviewers were resolved by consensus and reviewing reasons for disagreement. There was an additional reviewer available for instances where disagreement between the two main reviewers persisted but recourse to this reviewer was not necessary.

Data Collection Process

Along with the data extraction form, a quality assessment form was designed for this specific review (see Appendix B), refined after testing it on five papers. It consisted of 10 items, eight of which judged whether a study complied or not (scored 1 or 0) with a methodological aspect of relevance (e.g., "Is the BAT procedure clearly described?"); but some items could be given half a score depending on the case. The last two items required categorical scores about the overall quality of a paper (i.e., poor, acceptable, good), and its pertinence to the present review (i.e., low, medium, high). Quality and relevance assessment was coded independently by each reviewer, yielding an intraclass correlation (two-way model) of .88 (95% [CI: .71, .95], F [16, 16.4] = 15.7, $p < .001$), and a Cohen's Kappa (unweighted) of .87, $z = 4.74$, $p < .001$ for the categorical evaluation on study pertinence.

The data extraction form was used to extract the following information from the selected papers: Sample size; sampled gender (i.e., female, male, or both); age (*M*, *SD*, range); whether the sample was diagnosed as clinical population; grouping per level of fear (e.g., high/low fear); type of experimental threat implemented (e.g., spider-related images, semantic stimuli, shock); type of self-report/implicit and BAT measure; measures' descriptives (i.e., *M*, *SD*, *SE*, score range) and measured parameters for the BATs (i.e., distance from threat, speed, duration, scale-steps); and the bivariate correlations (or related statistical information) between the self-report/implicit and BATs (and corresponding *p* value). Data was extracted first by one of the reviewers and was subsequently checked by the second reviewer (see Appendix C).

Analysis and Summary Measures

The present review gathered data from experimental studies that took both self-report or implicit measures of fears/anxiety, and the degree to which these correlated with tasks of overt avoidance towards a feared stimulus (e.g., behavioural approach tasks–BATs). We conducted two meta-analyses separately. The first assessed the relationship between explicit self-report questionnaires and the BAT. The second assessed the relationship between implicit measures (i.e., associative response-time based tasks) and the BAT.

The analysis was conducted in *R* (Development Core Team, 2013) implementing the packages "metafor" (Viechtbauer, 2010) and "robumeta" (Fisher & Tipton, 2015).

Consequently, we used the method proposed by Higgins and Thompson (2002) to measure inconsistency (termed *I-squared*) for the Random Effects Models, and tested for heterogeneity using Cochran's *Q-test* (Cochran, 1954). As customary, Pearson's *r* values of individual effect sizes were converted into Fisher's *z* scale for the combined effect size estimate, representing the overall magnitude of the analysed relationships.

Pearson's *r* (95% confidence intervals) was the primary measure of a relation between self-report/implicit and BAT measures. Since BAT scores are sometimes expressed as steps towards the threat and sometimes expressed as steps from the threat, we standardized the obtained correlations. Specifically, we reversed the obtained correlations in paradigms that reported the steps from the threat, such that increased self-reported or implicit fear was related to reduced approach in the BAT (i.e., negative correlations were expected in all cases).

When a number of questionnaires were used, we chose the one measuring fear/anxiety more specifically with respect to the employed threat (e.g., the Spider Phobia Questionnaire was preferred over Beck Anxiety Inventory). If two threat-specific questionnaires were included, we gave priority to the Fear of Spider Questionnaire (FSQ; Szymanski & O'Donohue, 1995), as this was used by the majority of the studies (10 out of 17). The meta-analyses were performed using a random-effects model (in agreement with Field, 2003).

Additional analyses. Omnibus moderator analyses were conducted for both meta-effects on potential influential variables. These analyses, however, were of an exploratory nature and should be judged in light of their low statistical power.

Results

Study Selection

Figure 2.1 shows the process from identification of scientific papers to the final inclusion of experiments. A total of 16 authors were contacted with requests for additional data and relevant unpublished work, but no unpublished relevant studies were obtained (no attempts were made to obtained additional data from publications 15+ years old). A total of 17 studies (from 16 references) were included in the present review.

The search of *Scopus*, *Embase (encompassing PubMed)*, *PsychINFO*, *Cochrane*, *Web of Science* and *ProQuest*, as well as key-word searches on Google Scholar and hand-picked citations from key papers, provided a total of 1238 references on the 9th of October 2016. Control for duplicates returned 827 unique references to screen, to which the following exclusion criteria were applied: (a) *not on topic*: Papers that were not investigating the processes of fears/anxiety and behavioural avoidance (e.g., concerned with cognitive processes in decision-making or learning); (b) *non-experimental*: Papers that addressed theoretical issues or reported empirical data without the respective methodology, stemming from other sources; (c) *only one type of measure*: Papers that implemented either self-report/implicit or BAT measures, not both; (d) *non-aversive stimuli*: Papers that included appetitive stimuli (e.g., nicotine, alcohol) or "emotional" stimuli without a clear operationalization of their aversive nature (e.g., "negative faces"); (e) *Non-anxiety*: Papers that used samples characterized by symptoms unrelated to anxiety disorders; (f) *Non-English*: Papers published in another language; (g) *Incompatible methods*: Studies where the measurements were not comparable to response time measures (e.g., studies with BAT procedures defined in terms of frequency or probability of encountering the threat or verbal reports of hypothetical behavioural approach), or studies that introduced treatment (unless data from controls was available and the measures of interest where taken prior to the interventions); it also applied to BATs where only Spearman correlations were reported, due to its categorical format (e.g., approach/unapproached, touched/untouched). The foregoing criteria were applied in accordance with their numerical order. Namely, once a study met one criterion, that paper was excluded, regardless of how many of the other criteria it also met. This explains the comparatively fewer number of studies that were excluded for not meeting the latter criteria (see Figure 2.1).

These criteria yielded 52 potential publications, of which 11 could not be obtained in full-text format (all consisting of theses). Full-text versions of the 41 remaining references were examined in depth. Detailed examination of these records further excluded 32 studies for lack of data or incompatible methods. A final count of nine studies met the inclusion criteria. No researchers provided unpublished work of relevance upon request, but eight provided correlational data absent in their published work, yielding a final selection of 17 studies for our meta-analyses.

The foregoing search strategy was repeated on November 10th 2018 in order to include any papers that might have been published during data analysis and manuscript preparation. This search returned 72 new entries between 2016 and 2018. Seventy of these references were considered to be "not on topic" based on title and abstract scrutiny. The remaining two consisted of theses; one was excluded due to data of interest not being reported, the other one was unobtainable.

We divided the selected studies into two groups for separate meta-analyses. The first group consisted of 16 studies including both explicit self-report and BAT measures, the second group of 11 studies included both implicit and BAT measures (see Table 2.2 and 2.3).

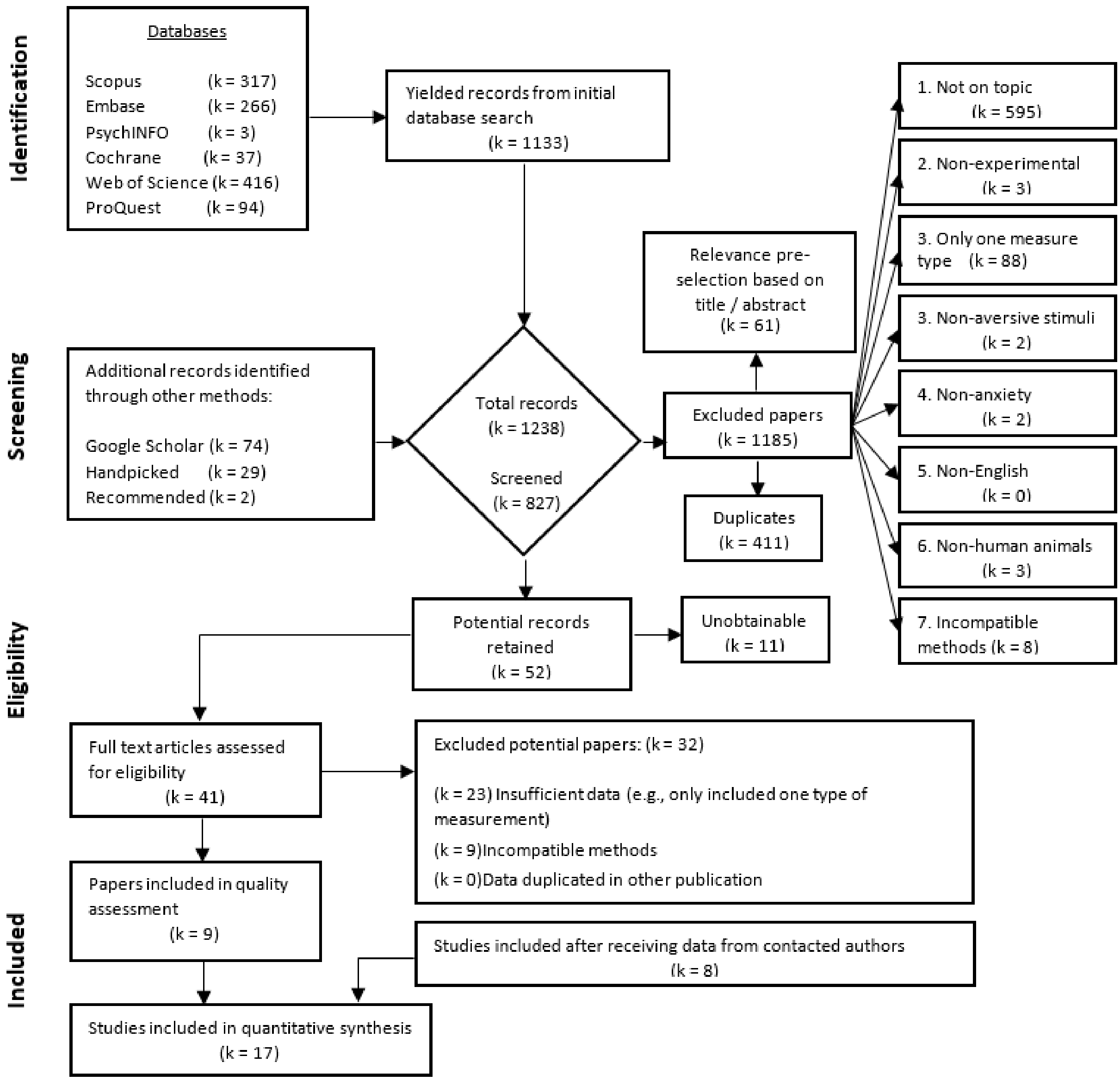


Figure 2.1. Flow diagram showing the different phases of study selection for the systematic review.

Study Characteristics

All 17 studies included both a self-report or an implicit measure of fears/anxiety and a measure of overt avoidance (i.e., BAT). Sixteen studies reported data from self-report measures (see Table 2.2) and 11 studies in total reported data from implicit measures, including the IAT, EAST, AAT, GNAT and IRAP (see Table 2.3). The majority of the BAT procedures used real spiders as threat (k = 13), the remainder used electric stimulation (k = 2), social speech (k = 1) and an enclosed chamber (k = 1). Except for three studies, the samples included both genders (although samples across studies were characterized by considerably fewer males than females), and four studies corroborated the clinical levels of fear of their participants via structured clinical interviews. The number of participants from all studies amounted to 918 (with a range of 31-120) for the studies with self-report measures (two studies included almost twice as many participants as the rest), and 518 (range of 30-68) for the studies that included implicit measures.

The majority of studies implemented spider-related stimuli as threats in the tasks and the corresponding psychometric measure for this specific phobia (i.e., FSQ). This could be partly due to the logistics of BAT procedures in terms of the required space and care costs, as well as institutional health and safety protocols or ethical challenges of exploring other fears (e.g., horses, heights, surgeries); not to mention their feasibility under laboratory conditions.

In addition, there was a high degree of procedural variability in the BATs described in the literature (see Appendix D). BATs varied with respect to the environmental context (e.g., sitting at a table or standing in a room), the maximum distance between the participant and the threat (1 or 5 m), the critical approach/avoidance measure (e.g., distance, duration), the units employed (e.g., steps, centimetres, seconds) and the graduation of the approach-avoidance continuum (e.g., levels of avoidance or approach steps). Also, some studies implemented a "dichotomous" BAT (touch/not-touch), but these studies were excluded from the present meta-analyses.

Correlation between self-report measures of fears and overt avoidance

Sixteen studies were selected for the first meta-analysis, containing self-report measures of fears/anxiety and correlational data with their respective BAT protocols (see Table 2.2).

Table 2.2

Studies selected and some of their characteristics, included in the explicit-BAT meta-analysis

ID	Authors	*n*	Age	Clin	Gender ♀	Explicit.M	BAT	BAT.unit	*r*	*p*	Quality
1	Valentiner et al. (1993)	116	18.9	No	80%	ASI	Chamber	Duration	-.22	.05	4/7
2	Teachman et al. (2003)	61	32.6	Yes	84%	FSQ+SPQ	Spider	Distance	-.77	.05[f]	6.25/8
3	Huijding & de Jong (2005)	66	19	No	100%	FSQ	Spider	Steps	-.75[c]	.01	6.75/8
4	Ellwart et al. (2006), Study 1	48	23.3	Yes	91%	FSQ	Spider	Distance	-.54[c,d]	.01	6/8
5	Huijding et al. (2006)	48	21.6	No	100%	FSQ	Spider	Steps	-.72	.01	7/8
6	Rinck et al. (2007), Study 1	46	21	Yes	92%	FSQ	Spider	Speed	-.75[e]	.005	5/8
7	Teachman B. A. (2007)	34	18.8	No	67%	FSQ	Spider	Steps	-.80[c]	.01	6/8
8	Cochrane et al. (2008)	120	24.4	No	100%	FSQ	P-Spider	Steps	-.64	.001	5/7
9	Reese et al. (2010)	41	26.3	No	77%	SPQ	Spider	Steps	-.37[c,d]	.017	6/8
10	Van Bockstaele et al. (2011)	68	19.8	No	80%	FSQ	Spider[a]	Distance	-.29[c,d]	.015	6/8
12	Asnaani et al. (2014)	43	27.6	Yes	*NA*	SPIN	Speech	Duration	-.30[c]	.036	6.75/8
13	Vervliet et al. (2015)	40	19	No	80%	STAI-T	Shock	Frequency	-.11[d]	.51	4/7
14	Dour et al. (2016)	61	*NA*	No	*NA*	SPQ	Spider	Steps	-.15[c]	.244	5/7
15	Leech et al. (2016), Study 1	45	21.5	No	47%	FSQ	Spider[b]	Steps	-.48	.001	5/8
16	Leech et al. (2016), Study 2	31	21.6	No	72%	FSQ	Spider	Steps	-.81	.001	5/8
17	Meulders et al. (2016)	50	24.9	No	28%	FPQ	Shock	Frequency	-.52[d]	.007	6/6

Note. ID: numeral assigned to each study for the meta-analysis; *n*: sample size for each of the studies (including both fearful and non-fearful participants); *Age*: mean age of the studies' sample; *Clin*: whether the sample consisted of clinically relevant participants according to the DSM, corroborated by stated structured interviews or clinical assessment; *Gender*: gender distribution in the studies' sample (some studies only reported percentages, so herein we present this data in the same format to keep consistency); *Explicit.M*: type of explicit measure selected from the studies; *BAT*: type of behavioural approach task used; *BAT.unit*: measure unit reported in the studies; *r*: correlation coefficient between the explicit measure and the BAT reported in the studies (negative correlations means that the more an individual scored in a questionnaire the less s/he approached the feared stimulus during the BAT); *p*: *r*'s corresponding p value (95% CI); *Quality*: Final – averaged – Quality Assessment score per each of the studies (over 7 for studies that included only explicit measures, over 8 for those that included implicit measures). FSQ = Fear of Spider Questionnaire; SPQ = Spider Phobia Questionnaire; STAI-T = State-Trait Anxiety Inventory (Trait scale); SPIN = Social Phobia Inventory; FPQ = Fear of Pain Questionnaire; ASI = Anxiety Sensitivity Index.

[a] The spider used in this BAT was dead (stuffed slough), and pushed on a table towards the participant. Participants were not told that it was dead, but there is not mention of steps taken to corroborate that participants did not notice it.

[b] This study used a spider mould, rather than a live spider.

[c] Correlations coefficients obtained directly from the corresponding authors.

[d] Measures whose reported correlation coefficients where reversed for the present meta-analysis for comparative purposes (i.e., more self-reported fear/negative implicit associations towards the threat is related to less approach in the BAT).

[f] No precise value reported (defaulted significance at 0.05; non-significance at 0.1).

[e] The polarity of the correlation reported in this study was corrected from the reported in the original paper after correspondence with the principal author.

There was considerable variation in the effect size of the relationship between self-report measures and avoidance measures, potentially reflecting the variety of the sampled studies. The random-effects model suggests considerable heterogeneity of effect size (I^2 = 84.84% [95% CI: 71.91, 93.85]), indicating that 84% of variation across studies is due to heterogeneity. Tau-squared was 0.10 (95% CI: 0.04, 0.28) and the *Q-statistic* testing for heterogeneity was significant ($Q = 96.25$, $df = 15$, $p < .001$) suggesting that the studies included may not share a common effect size.

One source of the variation in effect size was that a variety of self-report measures were employed addressing a variety of threat objects. To address this, we conducted a second meta-analysis including only correlations with the FSQ. In this analysis, heterogeneity was reduced, but remained in the moderate to substantial range $Q = 33.92$, $df = 9$, $p < .001$; I^2 = 74.2% (95% CI: 44.3, 92.4). Procedural variation in BATs is also a likely contributor to heterogeneity of effect (this is explored and discussed later).

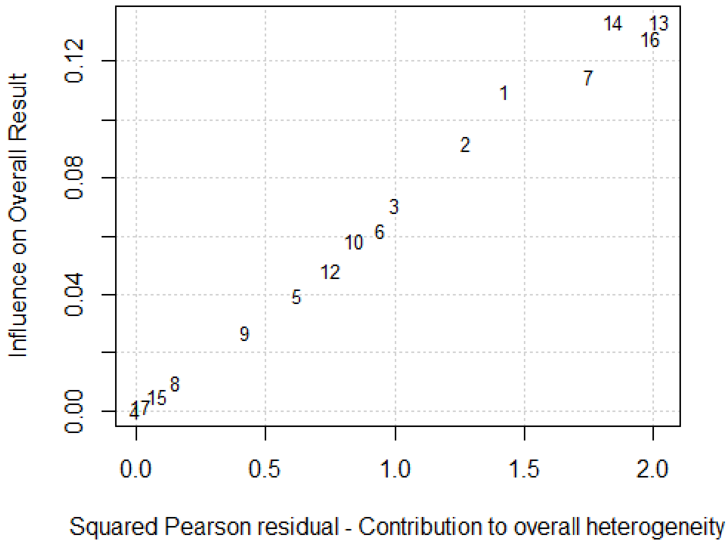


Figure 2.2. Baujat plot showing studies (identified by their numeric id) that are potentially contributing to heterogeneity and overall result (occupying the upper right quadrant) for the relation between explicit measures and BATs: 13 (Vervliet et al., 2015); 16 (Leech et al., 2016, study 2); 14 (Dour et al., 2016); 7 (Teachman, 2007); and 1 (Valentiner et al., 1993).

We produced a Baujat plot (Baujat, Mahé, Pignon, & Hill, 2002) to explore possible contributors to this heterogeneity. Figure 2.2 detected six studies contributing greatly to the overall result and heterogeneity. To further examine the observed heterogeneity we conducted numerical and graphical bias tests. Neither Egger's regression (Egger, Smith, Schneider, & Minder, 1997) nor the rank correlation test (Begg & Mazumdar, 1994) were significant, demonstrating a lack of evidence of the possibility of publication bias (these tests evaluate if effect estimates and sampling variances for each study are related). This was also corroborated by the visual symmetric distribution of the studies (see Figure 2.3a funnel plot), and since normal quantile plots are less ambiguous to interpret than funnel plots (see Wang & Bushman, 1998), we also produced a q-q plot which shows the distribution of the studies within the 95% confidence bands. The fact that in the sampled studies the BATs were included as an ancillary measure may contribute to the low publication bias.

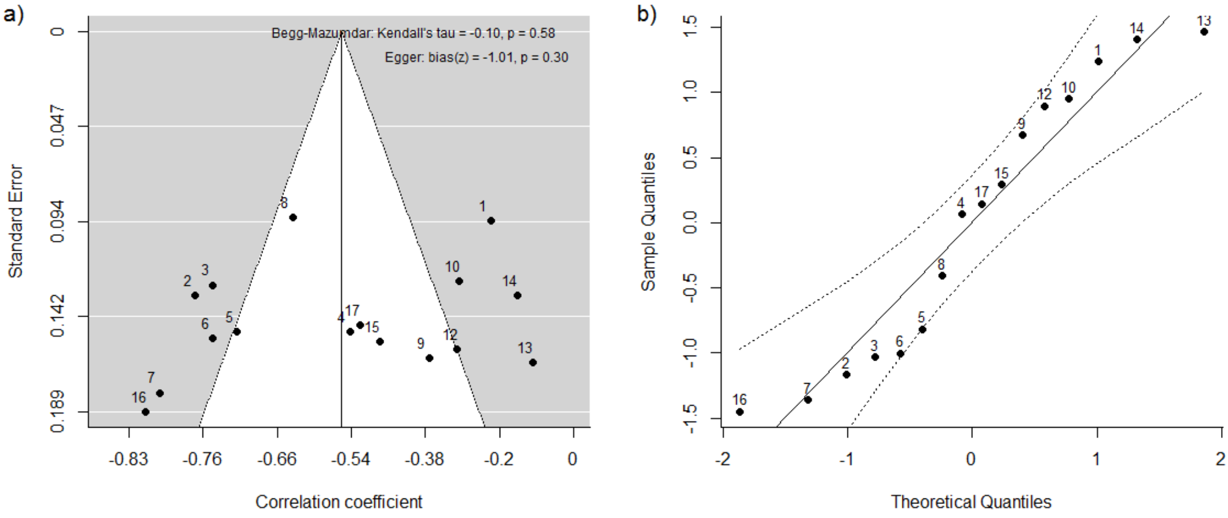


Figure 2.3. Graphical publication bias analysis for the 16 studies (identified by their numeric id) exploring the relation between explicit fears measures and measures of behavioural avoidance. a) Funnel plot on the left showing the observed outcomes (abscissa) against their corresponding standard errors (i.e., the squared root of the sampling variances) on the ordinate. The vertical line indicates the estimate based on the model. A pseudo confidence interval region ("triangle") is plotted around this value with bounds equal to $\pm$ 1.96 · SE (where SE is the standard error from the vertical axis). Values for Egger's regression test and Begg & Mazumdar's rank correlation test are included. Numerical tests for bias are non-significant and graphical distributions of the studies suggest that the sample included studies with both statistically significant and non-significant effects (unbiased). b) Normal quantile plot showing the observed quantiles of the (externally) standardized residuals (abscissa) against the theoretical quantiles of a normal distribution (ordinate). For reference, a line is added to the plot with a slope of 1, going through the (0,0) point. By default, a pseudo confidence envelope is also added, which is based on the quantiles of sets of pseudo residuals simulated from the given model. The plot confirms the normal distribution of the sampled studies (i.e., studies falling within the confidence intervals) and the lack of publication bias (i.e., no substantial spaces between the distribution of the studies).

The estimated model coefficient (r = -.56 [95% CI: -.66, -.42], p < .001) shows a confidence interval that does not cross zero, which coupled with a significant p value, demonstrates evidence of a moderate-to-strong relationship between the explicit self-report measures of fears and measures of—overt—avoidance (i.e., BATs). That is, increased fear, as measured by fears/anxiety questionnaires, predicted reduced approach (greater avoidance) towards threat stimuli. This summary data is also presented in the forest plot (see Figure 2.4). A second meta-analysis was conducted including only studies that implemented the FSQ (k = 10). This analysis indicated a larger effect size, r = -.67 (95% CI: -.75, -.57).

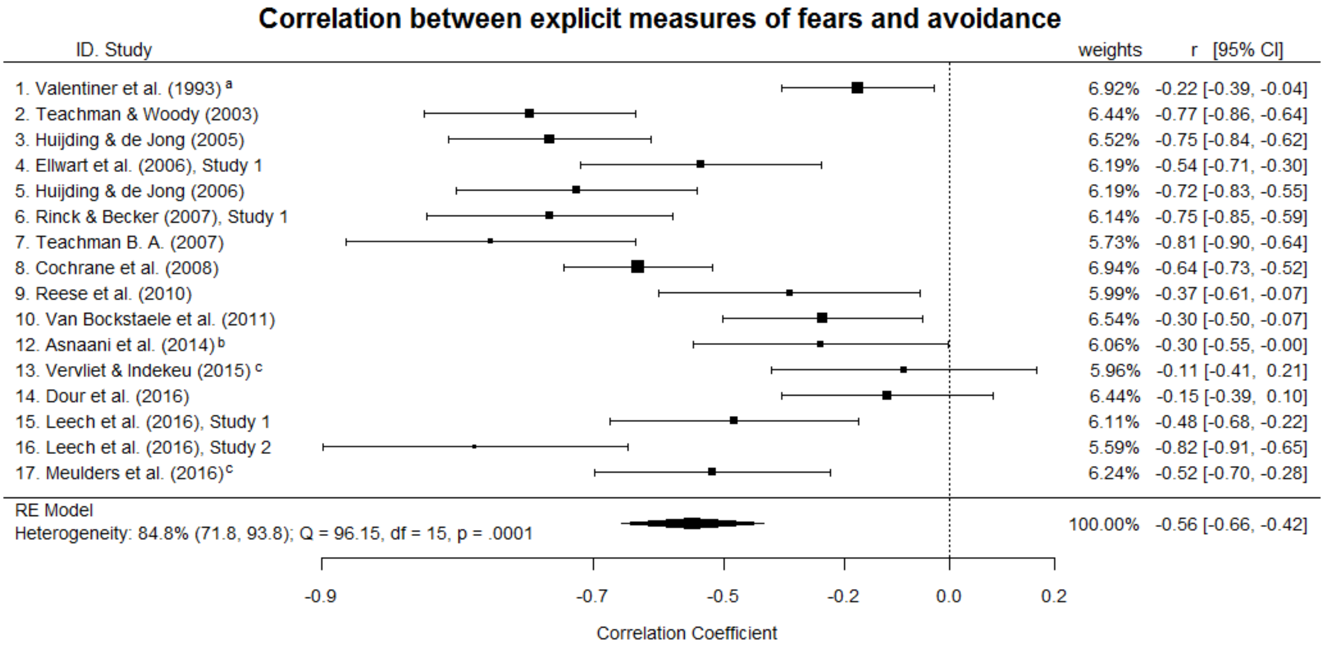


Figure 2.4. Forest plot of the observed relationships between explicit fears and overt avoidance measures. For each sampled study, the square represents the individual *r* effect (horizontal position with respect to scale at the bottom of the graph) and its respective 95% confidence interval indicated by the bars emanating from either side (whose specific values are visible in the rightmost column). The size of the square indicates the contribution of each criterion *r* to the overall meta-effect in terms of its sample size (as shown in the column labelled "weights"). Likewise, the diamond at the bottom represents the size of the overall meta-effect (r = -.56) and its width indicates the 95% credibility interval (-.66, -.42). Negative correlations means that the more self-reported fear the less individuals approached the feared stimulus during the BAT. Unless indicated, studies employed spiders as threat stimuli. Other threats are indicated with the superscripts: "a" for enclosed chamber, "b" for social speech task, and "c" for shock.

In an attempt to identify potential sources of heterogeneity and the contribution to the observed variability of the effects sizes among the studies, we conducted moderator analyses (i.e., omnibus test of parameters) on age, sample size, gender ratio, clinical nature of the sample, sampled gender (female only or both), type of questionnaire used, type of BAT, reported BAT unit (i.e., distance, duration, frequency, speed, steps), numeric quality score, and overall subjective quality evaluation (i.e., labelled as "poor," "acceptable" or "good"). Although, these were of an exploratory nature, we were particularly interested in whether variables of methodological/procedural relevance such as the BAT unit, type of BAT and questionnaire somewhat accounted for systematic differences in the size of the effect (see Appendix E for data on all moderators). The type of questionnaire measure was the only significant moderator (Q_{M1} = 16.60, *df* = 5, *p* = .047) with FSQ highlighted as having an influential regression coefficient (*b* = -.59, *p* = .02, [95% CI: -1.10, -.09]), and the overall quality assessment almost reaching significance (Q_{M2} = 3.70, *df* = 1, *p* = .054).

Finally, as the data for seven studies was sourced by contacting the authors directly, and hence its integrity was not subject to peer reviewing, we included it as another moderator (coded as published or emailed) to check if this influenced the overall meta-effect (Q_{M3} = .61(1), *df* = 1, *p* = .43). The obtained meta-regression coefficient did not support this assumption (*b* = .14, *p* = .43 [95% CI: -.21, .49]).

Correlation between implicit measures of fears and overt avoidance

It is oft-times argued that indirect behavioural measures (not based on self-reports or that are non-verbal) such as response-time, might have a stronger correlation with direct measures of avoidance as these tend to be more spontaneous and problems related to social desirability are minimized. Thus, we conducted a separate analysis for the implicit measures of fears/anxiety, and explored the extent to which these correlated with overt avoidance (i.e., performance in BATs).

Eleven studies were selected for the second meta-analysis, containing both implicit measures of fears and corresponding BAT protocols (see Table 2.3).

Table 2.3

Studies selected and some of their characteristics, included in the implicit-BAT meta-analysis

ID	Authors	*n*	Age	Clin	Gender ♀	Implicit.M	Threat	BAT	BAT.unit	*r*	*p*	Quality
2	Teachman et al. (2003)	61	32.6	Yes	84%	IAT	Images	Spider	Distance	-.35	.05[e]	6.25/8
3	Huijding & de Jong (2005)	66	19	No	100%	EAST	Images	Spider	Steps	-.12[c]	.31	6.75/8
4	Ellwart et al. (2006), Study 1	48	23.3	Yes	88%	IAT	Images	Spider	Distance	-.05[c]	.10[e]	6/8
5	Huijding et al. (2006)	48	21.6	No	100%	EAST	Words	Spider	Steps	-.08	.10	7/8
6	Rinck et al. (2007), Study 1	46	21	Yes	92%	AAT	Images	Spider	Distance	-.42[c]	.001	5/8
7	Teachman B. A. (2007)	34	18.8	No	67%	GNAT	Images	Spider	Steps	-.21[c]	.22	6/8
9	Reese et al. (2010)	41	26.3	No	77%	DPT	Images	Spider	Steps	-.16[c,d]	.30	6/8
10	Van Bockstaele et al. (2011)	68	19.8	No	80%	IAT	Images	Spider[a]	Distance	-.05[c]	.63	6/8
11	Nicholson et al. (2012)	30	21.5	No	57%	IRAP	Images	Spider	Steps	-.41	.02	6/8
15	Leech et al. (2016), Study 1	45	21.5	No	47%	F-IRAP	Images	Spider[b]	Steps	-.12[d]	.10	5/8
16	Leech et al. (2016), Study 2	31	21.6	No	72%	F-IRAP	Images	Spider	Steps	.16[d]	.10	5/8

Note. Study ID: numeral assigned to each study for the meta-analysis; *n*: sample size for each of the studies (including both fearful and non-fearful participants); *Age*: mean age of the studies' sample; *Clin*: whether the sample consisted of clinically relevant participants according to the DSM, corroborated by stated structured interviews or clinical assessment; *Gender*: gender distribution in the studies' sample (some studies only reported percentages, so herein we present this data in the same format for consistency); *Threat*: type of stimuli used as threat in the implicit task; *Implicit.M*: type of implicit measure selected from the studies; *BAT*: type of behavioural approach task used; *BAT.unit*: measure unit reported in the studies; *r*: correlation coefficient between the implicit measure and the BAT reported in the studies; *p*: *r*'s corresponding p value (95% CI); *Quality*: Final – averaged – Quality Assessment score per each of the studies (over 7 for studies that included only explicit measures, over 8 for those that included implicit measures). IAT = Implicit Association Test; EAST = Extrinsic Affective Simond Task; GNAT = Go/No-go association task; AAT = Approach-Avoidance Task; IRAP = Implicit Relational Assessment Procedure.

[a] The spider used in this BAT was dead (stuffed slough), and pushed on a table towards the participant. Participants were not told that it was dead, but there is not mention of steps taken to corroborate that participants did not notice it.

[b] This study used a spider mould, rather than a live spider.

[c] Correlations coefficients obtained directly from the corresponding authors.

[d] Measures whose reported correlation coefficients where reversed for the present meta-analysis (for comparative purposes); the stronger the negative associations towards the threat the less s/he approached the feared stimulus during the BAT.

[e] No precise value reported (defaulted significance at 0.05; non-significance at 0.1).

The *I-square* statistic indicated a heterogeneity of 17.23% (95% CI: .00, 76.98), with a *tau-squared* value of τ^2 = .00 (95% CI: .00, .07) and a non-significant *Q-statistic* (Q = 12.74; df = 10, p > .23). These tests seem to suggest effect size consistency and low heterogeneity. However, small-sample meta-analyses are known to lack power for detecting these, and confidence intervals should be interpreted in lieu of the point estimate I^2 (see von Hippel, 2015). In this case, the broad confidence intervals do not rule out large degrees of inconsistency.

As suggested by the Baujat plot (Figure 2.5), numerical case diagnostics identified three studies contributing greatly to the overall meta-effect.

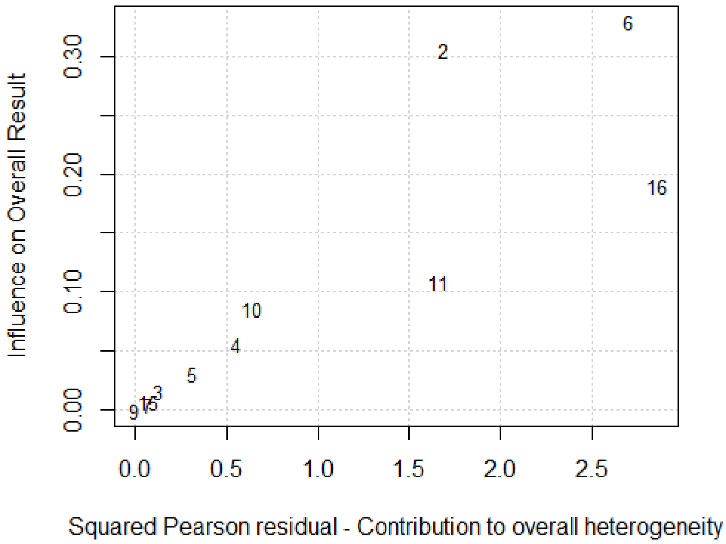


Figure 2.5. Baujat plot showing studies (upper right quadrant) contributing to heterogeneity and overall result for the relation between implicit measures of fears/avoidance and BATs: 6 (Rinck & Becker, 2007, study 1); 16 (Leech et al., 2016, study 2); and 2 (Huijding & de Jong, 2005).

The funnel plot (see Figure 2.6a) shows that all of the sampled studies fall within the confidence interval region and numerical tests did not identify influential cases suggesting publication biases for this meta-analysis according to Egger's regression test or Begg-Mazumdar's rank correlation test; this was further corroborated via a q-q plot (see Figure 2.6b).

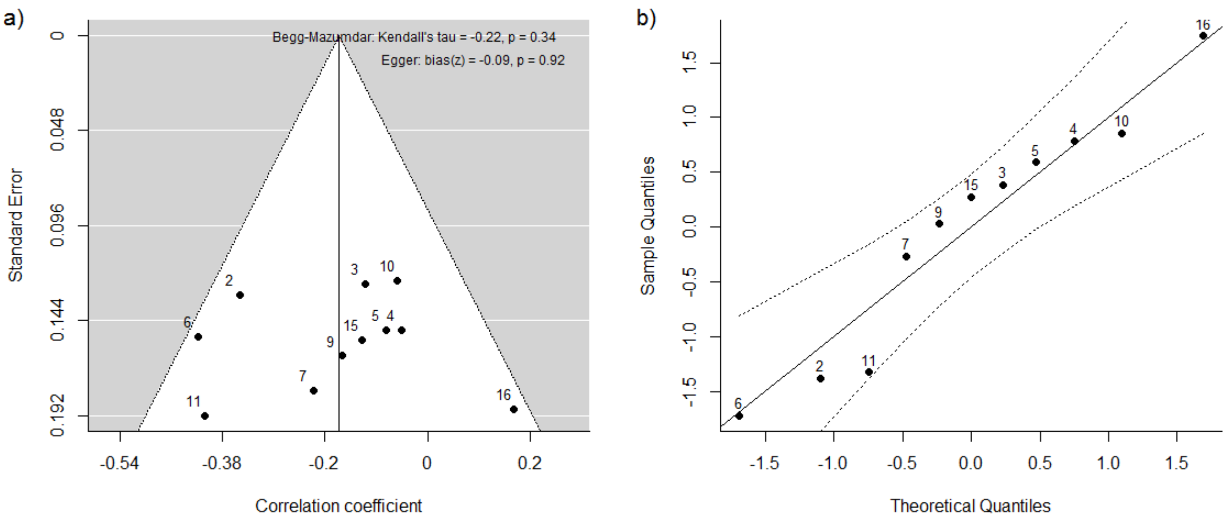


Figure 2.6. Graphical and numerical tests for potential publication bias present in the sample exploring the relation between implicit fears measures and measures of behavioural avoidance. a) Funnel plot (on the left) shows a visual symmetry and numerical tests suggesting absence of publication bias; b) Normal quantile plot (on the right) shows the normal distribution of the sampled studies and confirms lack of publication bias.

A random-effects model provided a weak correlational meta-effect that reached statistical significance between implicit fears measures and BATs: r = -.17 (95% CI: -.26, -.07), p < .001. Figure 2.7 shows the meta-analysis summary effects, in which correlations between implicit measures of fears and overt avoidance are computed and synthesized from 11 studies. The estimated model coefficient and confidence intervals suggest a weak relationship between these measures.

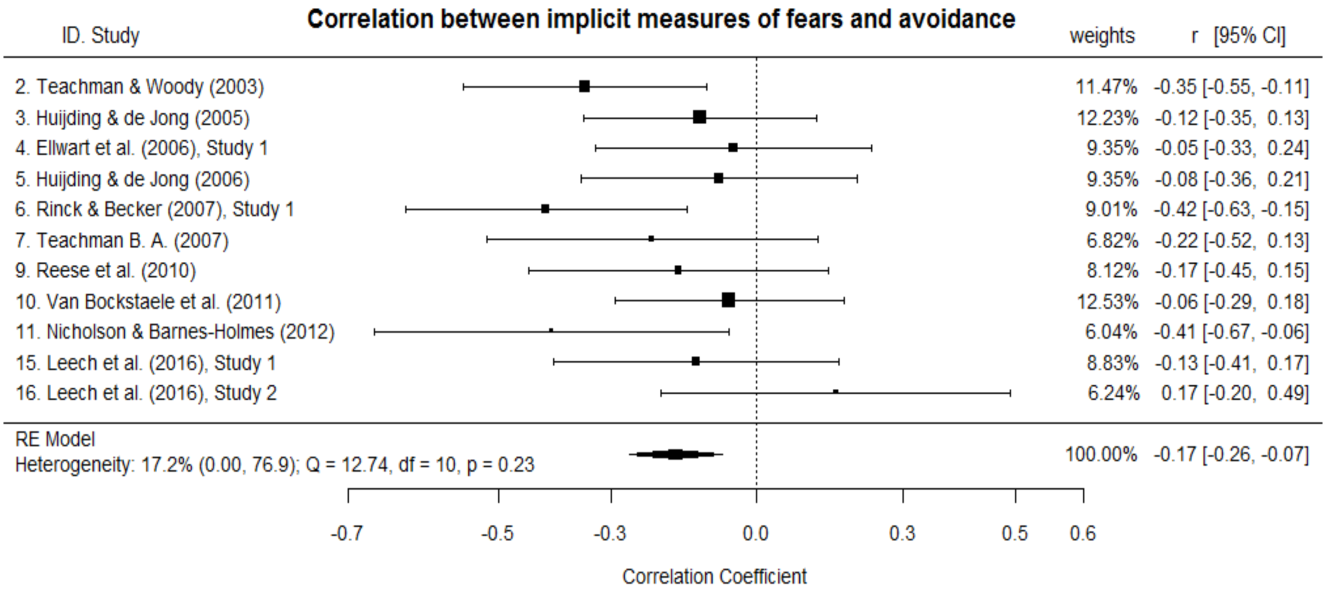


Figure 2.7. Forest plot of the observed relations between implicit fears and overt avoidance measures. Negative correlations means that the more time participants took to respond to conflicting stimuli associations (e.g., spiders = pleasant) as an index of spider-fear bias, the less they approached the feared stimulus during the BAT. All of the studies in this meta-analysis used spiders as threat.

The same moderation analyses as in the former meta-analysis were conducted (type of implicit RT task instead of questionnaire), but no moderators were identified (see Appendix E). Similarly, data for six of the sampled studies in this meta-analysis were obtained from the authors and, as such, it could be a significant moderator. Once more, based on the meta-regression coefficient, this aspect does not seem to have influenced the overall meta-effect (Q_M = .01, *df* = 1, *p* = .893; *b* = .01 [95% CI: -.19, .22], *p* = .893).

Finally, to test whether the correlation between self-report/implicit and BATs differ, we combined the two datasets (*k* = 27) and ran a random model meta-analysis including measure type (i.e., explicit or implicit) as a covariate. The meta-regression coefficients for measure type was significant (Q_M = 14.74, *df* = 1, *p* < .001; *b* = .45 [95% CI: .22, .67], *p* < .001) which suggests that the relationship between self-report measures and BATs is significantly greater than the relationship between implicit measures and BATs. That is, the correlation with BATs is stronger when indirect measures are of an explicit self-report nature.

Discussion

In the current review, we found that spiders were by far the most common fear object implemented in BAT procedures. Of the 17 empirical papers that satisfied the inclusion criteria, 14 employed spiders as threat stimuli. This is not surprising given: (a) the practical nature of using such a stimulus, (b) the cognitive processes and neuronal networks underlying many phobias (e.g., fears of specific objects or animals) share features with other anxiety-related conditions, and (c) the high prevalence of spider phobia in the population at large. In fact, the National Comorbidity Survey (Kessler et al., 1994) indicated that 11.3% of USA citizens suffer from simple phobia, and large-sample studies (Davey, 1994; Fredrikson, Annas, Fischer, & Wik, 1996) suggest that a high proportion of these statistics pertain to arachnophobia. The absence of other feared stimuli in the sampled papers, however, constitutes a gap in the literature at present. The range of fears for which fear-specific BATs have been developed is quite narrow; there have been BATs for snakes (e.g., Davison, 1968; Rimm & Mahoney, 1969; Wagner & Cauthen, 1968) but we did not find any BAT assessments of fear of dogs or heights (cf. Rothbaum et al., 1996)—representative of people's life styles in cities. Furthermore, most studies implemented one specific spider questionnaire, the FSQ, which has not only proven to distinguish between clinical and non-clinical populations, but also to predict performance in BATs (see Muris & Merckelbach, 1996; Szymanski & O'Donohue, 1995). In order to progress the field, we recommend the development of BATs to assess avoidance of other threats (e.g., fear of dogs) to better estimate the predictive validity of the wide range of fears scales in the literature, and improve the predictive validity of these measures.

While the majority of the sampled studies employed scales that assessed fear of a specific threat (e.g., spiders), some measured anxiety generally (e.g., STAI). One might expect anxiety questionnaires to correlate less strongly with threat-specific BATs (cf. Ajzen & Fishbein, 1977; Hodges, 1976; Hofmann et al., 2005), thus reducing the observed meta-effect between self-reported anxiety and the BAT. This assumption is somewhat corroborated by our analyses. Specifically, when we limited the sample to studies that only used the same type of specific questionnaire (i.e., FSQ), the observed heterogeneity reduced (from I^2 = 84.84 to I^2 = 74.2%) and the strength of the correlation increased (from r = -.56 to r = -.67). Such analyses were not conducted for implicit measures, since all the implicit measures in the second meta-analysis employed the same type of threat (i.e., spider visual stimuli).

Considerable variability in BAT procedures was also observed. For instance, some BATs required participants to move their hands towards a threat on a table 150 cm away (in a "table hand-approach" procedure), but others required walking towards a threat 5 m away. The degree of avoidance estimated in one BAT may not be comparable with another. In our view, greater standardization of BAT measurements is necessary to enable researchers to investigate the relationships between fears and avoidance. Such standardization will also inform the future implementation of virtual reality environments (e.g., Garcia-Palacios, Hoffman, Carlin, Furness, & Botella, 2002; Mühlberger, Sperber, Wieser, & Pauli, 2008; Rinck et al., 2010; Rothbaum et al., 1996) to determine if virtual threats (and their spatial measurements) operate similarly to real ones. Standardization of BATs minimizes researchers' degrees of freedom (Gelman & Loken, 2013) facilitating replication and comparison of results. Using, whenever possible, a standard approach-avoidance procedure (e.g., Kennedy, Gläscher, Tyszka, & Adolphs, 2009; Kircanski, Lieberman, & Craske, 2012; Shechner, Ginat-Frolich, Klein, 2018) and reporting key procedural aspects will serve the scientific community at large. A step in this direction would be for researchers to report, as a minimum, continuous (not just discrete) data on distance with respect to the threat. Combined with approach speed, such information could provide a sensitive index of avoidance (via time-distance analysis; Rinck & Becker, 2007). In addition, procedural aspects related to the degree of interaction with the experimenter and her or his positioning relative to both the participant and the threat should be described. This could help discern the extent to which BAT performance might be affected by social factors (e.g., modelling, perceived safety, reactivity to observation).

In our meta-analyses, self-report measures of fears were better predictors of overt behavioural avoidance than implicit measures based on response times. This disparity is in line with previous findings by Huijding and de Jong (2006; see also Huijding & de Jong, 2005), who found that self-reported spider fear was a better predictor of voluntary responses than implicit measures. As we proposed previously, avoidance responses in a BAT, constitute voluntary responses and might not be effectively predicted by implicit tests. For example, Huijding and de Jong found the EAST to be a good predictor of involuntary fear responses such as startle reflex. Likewise, Huijding and de Jong (2007) found that even though the IAT distinguished between contamination phobia-diagnosed and non-diagnosed individuals, only self-report measures had predictive power about participants' overt avoidance.

It is worth mentioning that the lack of correspondence between self-reports and implicit measures might be due to the complexity of fears as constructs (Lang, 1968; see also Mauss & Robinson, 2009). In our introduction, we highlighted that fear-related avoidance is typically the most problematic aspect of phobia, in that avoidance removes the individual from beneficial encounters with others and limits an individual's available behaviours and experiences. In light of the importance of avoidance in phobic disability, and the common-sense notion that avoidance correlates with the strength of the underlying phenomenal experience of fear, many self-report measures of fears include items that probe avoidance responses (e.g., "I now would do anything to try to avoid a spider"; FSQ). Consequently, self-report measures that target the phenomenal experience of fears might correlate more strongly with implicit measures (see Holfmann et al., 2005) than those that target behavioural responses or explicitly query expected avoidance. In line with this, whenever possible, studies on fear/anxiety should consider complementary psychometric measures that target the avoidance component specifically (e.g., the brief experiential avoidance questionnaire [BEAQ; Gámez et al., 2014]; the Cognitive-Behavioural Avoidance Scale [CBAS; Ottenbreit & Dobson, 2004]; the White Bear Suppression Inventory [WBSI; Wegner & Zanakos, 1994]; the Impact of Event Scale [IES; Zilberg, Weiss, & Horowitz, 1982]), as self-reported avoidance may yield better predictions of overt avoidance than "fear" (cf. LeDoux, & Pine, 2016).

All of the BATs scrutinized during our endeavour required the presence of the researchers to record the participants' performance (except for Cochrane, Barnes-Holmes, Barnes-Holmes, 2008). Since in everyday life most pathological avoidance is likely to take place in social contexts, this is an aspect might provide representativeness to the measurement. Conducting assessments in the presence of the experimenter implicitly take into account how people behave differentially in the presence or absence of others. Nonetheless, comparing performance between tasks that systematically control for social factors might lead to interesting insights.

By engaging verbal declarative processes, it is possible that self-report measures of fears generate an increased "good subject" effect. Specifically, participants may feel inclined to ensure that their verbal statements and their behaviour are consistent, as such consistency between what we say and what we do is expected in social interactions. If participants completed a BAT following a self-report fear measure, participants might attempt to act consistently with their prior statements. If they completed the fear measures after the BAT, then they might reference their recent experience when answering the questions. If participants behaved in this way, it would increase the strength of correlation between the self-report and avoidance (Robinson & Clore, 2002). Future studies should consider introducing a time lapse between self-report measures and BATs (e.g., online questionnaire at home two weeks prior to the BAT) as a means to mitigate consistency biases.

As a closing remark, whilst refining and conducting our systematic search, we came across an overwhelming quantity of studies related to “fear”. However, as is evident in this review, very few studies included measures of fear-related avoidance (psychometric or behavioural). Given the clinical relevance of the avoidance component of fear/anxiety related conditions, the development of ecologically valid measures of avoidance merits consideration as a priority for the field; an aspect that seems to have been neglected so far (Krypotos et al., 2018; cf. Lonsdorf et al., 2017). Despite the reported lack of standardization of BAT procedures, we believe that further development of such tasks has the potential to advance experimental psychopathology with direct implications for the applied field. For example, the overt, molar, and graded nature of the physical movement involved in BATs when someone is walking towards a threatening stimulus instantiates the face validity of these tasks (in comparison to the dichotomous button-press response typical in experimental paradigms). Moreover, using a “real” exemplar (e.g., alive specimen) of the feared object as well as the social context thereof (e.g., presence of the experimenter) may further contribute to their ecological validity (see Krypotos, Vervliet, & Engelhard, 2018 for a discussion).

Conclusions. The results from the present systematic review can be summarised as follows: (a) there is a moderate-to-strong correlation between self-reported measures of fears/anxiety and overt measures of avoidance; (b) there is a weak correlation between implicit RT-measures of fears and measures of overt avoidance; (c) most papers included in the present review dealt with spider fear, so the present meta-effects could be limited to specific fear/avoidance; (d) there is a need for standardisation of threat-specific behavioural approach tasks, agreement in measurement units to be reported, and minimum standards for reporting detailed information about the procedures—important for research replication; (e) behavioural approach tasks should be generated in order to assess further common phobic stimuli (e.g., dogs); (f) the findings align with theoretical postulations indicating that implicit measures tap onto involuntary processes, but explicit measures estimate controlled processes that facilitate behavioural avoidance.

Chapter III

Developing behavioural assessments of fear-motivated avoidance from an approach-avoidance perspective.

In the previous chapter, the review of the literature on fears and avoidance supports the conclusion that implicit measures are not particularly good measures of real-world avoidance. Questionnaire measures predicted considerably more variance in avoidance than such measures. However, implicit measures are not the only behavioural measures that can be employed in an experimental context. Focusing on approach-avoidance conflicts, we derived an alternative technique for estimating the strength of a fear by creating explicit trade-offs between avoiding one's fear and approaching something of value. In so doing, it is possible to derive a "price of fear"; that is, how much a person is willing to forego in order to avoid their feared object. The current chapter details two novel paradigms developed to estimate a price of fear, as an index of clinically relevant avoidance. In both cases, participants are required to choose between "approaching their fear" and earning more points or "avoiding their fear" and earning fewer points. The findings from the previous study provide a point of reference for the relationship between the calculated price in our tasks and "fear". Furthermore, the second experiment introduces an exposure based measure of fear directly derived from the some of the findings of the previous study.

We live in a world governed by physical laws and our behaviour—as movement—is described in a geometric relation to other objects. As a matter of fact, basic mechanisms of movement towards (approach) or away from stimuli (avoidance) can be found in all forms of life including unicellular organisms such as protozoa (Lang & Bradley, 2013; Schneirla, 1959; Zanjonc, 1984), and the form this takes is determined by biological affordances expressed in simple or complex action patterns. At the basic level, approach-avoidance response systems are said to optimise survival. Approach serves actions oriented at finding sources of energy supporting life, and avoidance (viz. withdrawal) serves actions that minimise potential harm (Schneirla, 1959).

Naturally, in humans, approach-avoidance response systems underlie complex forms of interaction, and can even give rise to behaviours whose functionality differs from survival optimization as in the case of addictive behaviours (Cooper, Talley, Sheldon, Levitt, & Barber, 2008; Elliot, Gable, & Mapes, 2006; McNaughton, DeYoung, & Corr, 2016; Maxwell & Davidson, 2007). The extent to which people feel motivated to approach or avoid a situation may be a function of factors such as fatigue and effort, but also of the relative value of the appetitive and aversive consequences of an action in the context of another (e.g., in need of medical intervention we may choose a surgical procedure that involves less risk of complication over a risky procedure, but choose a risky procedure over no treatment at all).

Theories of approach-avoidance seek to explain the processes at play when individuals are motivated to both approach and avoid a situation (e.g., Corr, 2013; Dickinson & Pearce, 1977; Elliot, 2006; Epstein & Fenz, 1965; Gray, 1975; Lang & Bradley, 2013; Lewin, 1935; McNaughton, DeYoung, & Corr, 2016; Miller, 1944; Rolls, 2013; see also Beatty, Cranley, Carnaby, & Janelle, 2016 for an empirical review), and situations in which positive (rewarding) outcomes are set against negative (punishing) outcomes are termed approach-avoidance conflicts (AACs; Hovland & Sears, 1937; Miller, 1944; Rolls, 2013). In this vein, experimental paradigms to study these processes involve choosing between options that entail both favourable (i.e., approachable) and unfavourable (i.e., avoidable) consequences (Aupperle, Sullivan, Melrose, Paulus, & Stein, 2011; Bublatzky, Alpers, & Pittig, 2017; Buetti, Juan, Rinck, & Kerzel, 2012; Meulders, Franssen, Fonteyne, & Vlaeyen, 2016; Rattel, Miedl, Blechert, & Wilhelm 2017; Sierra-Mercado et al., 2015).

Nevertheless, research about how we evaluate and respond to coexisting costs and benefits is still at an early stage (Talmi & Pine, 2012; Suri, Sheppes, & Gross, 2013). Thus far, empirical data from tasks involving conflicted approach-avoidance motivations indicates that the level of conflict experienced is manifested in response times (e.g., de la Asuncion, Docx, Sabbe, Morrens, & De Bruijn, 2015; Aupperle et al., 2011; Boyd, Robinson, & Fetterman, 2011; Radke, Güths, André, Müller, & de Bruijn, 2014; see also Diederich, 2003), varies depending on individual—sensitivity—differences (e.g., Heuer, Rinck, and Becker, 2007), and may impair executive processes such as decision-making (e.g., Pittig, Brand, Pawlikowski, & Alpers, 2014; Pittig, Alpers, Niles, & Craske, 2015).

For example, Heuer, Rinck, and Becker (2007) implemented an AAC task wherein participants with social anxiety were presented with images of emotional facial expressions (angry, neutral, or smiling) or non-emotional images (puzzles). Participants were instructed to respond to the stimuli by pulling a joystick towards themselves (approach) or pushing it away (avoidance). In this task, the outcome variable consists of the difference between response times to combinations of the instructed response (pull/push) and the type of stimuli used (positive/negative emotion). For example, having to approach images displaying negative emotions is assumed to generate incompatibility with behavioural predispositions to avoid them (yielding slow responses), whereas having to approach images showing positive emotions has the opposite facilitating effect (fast responses). Heuer et al. found that socially anxious individuals exhibit stronger avoidance than control participants when responding to the emotional images (smiling/angry faces) compared to neutral images. Interestingly, their data revealed that even though socially anxious individuals—verbally—evaluated smiling faces to be pleasant, their response patterns were consistent with avoidance. The authors interpreted this discrepancy as being based on a difference between implicit (automatic) and explicit (strategic) processes.

In a similar fashion, Pittig, Brand, Pawlikowski, and Alpers (2014), implemented a variant of the Iowa Gambling Task (IGT; Bechara et al., 1994; Bechara, Tranel, & Damasio, 2000). In this task participants have the potential to earn or lose credit depending on which deck of cards they choose. There are four decks (A, B, C, and D), decks A and B always yield $100 of earnings, whereas C and D always yield $50. However, each deck has a 50% chance of losing credit. For decks A and B, the credit loss is $250, whereas for decks C and D it is $50. This task is designed so choosing A and B incurs more costs in the long run (the disadvantageous options), in comparison to C and D which result in an overall gain (the advantageous options). Pittig et al. induced conflicted motivations to approach and avoid by displaying either images of butterflies or of spiders (as threat stimuli) on the response options. The results showed that spider-fearful participants chose the advantageous choices more when the response options contained butterflies (non-conflicted choices) than when they contained spiders (conflicted choices); leading to greater net gains and losses respectively than if they had chosen disregarding the images. The authors interpreted this conflict effect as indicative of impaired learning concerning the advantageous choices.

At first glance, the data coming from this type of tasks appear to be closely aligned with those found in implicit associative tasks (cf. Krieglmeyer & Deutsch, 2010). However, an important advantage of AAC tasks over traditional implicit measures (based solely on response times) is the fact that response effort can also be factored into the decision-making process. This response effort is typically operationalised as a greater number of responses relative to an alternative choice (usually required to travel a “symbolic distance” to arrive at the desired goal, e.g., Aupperle et al., 2011; Rattel et al., 2017), or even extra mechanical force required for responding (e.g., Meulders et al., 2016). All these forms of response cost, whether they are in the form of encountering emotional stimuli, extra time, or additional effort, have been found to affect behaviour (e.g., Aupperle et al. 2011; Meulders et al., 2016; Rattel et al., 2017).

Furthermore, one of the characteristics of anxiety disorders is that they all involve avoidance behaviours (American Psychological Association, 2013), and this avoidance typically implies additional costs, such as reduced opportunities where potential reinforcers (including treatment) can be accessed (Barlow, 2002; Forsyth, Eifert, Barrios, 2006). Consequently, approach-avoidance conflict paradigms are particularly suitable to explore the variables and processes that participate in anxiety disorders, and thus are potentially useful to psychopathologists who study the underlying mechanisms of clinically relevant behaviour under controlled conditions (Kimmel, 1971).

Accordingly, most paradigms that generate AAC by incorporating response costs have introduced threat stimuli and compared performance between individuals who differ in terms of their reported anxiety (e.g., Ellwart, Rinck, Becker, 2006; Heuer, Rinck, and Becker, 2007; Pittig, Hengen, Bublatzky, & Alpers, 2018; Rinck, and Becker, 2007). By demonstrating a relationship between performance in these AAC tasks and the scores from questionnaires, researchers have partially validated these measures. Nonetheless, to date, there is little data available regarding the predictive utility of these measures across different validity criteria or contexts. That is, the extent to which task performance (e.g., avoidance of spider images) is predictive of behaviour in more realistic scenarios (e.g., physically leaving a room with a spider in it).

A variety of criteria have been proposed for assessing the scientific reliability and validity of psychological measurements (see Cronbach & Meehl, 1955; cf. Messick, 1980), but three seem to be especially pertinent for experimental psychopathology: construct validity, face validity, and predictive validity (Krypotos, Vervliet & Engelhard, 2018; Scheveneels, Boddez, Vervliet, & Hermans, 2016; cf. Guion, 1980). Construct validity requires a correspondence between the processes assumed to be responsible for performance in the experimental paradigm and the processes underlying behaviour in clinical contexts; namely, it calls for theoretical consistency (Krypotos et al., 2018; Scheveneels, Boddez, Vervliet, & Hermans, 2016). Consequently, construct validity is typically examined in two ways: by methodologically manipulating variables related to the processes of interest; or by comparing a task' outcome against another—established—measure of the same (related or opposite) construct. The majority of AACs tasks have been cross validated with psychometric measures, in which the stimulus used to create motivational conflict is somewhat equivalent to the one measured via self-reports.

Face validity refers to a phenomenological similarity between the behaviour being tested and the one manifested as part of a psychological disorder (Krypotos, Vervliet & Engelhard, 2018). In other words, face validity appeals to whether the behaviour sampled in the laboratory is like the behaviour in real-life environments. For example, the manifestation of avoidance when people are exposed to an aversive stimulus can reliably take the form of physically withdrawing from it—unless there is a conflicted motivation to approach it. In experimental settings, the degree of behavioural similarity across (artificial vs. naturalistic) contexts is usually increased by ensuring similar contextual features. These features include the stimuli presented (e.g., digital vs. physical stimuli), as well as the responses to be emitted (e.g., button presses vs. full-body behaviour). Methodologically, this criterion is often referred to as the ecological validity of a test (e.g., Haynes & Lench, 2003). While it could be argued that the responses emitted when performing AAC tasks are similar to those found in situations outside the laboratory (e.g., computer-mouse movement towards or away from a choice contingency can resemble withdrawal or hand-gasping actions), the stimuli commonly employed (i.e., static digital images) may represent a significant difference from those found in natural environments.

Behavioural approach/avoidance tasks (BATs) can be used in research to tackle some of the limitations ensuing from the use of “artificial” stimuli. In these procedures both the threat stimuli and the emitted response closely resemble naturalistic situations. For example, in one of the first documented experimental BAT procedures, Lang & Lazovik (1963; see also Davison, 1968) instructed participants to enter a room in which there was a caged snake 15 feet away from the door. The experimenter removed the top of the cage and encouraged the participants to take a close look. Upon refusal, participants were instructed to get as close as they felt able to, and the remaining distance was recorded. If a participant stood next to the snake (after seeing the experimenter doing it) she or he was then instructed to touch it and hold it. This test produced an absolute measure (touching the snake or not) as well as a relative score based on the participant’s distance from the snake.

The last criterion, predictive validity, judges the applicability and pragmatic value of an experimental paradigm to predict performance in clinically relevant situations, irrespective of the underlying mechanisms (Krypotos et al., 2018; Scheveneels et al., 2016). As a consequence, it is expected that factors that lead to changes in task performance would correspond to factors that generate behavioural change in applied settings. For example, from an AAC perspective, competing contingencies to approach, if strong enough, should lead to a decrease in avoidance. This phenomenon has received some empirical support in basic AAC research (e.g., Miller, 1944; Pittig, Hengen, Bublatzky, & Alpers, 2018), but data using clinical populations are still pending.

It is important to note that both face and predictive validity are closely related in applied settings. Namely, implementing stimuli (in the experimental procedures) that are representative of (or closely resemble) the type of stimuli eliciting pathological behaviour outside the laboratory should produce behavioural consistency across contexts. Following Messick (1980), we will refer to these in terms of the clinical utility of a measure.

Avoidance, as the behavioural component of anxiety disorders, is critically responsible for individuals' maladjustment when its expression is disproportionate to the conditions under which it is manifested (Barlow, 2002; Judd & Burrows, 2001; Perna, 2013). From an approach-avoidance perspective, the expression of psychopathology, or more specifically, maladaptive avoidance, is the result of an imbalance between the approach and avoidance motivations involved (e.g., Lang & Bradley, 2013; Lewin, 1935; Miller, 1944; Rolls, 2013; Sheehan, 1953; Stein & Paulus, 2009).

In accordance with this, developing an approach-avoidance conflict task (AAC-T) through which not only approachable consequences can be manipulated, but also whose outcome variable can be predictive of overt avoidance—in realistic conditions—could be useful for clinical research. Therefore, we designed an AAC-T inspired by psychophysical procedures (see Treutwein, 1995; and Leek, 2001 for some overviews). Although our epistemological position differs from that of Fechner, he still believed that psychological phenomena were measurable at the behavioural level. In particular, Fechner (1860) developed a theory of the measurements of internal scales, on the premise that inner consciousness (of sensorial stimulation: perception) might be measurable by outward behaviour.

Psychophysicists have developed a range of procedures to determine the minimum difference in stimulation (i.e., the difference threshold) that an individual can detect. For example, one might seek to determine the minimum difference in amplitude (loudness) of auditory tones that a person can detect. In the classic *staircase method*, the experimenter first presents a sample tone at a fixed intensity followed by a comparison tone at a greater (or lower) intensity. The subject then reports whether the tones are of the same intensity or not. If she hears the tones as different, the comparison is replaced by a less (or more) intense tone in the next trial; that is, the difference is reduced. If not, it is replaced by a more (or less) intense tone, one at a greater distance from the sample. If the subject hears the second tone as different, the third difference is reduced and so on. Commonly, the initial difference (i.e., size of the steps) is large, with large changes in the differences between the sample and comparison presented at the start, and then progressively reduced to fine-tune the differences to the individual's ability to distinguish them (thereby obtaining narrow threshold limits of perception). The difference threshold is usually the point at which the probability that the individual hears the difference in tones equals 50%.

Translated to our approach-avoidance framework, in *Experiment 1*, the staircase procedure presents rewarding stimuli of varying magnitudes, starting with large differences (steps) between them, and gradually narrows the steps in a predetermined fashion to estimate the minimum magnitude difference controlling participants' decisions. On each trial, participants are presented with a decision between two choices (e.g., 16 points followed by an aversive stimulus vs. 8 points with no aversive stimulus), each of which has both appetitive (approachable: +) and aversive (avoidable: −) consequences. Namely, the option with a relative greater reward magnitude (16 points) is followed by exposure to a putative aversive stimulus such as an image of a spider (−), whereas the option with a relative smaller reward (8 points) is followed by a putative non-aversive stimulus such as an image of a chair (+).

Starting with trials where the reward magnitudes for one option are twice as great as the other, some (non-fearful) participants are expected to approach the threat option, and some (fearful) participants to avoid it. This decision preference would indicate a degree of imbalance in the approach-avoidance motivations, favouring the expression of one or the other. By decreasing or increasing the reward magnitude depending on whether the participant approaches or avoids the threat option respectively, it is possible to reduce the imbalance between these motivations (i.e., approximate the point of subjective equality).

Once the point of subjective equality (PSE) between the approach-only and approach-avoidance options has been established, it is possible to infer the value of the avoidance effect by subtraction. Let's assume, for example, that a participant is presented with two choices: 16 points followed by a spider, versus 8 points with no spider, from which she chooses the 16-point option instead of the 8-point. This means that, even though the value of the 16 points is probably reduced by the presentation of the spider, it is still of greater value to the participant than 8 points (16-Spider > 8). By subtraction, we infer that the negative value of the aversive stimulus (i.e., spider) is less than 8 points (Spider < 8). To put it simply, 8 additional points was enough incentive to choose the spider option. At the point of subjective equality, we know that the spider option (X − Spider) and the non-spider (Y) option are of equal value (X − Spider = Y), so we can subtract to determine the "price" of the spider threat (Spider = X − Y).

In *Experiment 2*, an alternative procedure was used for obtaining the point of subjective equality between the spider-absent and spider-present options was employed. This procedure was informed by the *method of limits* approach from psychophysics. In the method of limits, sequences of ascending and descending tone intensities are systematically presented and compared to a reference tone. When each intensity is presented, individuals report whether the intensity presentation is weaker, equal or stronger than the reference. The typical pattern is that, for an ascending series of tones, the tones are reported as weaker for a number of presentations, then equal and then stronger. The series stops after the transition from equal to stronger and the next series starts. In a descending series, the opposite pattern is observed; tones are reported as stronger for a number of presentations, then equal and finally weaker. It is common to alternate between ascending and descending series. After cycling between ascending and descending series, the mean upper transition point (from equal to stronger) and the mean lower transition point (from equal to weaker) are identified as the upper and lower limits of the window of subjective equality. The point of subjective equality is assumed to be halfway between the upper and lower limits (the window includes one just noticeable difference above and below the PSE; Treutwein, 1995; and Leek, 2001). In *Experiment 2*, participants completed sets of forced choices between the spider-absent and spider-present options, and the points values of the spider-present options were increased and decreased across blocks of trials. In this way, the upper and lower limits of the spider-present options were estimated to provide the point of subjective equality. Once the PSE was obtained (i.e., X − Spider = Y), the calculation of the spider price proceeded in the same fashion as for the staircase version.

Experiment 1

In line with the aforementioned framework, this study implements a staircase approach-avoidance procedure to investigate how we make decisions when relatively greater benefits of a choice also involve unpleasant consequences (i.e., exposure to a feared object). Specifically, we are investigating whether motivations to approach and avoid affect decisions when there is a possibility that (spider-fearful) individuals will see spiders. By varying the appetitiveness of the response options across decisions, we aim to provide a new method to estimate individuals' aversion of a (spider) threat stimulus. The predictive validity of such a method can then thus be discussed and compared with respect to the findings of the previous study (see Chapter II).

With an emphasis on the usefulness of the task, the first research question explored its diagnostic utility, and by extension the relationship between the "price score" derived from the task performance and self-reported fear. In other words, can the price score be used to distinguish between fearful and non-fearful individuals?

Unlike simple avoidance tasks wherein individuals do not have anything to lose by emitting the avoidance response, in our task avoiding implies a cost in terms of time (as well as effort due to additional trials required, and ensuing emotional reactions). Such an attribute resonates with the face validity criterion, as explained above, given the implicit costs of pathological avoidance for people suffering from it (e.g., social ostracism). Likewise, inasmuch as such an arrangement requires individuals to evaluate the relative risks/benefits of a decision, at the process level, it can also contribute to its construct validity. Specifically, does the price an individual is willing to pay to avoid a feared stimulus reflects that individual's level of fear?

Additionally, we will test two versions of the task that differ as regards the format of the threat stimuli (i.e., static photographs/video-clips). It is assumed that video-clips would be a more aversive threat stimuli than static photographs, as the animated format might resemble real stimuli more closely.

Finally, we measured participants' behavioural tendencies in accordance to the inhibition/approach systems scale (BIS-BAS; Carver, & White, 1994). This measure was included as an analogue of cross validation for the task-based price as an index of motivational conflict. Theoretically, participants' degree of approach or avoidance in the task could depend on their ("state/trait") behavioural disposition; that is, high approaching participants could be expected to differ from avoiders by having a higher sensitivity to approach (BAS score). We formulated this as an exploratory question as the structure of the BIS-BAS questionnaire implies fundamentally different mechanisms of interaction between these systems compared to the assumptions present in our AAC framework—addressed later.

Method

Sample and Participants Selection

Volunteers were selected through a university based system for research participation. A draw to win a voucher worth €15 at the end of the data collection phase was included as an incentive. In addition, students were able to earn credits for their time in the laboratory.

Due to the novel nature of the project, effect size estimates could not be directly based on previous studies; however, most of the reviewed studies employing comparable methodologies have used samples of approximately forty participants. Nevertheless, we anticipated an examination of the relationship between FSQ and the outcome variable of our task, via regression models potentially including two predictors. Thus, we calculated a potential sample size using G*Power (Faul, Erdfelder, Lang & Buchner, 2007). A medium effect size value of .15 was considered acceptable, with an alpha of .05, power of 0.8. This calculation yielded a sample size of 68. We recruited a total of 118 participants (age M = 21 [range 18-42], 90 females). Two individuals from this sample had missing data on the video-clips task, and five on the task that displayed images as stimuli; thus these participants' data were removed.

We employed eye-tracking to force the viewing of the stimuli and thereby pre-empt individual's passive avoidance by diverting their gaze away from the screen. As a consequence, participants were excluded if they presented any of the following characteristics, potentially compromising the recording of eye movements: (a) occlusion of the eye or part of the pupil: e.g., frame-glasses, heavy mascara, droopy eyelids (Nyström, Hooge, & Andersson, 2016; Holmqvist et al., 2011); (b) physical conditions that affected the eye's anatomy due to trauma or disorder of the eye, for instance, aphakic participants typically exhibit a large degree of iridodonesis—quivering of the iris—in conjunction with exacerbated saccades, also common in macular diseases (Nyström, Hooge, & Andersson, 2016; Chen et al., 2011); (c) perceptual disorders such as dyslexia (Bednarek, Tarnowski, & Grabowska, 2006; Biscaldi, Fischer, & Aiple, 1994; Biscaldi, Fischer, & Hartnegg, 2000;

Biscaldi, Gezeck, & Stuhr, 1998); (d) mental health conditions which affect eye-movements such as schizophrenia (Levy et al, 1993, 1994); and (e) neurodegenerative diseases affecting the motor system, including amyotrophic lateral sclerosis, Parkinson's, Alzheimer's, and Huntington's. We made participants aware of these criteria but we did not assess these conditions.

Experimental setting, Apparatus & stimuli

Setting and hardware. The data collection took place in a purpose-specific laboratory room with a computer terminal for the participants and one for the experimenter; separated by a standard floor divider, keeping the participant and experimenter visually isolated from each other. The task was programmed in Python 2.7 and run on a standard Desktop computer (SilverStone cased, SR Research Ltd. PC: win 7 pro; i7-4770 Intel-Core processor, CPU @ 3.40 GHz, 8 GB RAM), with a 24-in BenQ digital (XL2420Z) monitor (1920 x 1080 display size, refresh rate at 100 Hz). Participants sat facing the monitor 90 cm from it, with their heads fixed on an eye-tracker mount (80 cm from the monitor). The eye data was gathered via an EyeLink 1000 plus (SR Research Ltd.) eye-tracker (10000 Hz of temporal resolution, $< 0.01^{o}$ gaze resolution and gaze position accuracy of $< 0.5^{o}$).

Stimuli. The visual stimuli consisted of standardised spider and neutral images, selected[1] from the Geneva Affective PicturE Database (GAPED; Dan-Glauser & Scherer, 2011). Due to the absence of a suitable video-clip database for experimental research, we resorted to produce suitable stimuli from freely available material. We edited each video-clip to last 3-5 s. The displayed size of the images was 26.5 (width) x 19.5 (height) cm (subtending θ = 18.8° [horizontal], 13.8° [vertical] of visual angle), and for the video-clips 28 x 20.5 cm (θ = 19.8°, 14.6°). The size of start button was 1.5 x 1 cm (θ = 1.07°, 0.7°) presented at the lower centre of the computer' screen (2.5 cm off the margin), and the size of each response area ("deck of cards") was 5 x 3.5 cm (θ = 3.5°, 2.5°), presented on the upper corners of the computer screen (2.5 cm off the upper margin of the monitor and 4.5 cm off the side margin). The back-of-card motif displayed for each of the response areas, were blue and red; colour-coding the response areas was intended to speed up the time taken to learn the

[1] Identifiers: *Spiders*: Sp01, Sp02, Sp03, Sp04, Sp05, Sp06, Sp07, Sp09, Sp10, Sp11, Sp12, Sp14, Sp16, Sp17, Sp19, Sp20, Sp22, Sp23, Sp24, Sp25, Sp26, Sp27, Sp28, Sp29, Sp30, Sp31, Sp32, Sp33, Sp34, Sp35, Sp36, Sp38, Sp39, Sp41, Sp42, Sp43, Sp44, Sp45, Sp46, Sp47, Sp49, Sp51, Sp52, Sp53, Sp54, Sp55, Sp57, Sp58, Sp60, Sp61, Sp62, Sp63, Sp64, Sp65, Sp68, Sp76, Sp78, Sp81, Sp82, Sp83, Sp96, Sp97, Sp98; *Neutral*: N002, N003, N004, N009, N010, N013, N014, N017, N018, N019, N020, N023, N024, N025, N030, N031, N032, N033, N034, N035, N037, N041, N043, N046, N047, N062, N065, N067, N068, N069, N070, N071, N072, N073, N077, N078, N079, N080, N082, N083, N085, N086, N087, N088, N089, N091, N094, N095, N097, N098, N099, N100, N101, N102, N104, N105, N108, N109, N111.

associated contingencies. A flat high pitch tone (average 65 dB, 1 s duration) was used to indicate delayed response initiation (i.e., exceeding 500 ms).

Assessments and Measures

Data collection from the performance in the task was recorded by the computer such as frequency of response selection during the decision-making task and mouse-data. Response time data was recorded from the moment of the presentation of the stimuli (i.e., response areas) to the moment in which a click-response was emitted on one of them. Eye data was recorded at 100 Hz and mouse data was sampled at 99 Hz.

In addition, after computer task completion, participants were asked to report basic demographic information (limited to age, gender and hand/eye dominance, and some task related questions), as well as to answer digital versions of the Fear of Spiders Questionnaire (Szymanski & O'Donohue, 1995), and the Behavioural Inhibition System/Behavioural Approach System (BIS/BAS; Carver, & White, 2013).

Fear of Spiders Questionnaire (FSQ). The FSQ measures arachnophobic traits in five different domains: (1) cognitive, (2) behavioural, (3) physiological, (4) negative attitudes, and (5) fear of harm by spiders. People rate their agreement with statements such as “spiders are one of my worst fears” in a 7-point Likert scale (0 = strongly disagree, 6 = strongly agree)[2]. The FSQ has been shown to significantly correlate with other construct-related questionnaires. Additionally, it has been proven to differentiate between phobic and non-phobic samples, as well as corresponding changes in its score following treatment (O'Donohue & Szymanski, 1993; Szymanski & O'Donohue, 1994). The FSQ has demonstrated an adequate stability over time, with (one-month) test-retest reliability correlations of .97, and a Cronbach’s alpha of .92 indicating high internal consistency (Szymanski & O'Donohue, 1995; Muris and Merckelbach, 1996). Moreover, as demonstrated in *Study 1*, the FSQ has a moderate-to-strong correlation strength with realistic behavioural tasks (BATs) of r = -.67.

Behavioural Inhibition System/Behavioural Approach System (BIS/BAS). The BIS/BAS was developed to assess sensibility to motivational/behavioural systems of approach (BAS) and avoidance or inhibition (BIS). The former is believed to regulate

[2] Though, there is inconsistency about the scoring as some researchers implement a 1-7 scale (e.g., Huijding & de Jong, 2007; Muris & Merckelbach, 1996; Teachman et al., 2007)

appetitive motives toward something desired, the latter system is said to regulate aversive motives to move away from something unpleasant. Each item on this questionnaire is a statement (e.g. "A person's family is the most important thing in life") with which a participant may either agree or disagree (1 = very true for me, 4 = very false for me). This scale is based on Gray's (1972, 1981 as cited by Carver, & White, 1994) theory of personality, with greater BIS sensibility underlying proneness to anxiety, and greater BAS sensibility reflecting proneness to engage in goal-directed efforts and seek positive feelings associated with impending reward. The initial (eight-week) test-retest reliability correlation of the individual subscales of the BIS/BAS were .66 for BIS and .59 for BAS (Carver, & White, 1994).

Although many studies have provided cross validation data around its construct validity compared to other personality questionnaires (e.g., Jorm et al., 1999; Ross, Benning, Patrick, Thompson, & Thurston, 2009; Vandeweghe et al., 2016), very few studies have related the BIS/BAS scales to behavioural outcome variables (e.g., Poythress et al., 2008), and the underlying theory of the scale has been reformulated (Gray & McNaughton, 2000; McNaughton & Corr, 2008). This may undermine the usefulness of this measure for the purposes of the present study. Nevertheless, it is a questionnaire that it is thematically related to the approach-avoidance concept. Thus, in the absence of a more adequate and specialised self-report measure (cf. Muris, Van Zuuren, De Jong, De Beurs, & Hanewald, 1994), the BIS/BAS still serves as a point of comparison—it could also be interpreted as negative cross validation insofar as such a questionnaire could be assessing an unrelated construct.

Procedure and Computer task

This research was examined and approved by the Research Ethics Committee of the National University of Ireland, Galway. After customary consent procedures (see Appendix F), participants were asked to sit in front of the computer and place their heads in the eye-tracker head-mount.

After eye-tracking calibration, participants read the task instructions (see Appendix G for all instructions presented during the task) and completed two practice blocks of maximum four trials each. During this time, they had the opportunity to ask questions, familiarise themselves with the layout, and the experimenter ensured that the participants understood the task.

Approach-avoidance computer task. The computer task was designed to estimate the "price" of exposure to the spider stimuli for each participant. In each trial, participants chose between two contingencies: greater reward points and consequent exposure to an aversive visual stimulus (spider) or fewer reward points and consequent exposure to a neutral visual stimulus (furniture; see Figure 3.1). The staircase procedure (see Figure 3.2) adjusted the values of the High and Low rewards across blocks to calibrate the point of subjective equality between these two options (High + Spider = Low).

Figure 3.1 below illustrates the sequence and some of the screen features of the task. On each trial, participants first clicked on a "start" button located at the lower middle of the screen. Clicking this button resulted in its disappearance and the appearance of two response buttons at the upper corners of the screen. The response keys looked like decks of cards, one with a red back motif, the other one with a blue motif, over which a reward value was displayed in green colour. Failure to move the mouse outside the start button's area (exceeding 1500 ms) resulted in a beep prompting participants to initiate a response sooner the next time.

Clicking on either deck cleared the screen and a visual stimulus (i.e., image or video) was presented in the centre of the screen. An instruction to "Look at the image for 4 seconds to continue" appeared just below the image whilst in view. The eye-tracker counted the total amount of time viewing the stimulus and removed the stimulus from the screen after 4 seconds. If a participant avoided looking at the stimulus, the stimulus remained displayed (or looping) until the 4-second viewing criterion was fulfilled or until 30 seconds had elapsed (only two participants contacted this contingency). Once the viewing time was completed, the instruction to look at the stimulus was replaced by "click to continue". On clicking, participants were informed about the points earned, depending on the selected card (e.g., "You've earned ## points"), and their tally (e.g., "Accumulated points: ## out of ##"). The next trial started after the participants clicked once more (followed by a pause of 100 ms).

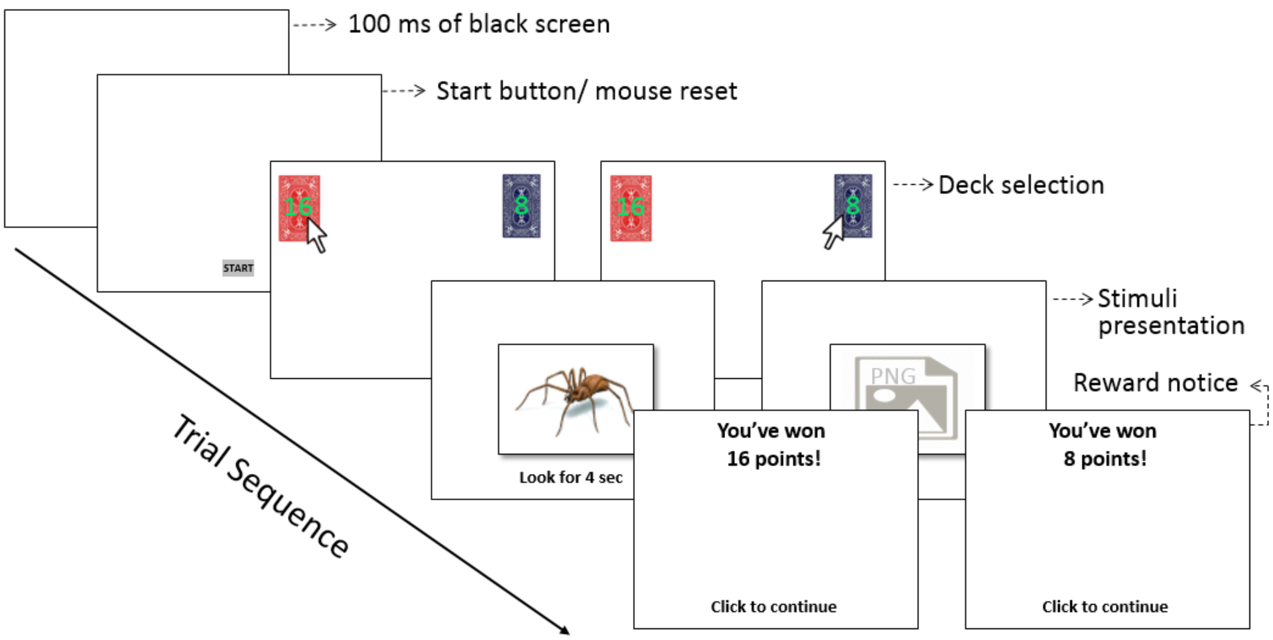


Figure 3.1. Schematic representation of a trial. Participants clicked on a "start" button to make the decks response options appear at the upper corners of the screen. Clicking on a deck earned the points displayed on the deck followed by exposure to an aversive stimulus if the red deck was chosen (left), or a neutral image if the blue deck was chosen (right). After the stimulus' viewing time was fulfilled, clicking led to the feedback screen (bottom row).

During baseline, no spider stimuli were presented regardless of the participant's selections. However, from the first experimental block of trials onwards, the rewards in the next block depended on the preferred option in the current block (see Figure 3.2). The preferred option was defined as the option that participant chose more often. If participants allocated responses equally to both alternatives (50/50), participants proceeded as though they had chosen the lower reward more frequently. On completion of a block, the reward for the preferred option was reduced in the next block. For example, if a participant chose 16 more times than the 8 reward option during the first experimental block, the subsequent trial block presented reward magnitudes of 12 vs. 8. Choosing the 8 reward more times than the 12 option during that trial-block led to the next trial-block presenting rewards of 12 vs. 6. An equal selection of the 12 and 6 options then meant having to choose between 12 vs. 5 in the last trial-block; and assuming the person chose the 5 reward option more often, her calculated price corresponded to 7.5.

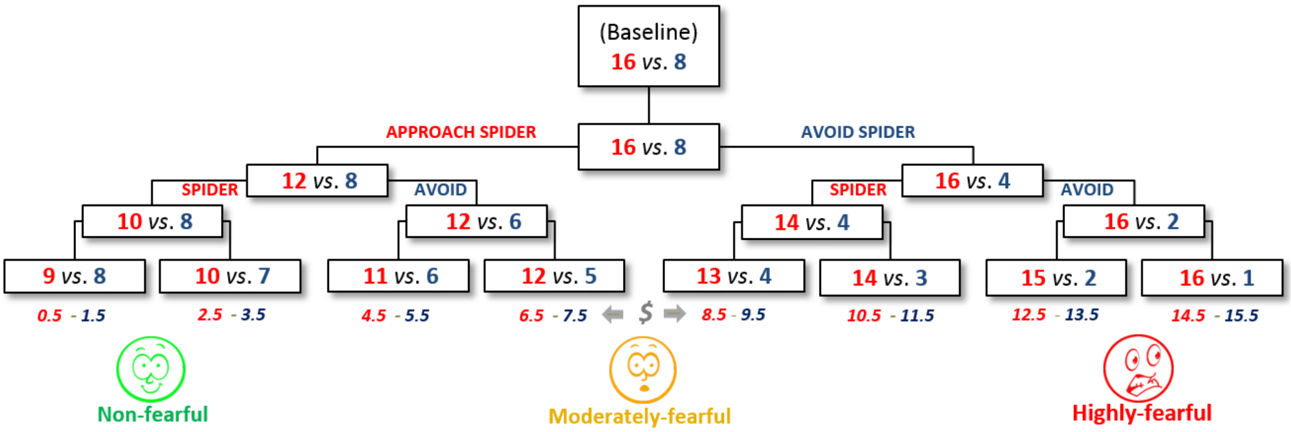


Figure 3.2. Schematic representation of the staircase procedure used to reduce the decks' payoff depending on the participant's preferential choices across blocks. Each row represents a trial-block and the left (spider) or right (avoid) branching direction at each "block decision node" (box) illustrates whether a participant preferred (i.e., chose ≥ 50% of the time) the deck with the spiders (red value on the left) or not (blue value on the right). The values underneath the bottom boxes are the calculated "price", based on the points that participants forego when opting for the spider-free option.

The starting location of the response options were counterbalanced across participants (and henceforward alternated across blocks), as was the order in which participants were exposed to the staircase procedure using videos or images of spiders.

The reduction in rewards gradually lessened across trial-blocks as the staircase approaches the point of subjective equality. From block 1 to 2, the reward was reduced by four points (16 vs. 8 in block 1 was followed by 12 vs. 8 or 16 vs. 4 in block 2), from block 2 to 3, rewards reduced by two points and from block 3 to 4 rewards reduced by one point. To complete a block, the participant was required to earn a set number of points equal to ten consecutive selections of the lower reward. For example, the points' criteria to finish block 1 was 80. Thus, the maximum number of responses in any block was 10 if the participant chose the lower reward on every trial.

As introduced, by varying the difference in payoff between the decks, or in other words, by narrowing the steps around the subjective equality between the approachable and avoidable choice outcomes, we calculated the "price" of the threat for each participant (see numbers at the button of Figure 3.2 ranging from 0.5 to 15.5); namely, the amount of points that the person was willing to forego in order to avoid spiders: higher price = higher fear.

At the end, participants received their own calculated ("price of fear") score as a form of feedback, and an explanation about the rationale of the task. Following this, participants were asked to provide some sociodemographic information and answer some questions.

Results

Participants completed an average of 34 trials for both versions of the task (with a range of 23–41 trials for the version with images, and a range of 23–50 for the version with videos). Participants were categorised as “approachers” or “avoiders” depending on their calculated price (i.e., their decision pattern or their progression through the staircase block structure). That is, participants with a price below five where classified as approachers (see Figure 3.3). This resulted in a total sample of 113 participants (90 approachers; 23 avoiders) for the experiment using photographic stimuli, and a total of 116 participants (89 approachers; 27 avoiders) for the experiment using video stimuli.

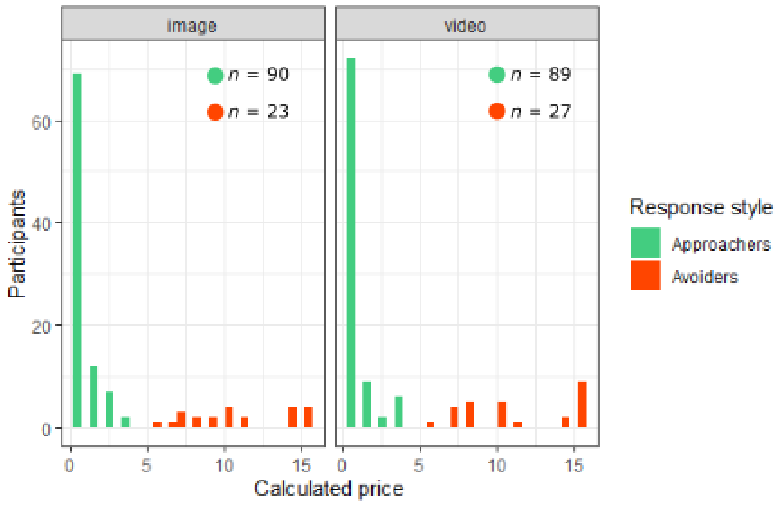


Figure 3.3. Histogram showing the frequency distribution of price in the sample. The numbers and colours denote those participants categorised as approachers/avoiders based on price. Individuals who scored less than five were considered approachers (in green) and those who scored greater than five were considered avoiders (in red).

The structure of the task allows for response variability potentially yielding any value within the pricing range (0.5 – 15.5). However, as it is evident in the distribution, there was a greater proportion in both experiments of participants who approached and had low prices with respect to participants who avoided. The same can be noticed in Figure 3.4, which shows a greater number of trial decisions allocated to the left branching (approaching threat) of the task’ block structure, as opposed to the middle or right hand-side. Figure 3.4 also constitutes a graphic representation of how the systematic manipulation of the consequences exerted control over participants’ choice behaviour across the task.

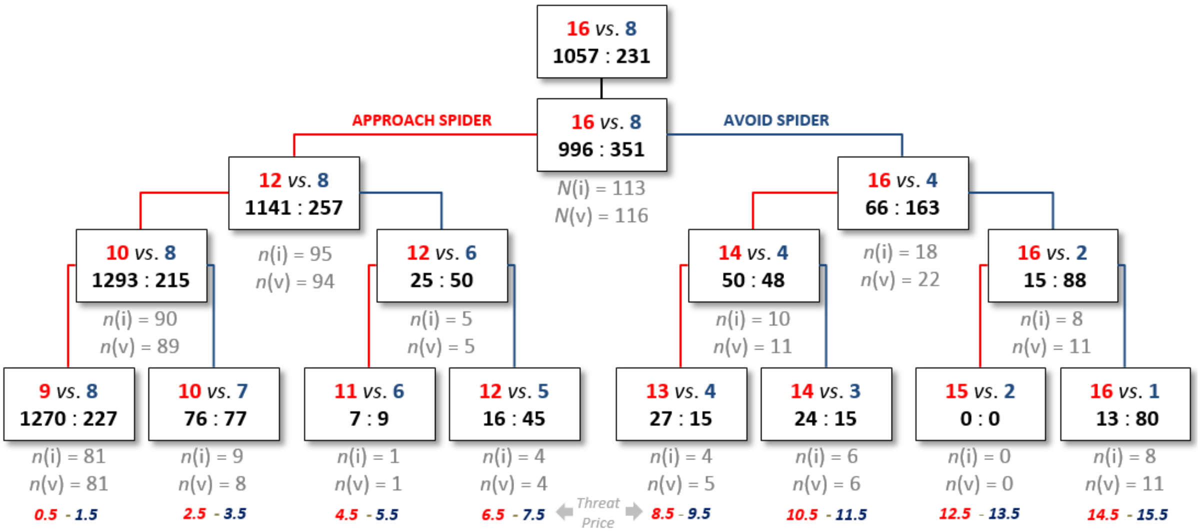


Figure 3.4. Schematic representation of the staircase structure of the experimental blocks showing the total number of times participants in both experiments chose to either approach or avoid (indicated by the bold numbers within the boxes). The number of participants that ended up on each of the decision nodes as they progressed through the task is indicated underneath (in grey), for each version of the experiment depending on whether the threat stimuli consisted of images (i) or videos (v).

As can be observed in Figure 3.4 above, the number of participants from each experiment that moved through the task's decision branches of the staircase procedure was very similar—despite the slight difference in the sample sizes. Overall, this means that participants treated both formats of the threat stimuli in the same fashion and their evaluation of the options was consistent.

In order to determine the diagnostic utility of the task, or specifically, the extent to which it can be used to detect fearful and non-fearful individuals, we conducted regression analyses with FSQ score as predictor of the classification of the participants based on the calculated price. Logistical regressions for each version of the task indicated that the level of fear, measured via the FSQ, predicted our classification of avoiders, both when responding to the images of spiders $b = .03$ ($SE = .01$), $p < .001$, $OR = 1.03$ (95% CI: 1.01, 1.06), Hosmer-Lemehow = .17, Cox-Snell = .15, Nagelkerke = .24, and when responding to videos $b = .03$ ($SE = .01$), $p < .001$, $OR = 1.03$ (95% CI: 1.01, 1.05), Hosmer-Lemehow = .14, Cox-Snell = .15, Nagelkerke = .22. These findings provide support to the idea that the calculated price can categorically differentiate between individuals presenting high and low levels of fear.

Moreover, the FSQ level of spider fear predicted the price score ensuing from the choice task. Linear regressions revealed a positive trend $b = .05$ (95% CI: .03, .07), $SE = .01$,

$t = 2.29$, $p < .001$, $R^2 = .17$ for the version of the task implementing images of spiders, as well as for the version with videos $b = .06$ (95% CI: .04, .09), $SE = .01$, $t = 5.42$, $p < .001$, $R^2 = .20$. This provides support for the price method as an index of an individual's level of fear. However, there was a floor effect caused by the disproportionally high number of people who mostly approached (see Figure 3.5). Visual examination of the data comparing linear (Figure 3.5a.), quadratic (Figure 3.5b.) and cubic (Figure 3.5c.) functions, suggested that a third order function may be a better fit to the data.

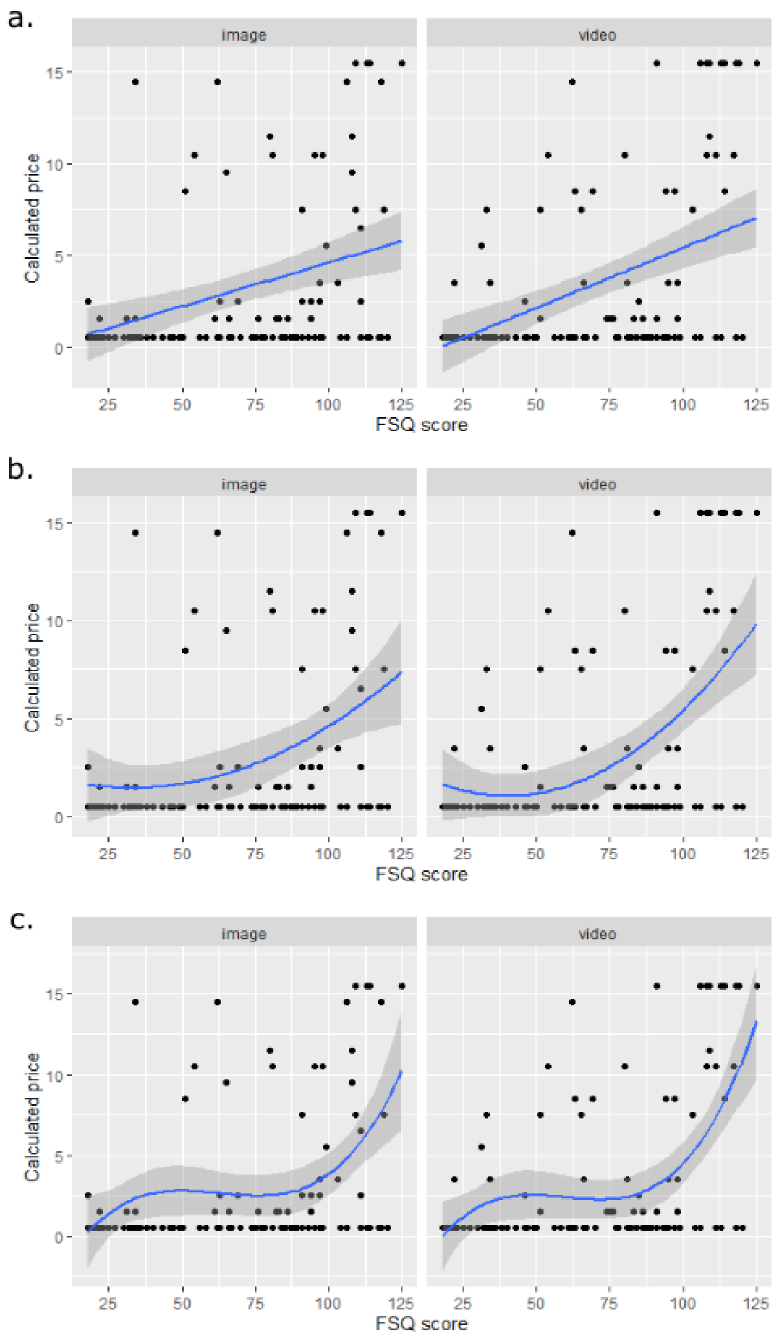


Figure 3.5. Scatter plots of participants' price score by the FSQ, for both versions of the task (image on the left panels; video on the right ones). The blue line corresponds

to the linear (a. top row), quadratic (b. middle row), and cubic (c. bottom row) fitted model; the shaded areas are their respective standard errors.

A cubic function as best fit for the data was corroborated by numerical analyses. For example, for the image version, the regression model went from explaining 17% of the proportion of the variance with a linear function $F(1,108) = 22.82$, $p < .001$, $R^2 = .174$, and 19% with a quadratic function $F(2, 107) = 12.85$, $p < .001$, $R^2 = .193$, to explaining 21% of the variance with a cubic function $F(3, 106) = 9.72$, $p < .001$, $R^2 = .215$. Likewise, for the video version, a linear regression model explained 20% of the variance $F(1, 111) = 29.38$, $p < .001$, $R^2 = .209$, a quadratic model explained 24% of the variance $F(2, 110) = 18.26$, $p < .001$, $R^2 = .249$, and a cubic explained 28% of the proportion of the variance $F(3, 1.9) = 14.39$, $p < .001$, $R^2 = .283$. Arguably, a cubic function explains the observed early and later rise of cost of avoidance (fear price) as a function of spider fear measured via the FSQ. That is, the plateau like shape of the cubic function captures the insensibility (i.e., variability in the data) of the middle prices (i.e., for people with moderate levels of avoidance).

We also examined whether changing the format of the threat stimuli (photos vs. videos) would affect task performance. A close examination of Figures 3.3 and 3.4 already provides information in this regard. Nonetheless, paired *t*-tests comparing the mean of the price score of each version of the experiment did not reveal significant differences $t(111) = -1.20$, $p = .23$ as expected. This was further explored visually in Figure 3.6, which shows the probability of choosing the threat option across blocks for both versions of the experiment using photographic or video threat stimuli.

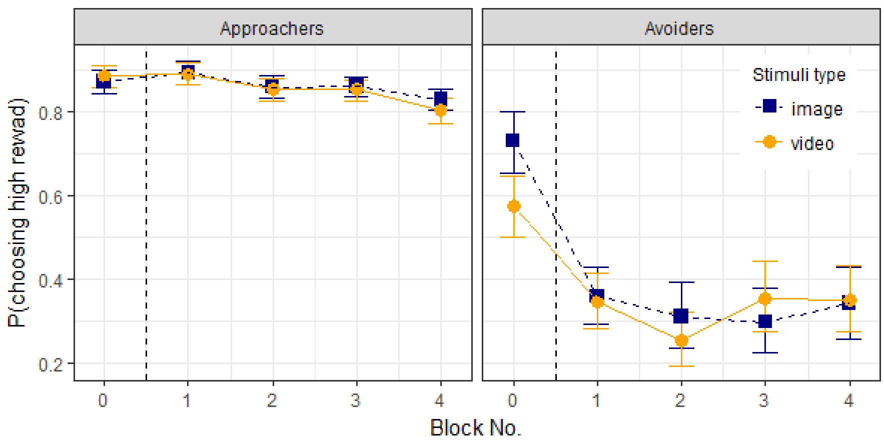


Figure 3.6. Probability of approaching (i.e., choosing the high reward option) as a function of trial-block number, for participants classified as “approachers” (left panel) and “avoiders” (right panel). The bars projecting out of the data points correspond to the respective standard error estimates (95% CIs). The data represented

by the squares and dashed lines correspond to the version of the computer task that employed images of spiders as threat; the data with the bullet-points and solid lines correspond to the version that employed videos-clips of alive spiders. The vertical dished line separates the baseline (block 0) from the experimental blocks (1-4).

Finally, we explored whether the participants classified as approachers or avoiders differed with respect to their motivation to approach, measured via the BIS/BAS questionnaire. From a theoretical stance, the degree to which approachable and avoidable consequences affect actual behaviour will depend on the strength of an individual's motivation (in Miller's [1944] terms, the approach/avoidance gradient). In this sense, we would expect approachers (driven by the rewards) to be characterised by high scores in the BAS scale, and avoiders (driven by the threat) to be characterised by high scores in the BIS scale. The BIS is of particular interest as it is also theorised to be directly related to anxiety derived from approach-approach conflict/threat (Barker, Buzzell, Fox, 2019; McNaughton & Corr, 2008). However, it is important to note that the BIS/BAS fundamentally departs from the theory in the sense that its scales do not necessarily imply an inverse correlation between the purported approach-avoidance systems being measured (i.e., people can score high or low on both scales, or high in one and low in the other with no direct co-dependency between the scales).

Dependent sample *t*-tests measuring mean differences in the BIS scores between approachers and avoiders revealed no statistically significant differences $t(38) = -1.85$, $p = .071$ for the version of the task that employed photos as threat. Though, there were significant differences for the version of the experiment using videos $t(49) = -2.35$ (95% CI: -3.55, -.27), $p = .022$, with approachers experiencing less conflict ($M = 22$, $SD = 4$) than avoiders ($M = 24$, $SD = 3.5$). As for the behavioural approach tendency, measured via the BAS scale, there were no significant mean differences between these subgroups $t(29) = .93$, $p = .357$ for the photo version. In contrast, for the video version, mean differences in the BAS score did reach significance $t(49) = 2.22$ (95% CI: .08, 1.92), $p = .032$, with approachers ($M = 18$, $SD = 1$) having a higher approach motivation than avoiders ($M = 17$, $SD = 2$).

Discussion

Previous examination of implicit tasks in terms of their predictive power of fear-related avoidance yielded low correlations in comparison to self-report measures. In this experiment we set out to test a novel paradigm to measure a fear (i.e., of spiders), based on an individual's balance of approach and avoidance motivations. Across several trials, participants had to decide between two choices: one which granted a relatively higher reward but entailed exposure to spider-related stimuli (the threat option), and one which granted a relatively lower reward but entailed exposure to neutral stimuli (the safe option). In addition, the task was designed so the amount of reward in the response options changed depending on participants' preferences across blocks. In order to cross validate the paradigm, its outcome variable, reflecting participants' approach-avoidance motivation, was then related to a self-report measure of spider fear.

The paradigm produced a skewed distribution of the calculated price, in which approximately 69% of all participants demonstrated the lowest fear price (0.5), and 9% the highest fear price (15.5). These prices were the product of consistently choosing the higher reward (approaching the threat) or the lower (avoiding the threat) respectively. As a consequence, 22% of participants received price values that were between the extremes (i.e., within the inclusive range of 1.5 – 14.5), indicative of having switched from approaching to avoiding and vice versa at one point during the task.

Statistical analyses provided support for the diagnostic utility of the task, in the sense that it distinguished between highly fearful and non-fearful individuals (despite the high proportion of approachers). Further, our analyses revealed a statistically significant relationship between self-reported fear of spiders and the outcome variable of the task (i.e., the price score), which cross validates the relationship between the price and the "fear" construct. Nonetheless, regression analyses predicting the price score suggest that the relationship between verbal estimations of fear and avoidance (as the basis for the calculated price score) is attenuated for individuals with moderate levels of reported fear (as reflected in the plateau shape of the model for the relation between FSQ score and price index). While the uneven distribution of our sample could somewhat explain this pattern in the data, some evidence from AAC-Ts resonates with the findings herein. For example, Sierra-Mercado et al. (2015) found that human participants did not respond differentially to changes in the magnitude of aversive stimulation between moderate and high, when in interaction with medium and high reward. Such effects can be interpreted as indicative of a degree of insensitivity to subtle changes in the stimulation impinging upon behaviour, also observed in our data. Similar insensitivity has been reported in the literature, in particular as it concerns apparent resistance to extinction of avoidance behaviours in experimental paradigms where such a behaviour has little cost (Rattel, Miedl, Blechert, & Wilhelm 2017; Vervliet, Lange, & Milad, 2017; Vervliet, & Indekeu, 2015).

From a theoretical point of view, a more likely explanation behind the weakened relationship between FSQ scores and individuals with “moderate prices” could be an artefact of the intended effect of the paradigm on behaviour. Namely, since individuals with price values in the middle changed their behavioural patterns in accordance with changes in the approach contingencies (a characteristic of adaptive avoidance from our theoretical stance), this observation reflects the difference between self-report static measures of fears and the dynamic nature of avoidance—where a weak correlation could be expected. This could also explain why the task was able to categorically discriminate between high avoiders and non-avoiders (where participants’ extreme scores corresponded with the possible extreme prices given the structured of the task). Following this reasoning, the FSQ scores for individuals who change their behaviour as the result of competing consequences introduced in the task would not be expected to correlate with their calculated prices. Moreover, the high proportion of participants who approached, despite the reported fear, could be the direct effect of introducing approachable contingencies in competition with avoidance (this aspect will be addressed in more depth in the general discussion).

The structure chosen for the present task was inspired by previous work in the area of intertemporal choice (O’Hora, Carey, Kervick, Crowley, & Dabrowski, 2016). A benefit of this was that the paradigm included elements that made the decision-making task dynamic (Brehmer & Allard, 1991), as the decisions that participants encountered across trial-blocks depended on the decisions they made in the previous block. Nonetheless, one of the limitations of a staircase structure is the fact that the range of potential prices that individuals could be assigned was restricted.

The decisions in the current paradigm forced a trade-off between the pros and cons of the available response options, and the staircase structure of the task was designed to find the subjective equality between these (i.e., price index). However, the systematic manipulation of the competing consequences (the step size) seems to have only been able to precisely detect this equality index for a portion (i.e., 22%) of the sample (those who switch from approach to avoidance and vice versa). Correspondingly, there could be a portion of individuals with price indices at the extremes (i.e., 0.5, 15.5) who might have potentially exhibited switches and therefore received a moderate price index if the structure of the task allowed for a wider range of values. In other words, how the task calibrated the approach choice consequence to find the subjective equality might not have been sensitive enough for some individuals who ended up with extreme price values. Having either a very strong predisposition to approach or avoid means that the competing consequences need to be as strong in order to find the subjective equality point (i.e., theoretically speaking, permitting the motivational gradients to cross; see Appendix A). That is, individuals with extreme low prices found the appetitive (approachable) consequence a very strong motivator relative to the (avoidable) aversive consequence, and individuals with extreme high prices found the aversive consequence a very strong motivator relative to the appetitive consequence. Therefore, a possible factor in this respect might have been that the initial block represented too great a step, robustly allocating participants to one side or the other (as approachers or avoiders) at each node of the staircase. Future research should take this aspect into account, that is, including narrower steps in the procedure might bring in more sensitivity in the classification of individuals.

In addition, we exposed participants to both photographs and video-clips of spiders on the assumption that video-clips of spiders represented elicitors of greater magnitude than photographs. The results show that participants did not respond differentially to the format of the threat. This indicates that although the form of the stimuli was qualitatively different, they were functionally similar in the sense that both gave rise to avoidance behaviour at almost the same rate. It should be noted that each version of the task only used one format of the stimuli (either images or videos). In the study by Sierra-Mercado et al. (2015) participants responded to different magnitudes of the threat stimulus. In a similar vein, perhaps if the decisions in our task had also included the type of consequential aversive stimuli that participants would encounter different patterns of avoidance might have emerged.

Furthermore, in contrast to the photographic stimuli used in the task, which has already received some validation (Dan-Glauser & Scherer, 2011), the video stimuli were produced by the experimenter. While using stimuli that have not received previous empirical validation can question their usefulness as effective elicitors, the data does not provide support in this sense. That is, had the video-clips been insufficiently aversive, we would have expected to see a significantly higher approach rate among avoiders; or if they had failed to exert control over avoidance, the response pattern would have been somewhat random. Instead, at the group level, the performance closely matched that of the photographic stimuli for both approachers and avoiders.

As described in the method, we colour-coded the non-threat response option with blue, and the threat option with red. It has been demonstrated that blue and red activate approach and avoidance motivations respectively, having a bearing on cognitive tasks (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007; Mehta & Zhu, 2009). This is an aspect which can have undesirable performance implications in cognitive tasks where the processes of interest are those of a different nature compared to the present work (e.g., memory). However, in the current context dealing directly with approach-avoidance motivations such an effect was considered favourable, given the short duration of the task. Namely, colour-coding the response options facilitated an explicit understanding of the (threat vs. non-threat) contingencies, which prevented delayed learning in the participants.

Finally, for the development of the present task we tackled aspects related to its diagnostic and construct validity. The focus on these criteria is consistent with the validation criteria usually addressed by most AAC-Ts developed in the last decade. However, additional tests can be considered such as the predictive power of the task in realistic scenarios. As previously argued (see Chapter II), behavioural exposure exercises, commonly referred to as behavioural approach tasks (BATs), constitute a valid method whereby to test the ecological validity of a measure. The potential of a BAT procedure rests on the fact that the conditions under which behaviour is examined closely resemble those of real situations; thus, of particular relevance to research of clinical significance and psychopathology.

To address some of the limitations of the present task, a second experiment was programmed. Its general objective is to develop an alternative method to index “fear-motivated” avoidance, and to further investigate approach-avoidance motivations present in decision-making and their relationship with other—behavioural—measures of avoidance. In this respect, first, a different method to calculate the (fear) price index was employed. Specifically, as introduced, we decided to implement the method of limits. The advantage of this procedure over the staircase structure is twofold: (a) each step represents smaller in-/decrements (i.e., smaller differences in the reward magnitudes); and (b) it could be faster depending on the ascending and descending step series required for each individual. The latter is also an optimal feature inasmuch as the procedure uniquely adapts to an individual’s approach-avoidance behaviour. Translated to our paradigm, increasing and decreasing amounts of reward will be presented across trials until an individual’s choices switch from approaching to avoiding and vice versa; thereby providing approach-avoidance switch threshold, as an index of fear.

Second, in order to test the predictive, and hence, clinical utility of the calculated fear index, we will include a behavioural approach task (BAT). As previously argued, a behavioural measure in which participants decide how much they are willing to approach a real spider can be a scientifically useful method to test the ecological generalizability of a measure.

Experiment 2

The following experiment employed a trial structure in accordance with a method of limits procedure. Furthermore, keeping in line with the recommendations ensuing from *Study 1,* this experiment also seeks to provide a rigorous and detailed operationalization of the BAT procedure; specifically devised for the present purpose but—we hope—applicable to cognate research projects. The inclusion of a BAT not only adds to the predictive validity of our index, but it also permits us to capture an aspect of fear that differs from self-reports.

Thus, this experiment developed a new AAC measure to index fear. In so doing, it further explores the relationships between performance in the AAC computer task, psychometric questionnaires, and a behavioural approach task (BAT). Specifically, this experiment aims to answer the following two research questions: Does the outcome variable of the method of limits capture fear of spiders? Does the performance on the computer task relate to BAT and self-reported spider fear?

Once more, of an exploratory nature, we will examine group differences in terms of the BIS/BAS; as well as in light of a new questionnaire: the Brief Experiential Avoidance Questionnaire (BEAQ). The inclusion of these measures allows us to explore the extent to which our outcome variable relates to the constructs measured by these questionnaires.

Method

Experiment 2 was conducted in the same academic environment and under the same laboratory settings as for *Experiment 1*. Hence, only the methodological aspects unique to the present experiment are reported (see appendices H, I, and J for protocol forms).

Sample and Participants Selection

Effect size estimates were based on analogue AAC experiments (e.g., de la Asuncion et al., 2015; Pittig, Brand et a., 2014; Pittig et al., 2014; Meulders et al., 2016) in addition to

G*Power a priori calculation (effect size of .2, alpha of .05, power of .8, four measurements [FSQ score, price score, avoidance level, BEAQ, BIS/BAS]) suggested a sample size of 45 for regressions (with two predictors).

Fifty-four students (age *M* = 20 [18-42], 44 females) were selected based on a preliminary screening using the Fear of Spiders Questionnaire (FSQ) scale: participants who reported no fear of spiders (i.e., with a score < 15) were not invited to complete the subsequent parts of the experiment[3].

Apparatus & stimuli

Setting and hardware. In addition to the room where the computer task took place, an adjacent room was exclusively reserved for the behavioural approach task (BAT). This room was arranged so, once participants opened its door, they faced a corridor (6 m long) at the end of which there was a terrarium (85 cm of height from the ground) with a tarantula inside (see Appendix L). This task was timed using a professional chronometer (RS PRO Digital Desk Stopclock, model 134-7536, 1/100 s resolution, accuracy within 0.5 s, UKAS calibrated).

Stimuli. The arachnid specimen used as visual threat stimulus during the behavioural approach task was a "Brazilian salmon pink" tarantula (*lasiodora parahybana*), with a leg span of approximately 18 cm (± 5 mm) from diagonal measurement[4].

The photographic visual stimuli consisted of the same selection used in *Experiment 1*, and were presented at the centre of the computer screen (26.5 x 20 cm; θ = 18.8°, 14.2°). There were two response areas (5 cm x 6.5 cm; θ = 3.5° x 4.6°), presented on the upper corners of the screen. These response areas could be distinguished based on their motifs (corresponding to the clubs and spade suit of the French deck of playing cards). The reward value for selecting either option was displayed underneath the option's motif (each digit was 1.5 x 2 cm; θ = 1.07° x 1.4°). Since it is intended that participants make their decisions "in flight" (i.e., as they move the computer cursor towards the response areas), the availability of the response areas was contingent on movement to promote response initiation (instead of using a tone, cf. *Experiment 1*)[5].

[3] This was done in order to minimise the disproportion of non-fearful individuals ("approachers") found in *Experiment 1*.
[4] The reason for using a sizable specimen was to ensure its sighting from the farthest step in the approach task.
[5] This feature was introduced in the task—piloted—in anticipation to experiments in Chapter IV.

Assessments and Measures

In addition to the FSQ, the BIS/BAS (see *Experiment 1*) and some task related questions, participants were asked to answer a digital version of the BEAQ (Gámez, et al., 2014).

The Brief Experiential Avoidance Questionnaire. The BEAQ is a 15-item revised version of the Multidimensional Experiential Avoidance Questionnaire (Gámez et al., 2011) used to assess unwillingness to remain in contact with any type of distressing experience (emotions, thoughts, memories, physical sensations), and hence a tendency to engage in any activity that reduces such an experience (e.g., physical/emotional distancing, compulsive rituals, etc.). Items refer to life events or emotional responses in the form of statements (e.g., "I'm quick to leave situations that make me uneasy"), and people rate their agreement or disagreement on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). The BEAQ has been proven to significantly differentiate student, clinical and community population samples (Gámez, et al., 2014). In addition, it seems to moderately correlate with other self-report measures of avoidance (mean $r = .52$), and it has satisfactory internal consistency with Cronbach's alphas ranging from .80 to .89 (Gámez, et al., 2014).

We considered this questionnaire as a potentially viable alternative to the BIS/BAS. However, it is important to note that this questionnaire has not yet received extensive use in the literature (cf. Bardeen, Fergus, & & Orcutt, 2014; Fergus, 2015; Tyndall et al., 2019), and, to our knowledge, no test–retest reliability has been conducted.

Procedure, Computer task and Behavioural exercise

Days before participants were invited to take part in the experimental tasks, they were required to complete a digital version of the FSQ (see Appendix I for the invitation letter and consent forms). This time lapse was done to mitigate consistency biases with respect to the BAT. Namely, independent measurement of verbal estimation and BAT might prevent participants from behaving in accordance with their answers to the questionnaire (see *Study 1* recommendations).

Computer task. The computer task was designed to provide a response-based index of fear or subjective evaluation of the threat stimulus. This was achieved by finding the points at which an individual's behaviour changes depending on the appetitive (approachable) and aversive (avoidable) consequences of—competing—available choice options.

Prior to commencing the experimental trials, participants read the instructions with the experimenter (see Appendix J), and had the opportunity to familiarise themselves with the layout and mechanics of the task by responding to a few practice trials. In this phase, the response options offered the same amount of points (i.e., 5), to focus on the task mechanics rather than engaging decision-making processes. During these trials, the experimenter talked the participant through the task and she or he was encouraged to ask questions.

In the method of limits procedure, participants were exposed to a series of blocks of trials in which the reward values changed in ascending or descending order. In an ascending series, assuming participants started avoiding the threat option, the reward value of the threat option was increased (by a factor of two points) across blocks until participants switched to choosing the threat; at this point a descending series was introduced in which the threat reward was then systematically reduced until participants switched back to avoidance. In a descending series, assuming participants started approaching the threat option, the threat reward was reduced until participants switched to choosing the non-threat option; whereupon it was increased until participants transitioned back to approach.

At the beginning of each trial-block, participants were informed about the points they needed to accumulate in order to complete it. This criterion was equal to a minimum of ten consecutive selections of the high reward option at any given trial-block. For example, the starting reward values (for baseline and first experimental block) were 10 vs. 12, and so the minimum amount of points a participant needed to obtain in order to finish a trial-block was 120 (10×12); or 180 if the highest reward happened to be 18, and so forth.

Each trial started with participants clicking on the "start" button located at the lower middle of the screen. Clicking this button resulted in its disappearance, and participants then had to move the mouse-cursor upwards (90 px) in order to make the response areas appear (to promote movement by the time the stimuli came into view).

Clicking on a response area inverted its colours (as feedback) and each selection was followed by the presentation of a photographic visual stimulus. Participants were instructed to view the stimulus for four seconds, after which the stimulus automatically disappeared; any other response from the participant had no effect. A feedback screen appeared confirming the amount of points earned or lost for that trial choice, along with the participant's tally (i.e., "You have earned ## points | Accumulated points: ## out of ##") and an instruction to "click to continue". Clicking once more removed this feedback screen and the next trial started (see Figure 3.7). The initial reward values were 12 points (for the "clubs" response area) vs. 10 points (for the "spades" response area). The first block constituted the baseline so choosing either option resulted in the presentation of randomly selected neutral photographs as response consequence. From the first experimental block onwards, choosing the option with the clubs suit (the threat option) was followed by a photo of a spider, whereas choosing the option with the spades suit (the safe option) was followed by a photo of a neutral—non-spider—object such as a piece of furniture.

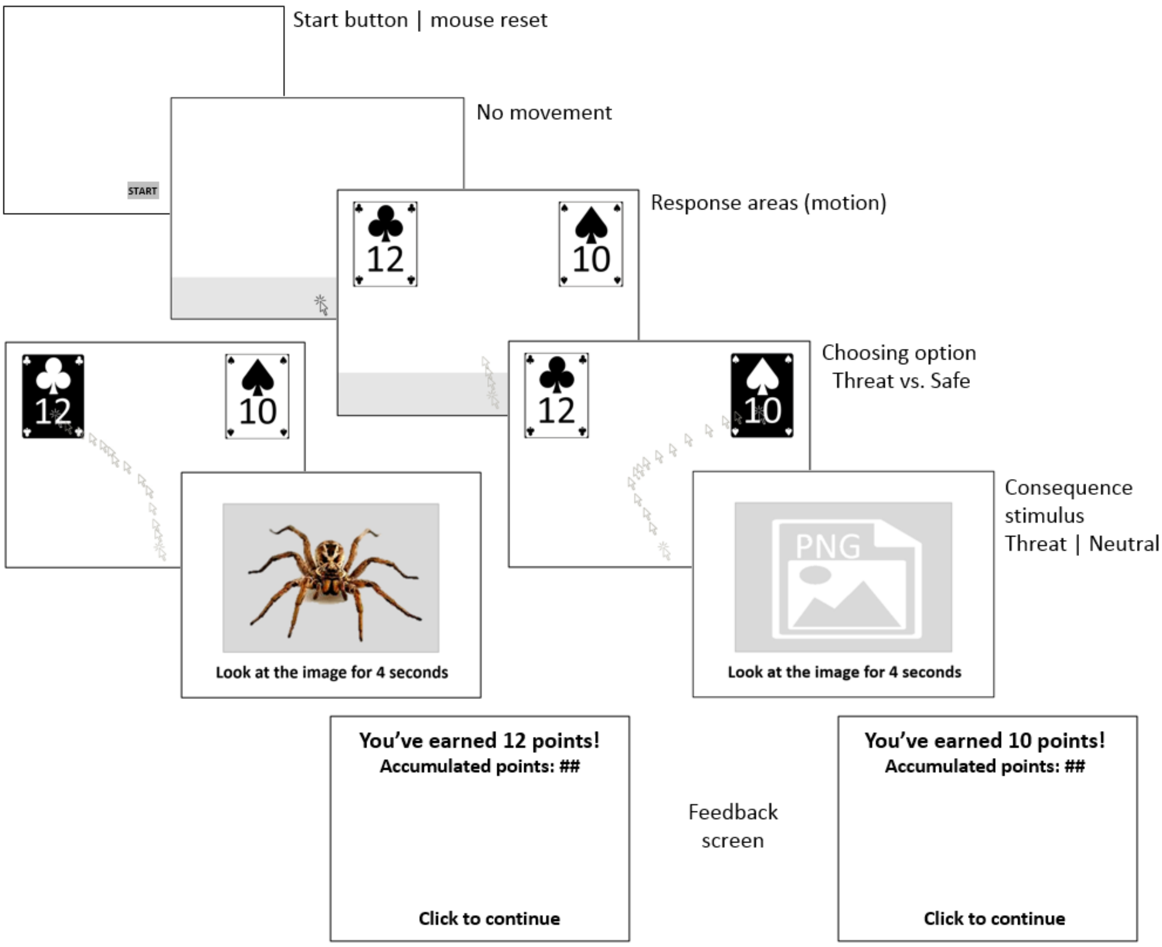


Figure 3.7. Schematic representation of the trial sequence (top to bottom). The top three frames show the sequence from clicking the start button to the presentation of the response areas ("cards"). Choice selection is represented by the darkened cards: choosing the clubs-option implied seeing a spider stimulus; choosing the spades-option was followed by a neutral stimulus. The last screen (bottom row) represents the reward feedback corresponding to each selection.

The amount of points offered by the threat response option varied across experimental blocks. For example, we expected fearful participants to start avoiding the threat option after first encountering the aversive stimulus. If a participant then chose the safe option more than 50% of the time, the reward offered for the threat option was increased by a factor of two points in the following trial-block. This was designed to find the minimum reward incentive to motivate a switch from avoiding to approaching. Contrariwise, if a participant chose the threat option more than 50% of the time, its reward value was decreased in the following block. The location of the response areas was counterbalanced across blocks, and their starting location was randomised across participants.

The threat reward value at which participants switched from avoidance to approach thus constituted the *upper limit* of their approach-avoidance threshold; that is, the point at which the motivation to approach (given the reward offered) outweighed the motivation to avoid looking at the aversive stimulus (X-Spider > Y). Equally, the threat reward value at which participants switched from approach to avoidance constituted the *lower limit* of this approach-avoidance threshold (X-Spider < Y). The average of these limits, thus, is operationalised as an individual's *point of subjective equality (PSE)*; and the price index (equivalent to *Experiment 1*) is calculated by subtracting ten (the baseline—safe—reward value) from the PSE. Consequently, participants who always avoided the threat exhibited wide switch thresholds and had high prices, whereas participants who always approached exhibited narrow switch thresholds and were recorded as having a price equal to zero.

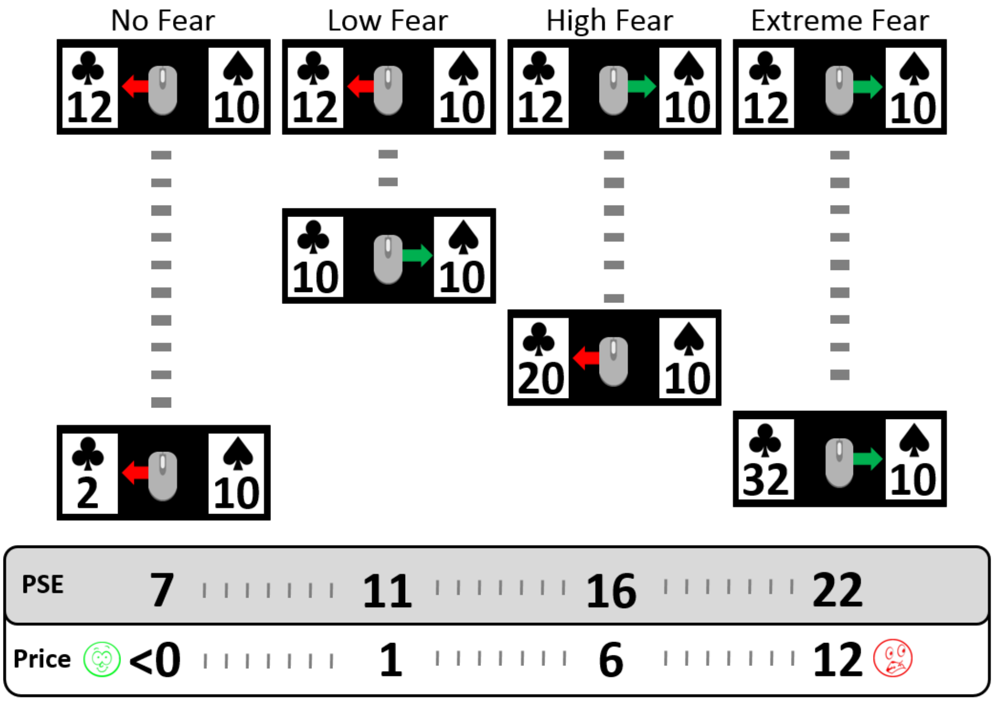


Figure 3.8. Rudimentary representation of the classification of four hypothetical individuals based on their response patterns (top labels); from extreme approachers on the leftmost column, to extreme avoiders on the rightmost column. Each box represents a trial with an example of the potential choices, the arrow from the computer-mouse in the middle indicates the individuals' preferential response choice, and the—quasi-proportional—vertical ellipses stand in place of the trials in between the top trial-choices and the terminal ones at the bottom. Threat approach responses are mapped to the left (clubs) and further indicated by the red arrows; avoidance responses are mapped to the right (spades) and indicated by the green arrows. The dual scale at the bottom corresponds to the point of subjective equality (PSE) and price of these individuals.

In other words, a participant could decide to choose the threat option (clubs suit) if the amount of points offered were "worth it" enough. Otherwise, she or he could decide to avoid the spider stimulus by choosing the alternative safe option (spades suit); taking into account that choosing the options with fewer points entailed having to complete more trials in order to fulfil the points' criteria.

A trial-block terminated once the participants reached the specified points' criterion, and participants were presented with a rating scale to indicate the level of difficulty experienced whilst completing the trials of that particular block (see appendix Figure J1).

The experiment terminated once either of two conditions were met: (a) a participant's response pattern exhibited two switches (i.e., 1. avoidance → approach; 2. approach → avoidance), thereby providing the limits of their approach-avoidance motivation threshold; or (b) they completed a total of ten trial-blocks in one direction without switching (i.e., if a switch occurred during a block number under ten, the experiment would terminate after ten more blocks without switching back). As a consequence, the number of trials that participants completed varied depending on their individual performance. Participants concluded this phase of the experiment by answering some questions related to the decision-making task (see Appendix K).

Behavioural exercise. After completing the computer task, participants were reminded of and offered the opportunity to continue onto the second part of the experiment. Participants were reassured that declining to attempt the behavioural approach task (BAT) was acceptable. During the BAT participants could decide to enter a room and walk towards the location of a terrarium (on a table 6 m away, at the other end of the room) containing a tarantula (see Figure 3.9). For this task, participants were directed to the designated experimental room, outside of which they were briefed about the specifics of the procedure and respective instructions (see Appendix L for more detail and appendix Figure L1 for a photographic record of the BAT layout and the threat stimulus).

Participants were instructed to start walking towards the terrarium soon after opening the door, and to only stop at the point where they did not want to approach any further. The researcher remained behind the participant as she or he engaged in the task, and recorded the time it took the participant from opening the door to settling at a full stop, as well as the remaining distance to the terrarium (i.e., *BAT-duration* and *BAT-distance* as outcome variables respectively). At this point, participants were asked to provide a verbal rating of the level of anxiety being experienced (*BAT-anxiety*) and a few additional questions in order to get a sense of the participant's approach-avoidance evaluation processes in situ. Before dismissing participants, they were offered a last challenge by asking them whether they would dare approaching the tarantula any further (it was left to the participants to decide how much). If upon this prompt a participant moved any distance forward, the researcher, once more, recorded the remaining distance to the threatening stimulus; time was not recorded during this second attempt.

In the literature, it is common to find a discretised distance variable labelled "steps" (see *Study 1*; e.g., Table 2.2). While a justification for its use is usually absent, we consider it a valuable option in cases where the BAT procedure includes steps that represent a qualitatively significant difference in the exposure to the threat stimulus, not captured by the distance unit (e.g., Cochrane, Barnes-Holmes, & Barnes-Holmes, 2008). In our case, transitioning from *BAT-step* ① to ②, and from *BAT-step* ⑥ to ⑦, as indicated by the circled numbers heading Figure 3.9, represented a significant change in terms of their potential to elicit increased emotional reactivity: the former is a difference between seeing and not seeing the threat (stay behind the door or open it), the latter a difference in proximity independent of walked distance (leaning over the threat stimulus).

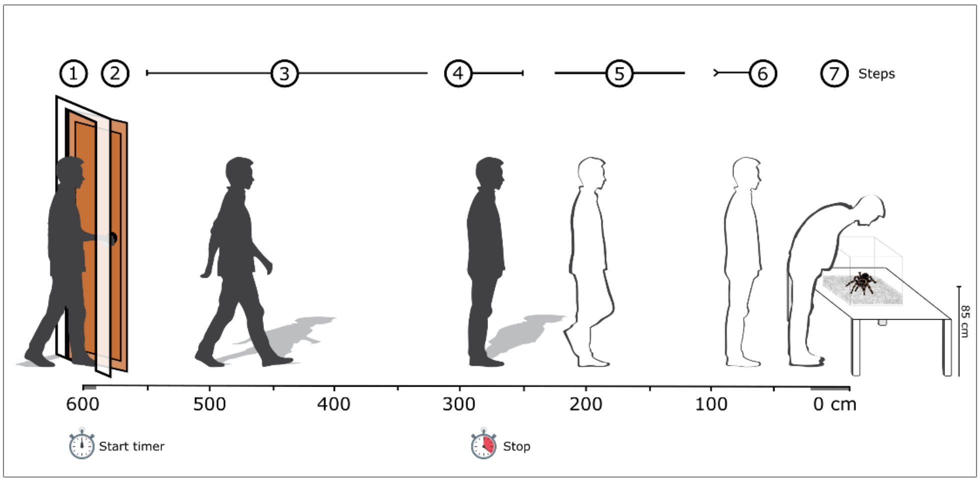


Figure 3.9. Illustration of the approach avoidance task (BAT) and its operationalization. The circled numbers at the top (and the area covered by the lines projecting out) represent the discrete *BAT-steps* to be recorded depending on the distance approached towards the threat. *BAT-distance* refers to the remaining distance in cm (measured floor) between the participants and the threat stimulus once their approach locomotion came to a halt. The silhouetted avatars exemplify an approach sequence from opening the door and entering it, to fully stopping. The timing of such a performance (*BAT-duration*) is indicated by the stopwatches at the bottom. The outlined avatars complement the potential additional steps and their requirement; for example, BAT-step 6 corresponded to fully approaching the terrarium holding an upright posture next to it, whereas BAT-step 7 consisted of leaning over (approximately 45º) bringing the face close to the tarantula and keeping that position for 4 seconds—same viewing time as in the computer task.

Once both experimental tasks concluded, participants were asked to complete both the BIS/BAS and BEAQ questionnaires. After signing a retroactive consent, participants were debriefed about the rationale of the experiment.

Results

This experiment tested a method to produce an index of fear based on response patterns to conflicting approach-avoidance contingencies in a decision-making task. Moreover, this experiment went a step further than many of the studies published to date developing AAC-Ts by incorporating overt behavioural measures involving whole-body movements.

Due to the nature of the task and the expected individual differences in approach-avoidance thresholds, participants varied considerably in the number of trials completed (*M* = 58, range = 22–216). Similar to *Experiment 1*, our sample was constituted, on the one hand, by a large proportion of "extreme approachers" (*n* = 10) who never switched to avoidance, and on the other hand, by a few "extreme avoiders" (*n* = 4) who never chose the threat option (see Figure 3.10). The approach-avoidance thresholds for these participants were therefore defaulted to 10 (the baseline) and 28 (the maximum upper bound value recorded) respectively.

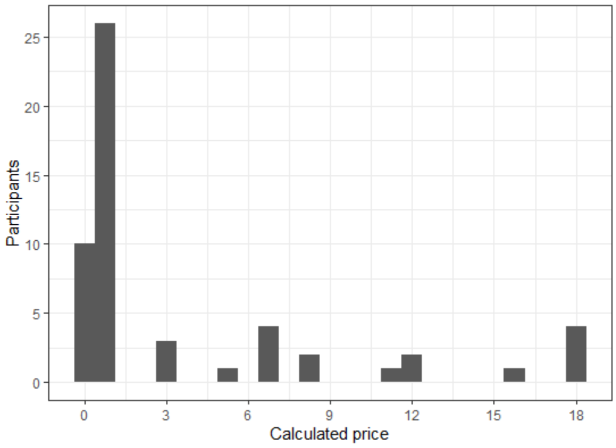


Figure 3.10. Histogram showing the frequency distribution of price in the sample. A price of zero is indicative of no motivation to avoid the (spider) threat consequence.

In order to generate a unified index of the strength of the approach-avoidance motivational conflict, the thresholds (lower and upper bounds) were averaged for each individual. We refer to this calculated value as the point of subjective equality (PSE). This index number represents the difference in reward magnitude between appetitive and aversive consequence necessary to override an individual's behavioural tendency or motivation. The price index was then calculated by deducting the baseline choice reward of ten from the PSE. Since the percentage of avoidance behaviour during the computer task (i.e., choosing the non-threat option) constituted a direct measure of avoidance during the decision-making task, tertile splits based on this were used to divide our sample into three categories of avoidance behaviour: low (*n* = 32), moderate (*n* = 14), and high (*n* = 8).

In order to answer our first research question addressing the relationship between self-reported fear and performance on the computerised task, we conducted regression analyses with FSQ as predictor and participants' price indices as outcome variable. These tests did not quite reach significance *b* = .071, *SE* = .036, *t* = 1.94, *p* = .057, consequently, the null hypothesis indicating that there is no relationship between the price index and self-reported fear is not rejected. However, further analyses including avoidance level as predictor into the model, suggest that the effect of FSQ was moderated by the level of avoidance $F(5, 47) = 9.10$, $p < .001$, with trend analyses indicating the FSQ to be a stronger predictor of the price index for moderate avoiders *b* = .12, *SE* = .03, *t* =3.97, $p < .001$, and high avoiders *b* = .13, *SE* = .06, *t* = 2.01, *p* = .05 in contrast to low avoiders. Unsurprisingly, this reflects the fact that there was less variability in the price index for individuals for whom the spider did not seem to represent a strong aversive stimulus.

Our second research question addressed the relation between the decision-making task and a whole-body behavioural approach task (BAT). Using regression analyses, the price index proved to be a good predictor of BAT-distance *b* = 11.25, *SE* = 3.80, *t* = 2.95, *p* = .004, explaining 14% of the variance $F(1, 52) = 8.75$, $p = .004$, $R^2 = .14$. Adding the FSQ score as an additional predictor improved the model $F(2, 50) = 6.43$, p = .003, $R^2 = .20$, explaining 6% more of the variance. These results suggest a stronger relationship between the approach-avoidance processes measured via our AAC-T and whole-body avoidance, than that between AAC-T and FSQ (see Figure 3.11).

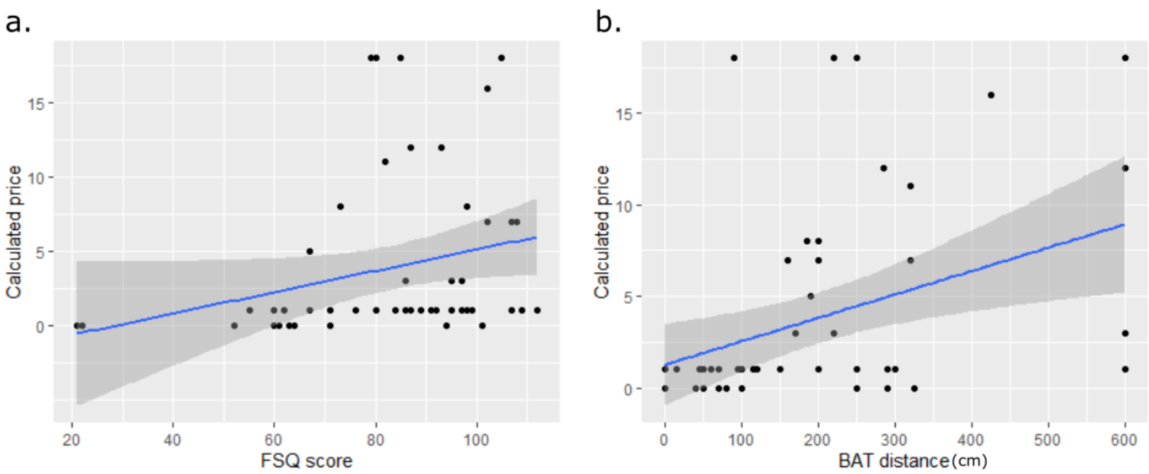


Figure 3.11. Scatter plots showing the relationship between participants' approach-avoidance price index and two measures: (a.) fear score as per FSQ, and (b.) approach distance in the BAT. The lines conrrespond to linear functions—better fit.

Table 3.1 below provides the correlation between the different variables under investigation. In confirmation of the foregoing analyses, the price index had a moderate strength correlation with BAT-distance (i.e., remaining centimetres relative to the location of the tarantula) *r* = .379 (95% CI: .124, .587), *p* = .004, as well as with BAT-steps (i.e., walked distance towards the location of the threat) *r* = -.429 (95% CI: -.628, -.177), *p* = .001. The correlation between FSQ and the price index failed tests of significance *r* = .26, *p* = .057, potentially indicating that these measures assess different psychological processes. The fact that, in comparison to the price index, BAT-anxiety (i.e., verbal reports of anxiety during the exercise) correlates with both FSQ and physical proximity to the threat (BAT-steps and -distance) further suggests a degree of domain specificity of the price, different from purely verbal estimations and approach behaviour. Nonetheless, the price index appears to be somewhat better at predicting behavioural approach than the FSQ score. Interestingly, neither the FSQ nor the price index correlated with the time it took participants to approach (i.e., BAT-duration in seconds).

Table 3.1

Peason's correlations between the variables of interest: computer-based score (price index), self-reports (FSQ, anxiety), and BAT units (distance, duration, steps, anxiety).

	1.	2.	3.	4.	5.
Price index	.26	-.43**	.38**	-.05	.21
1. FSQ		-.40**	.34*	.14	.50***
2. BAT-steps			-.97***	.22	-.64***
3. BAT-distance				-.28*	.58***
4. BAT-duration					.06
5. BAT-anxiety					—

Note. Significance *p* levels as: .05*, .001**, <.001***

At the end of each block, we asked participants to rate the degree to which they found the decisions during each block to be difficult. Linear regression analyses predicting this rating suggest that as the number of blocks increased (thus the greater the incentive offered to switch from avoidance to approach) the more difficult it was for participants to decide *b* = .129, *SE* = .034, *t* = 3.77, *p* < .001, but its relationship was weak (*r* = .25, *p* < .001).

As previously, we asked participants to complete two additional psychometric questionnaires: the BIS/BAS and the BEAQ. The reasoning for this was that individuals may differ in their (self-reported) behavioural predispositions and this might moderate the degree of approach/avoidance during the task performance. Nevertheless, none of these scales predicted the price index via linear regression analyses (BIS: *b* = .35, *p* = .201; BAS: *b* = -.54, *p* = .294; BEAQ: *b* = .01, *p* = .958). Neither were there any differences among subgroups based on them via one-way ANOVAs (BIS: $F[2, 51] = .24$, $p = .78$; BAS: $F[2, 51] = .40$, $p = .66$; BEAQ: $F[2, 51] = .01$, $p = .98$).

Discussion

This second experiment tested an alternative method for assessing threat fear, derived from behavioural (approach-avoidance) motivational processes present in decision-making. The decisions in this task involved a trade-off between the magnitudes of the choice reward in relation to the emotional costs of contacting an unwanted choice outcome (i.e., exposure to a threat). In this way, the current paradigm represents a method for indexing, at the individual level, the imbalance in the motivation to approach and avoid present at the moment of making decisions.

In the method of limits participants' equality point between approach and avoidance motivations was achieved by systematically increasing or decreasing the value of the threat option. For participants who approached, the threat value was reduced until they switched to choosing the alternative non-threat option, whereupon the threat value was continuously increased until a switch back to choosing the threat option occurred. Inversely, for participants who avoided, the threat value was sequentially increased until participants switched to choosing the threat option, whereupon its reward value was reduced until participants switched back to avoiding the threat. The value of the threat at the moment in which these switches in choice preference took place (the upper/lower limits), were then averaged for each participant (i.e., the point of subjective equality). We then produced each participant's price index by deducting the (baseline) value of the non-threat option (always ten).

Consequently, fearful participants were expected to switch to avoidance soon after encountering the threat and back to approach only as a function of a rewarding consequence sufficiently great to override the repulsive effect of the aversive outcome (e.g., upper limit ≈ 24). Thus, the greater the upper limit values in the case of fearful participants, the higher the price index. Non-fearful individuals, on the other hand, were expected to switch to avoidance soon after the offered reward was less than that of the non-threat option (lower limit ≤ 10) and back again once the threat reward was greater than the non-threat reward; reflecting the fact that their behaviour was heavily controlled by the points. Thus, low limit values in the case of non-fearful participants yielded small prices.

As reflected in the range of the price indices (0 – 18), the AAC-T paradigm implemented in *Experiment 2* generated a better distribution of fear prices than that employed in *Experiment 1*. Therefore, the method of limits captured fear-motivated approach-avoidance response tendencies in more individuals than the staircase procedure did in the previous experiment. Specifically, whereas the AAC-T in *Experiment 1* was sensitive to response switches in 22% of the sample, the modified AAC-T in the current experiment was fine-tuned to capture response switches in 81% of the sample (excluding ten extreme approachers whose prices were defaulted to zero), demonstrating greater sensitivity. It is important to note that the majority of participants in this sample were highly afraid of spiders. In fact, 35 participants (out of 54) had a score above 80 in the FSQ, considered characteristic of phobic populations (Teachman, 2007; Muris & Merckelbach, 1996). Based on this, one would expect high levels of avoidance. Nonetheless, there was still a high proportion of participants (n = 26) whose approach patterns corresponded to the very low price of one. Similar to *Experiment 1*, this high number of approachers could be the result of strong competing contingencies promoting approach. Given the structure of the task, it took less time for approachers to complete the task (i.e., requiring only between 20 and 30 trials); inversely, completing the task took longer for fearful (or less reward-motivated) participants depending on the strength of avoidance exhibited (this point is further discussed in the general discussion).

As emphasised, providing ecological validity for measures of clinical relevance is of utmost importance. As a consequence, one of the main objectives of this experiment was to tackle not only the relationship between self-report measures of fear and decisions in our AAC-T, but also between these and behavioural responses in a realistic context (i.e., approaching a live exemplar of the phobic stimulus). Given the validation of the FSQ measure, self-reported fear of spiders was expected to correlate with the BAT. Interestingly, the strength of this relationship between the FSQ and the BAT-distance was stronger in this experiment (r = .34) than that reported (r = .28) by Szymanski and O'Donohue (1995). While these findings could result from procedural differences between these studies, they also suggest that our operationalisation of the BAT has the potential to provide a stronger relation with reports of fear in general.

Specifically, in accordance with the recommendations ensuing from *Study 1*, the BAT protocol implemented in the current experiment introduced a time lapse between the level of fear measured explicitly via the FSQ and the BAT. This procedural aspect might diminish a tendency to appear verbally consistent and thus constitute an especially reliable measure of avoidance in realistic situations. Furthermore, the current BAT was designed taking into consideration all of the BAT features found in the literature review from *Study 1* (see Table D1). Like some of the reviewed studies (i.e., Ellwart et al., 2006; Leech et al., 2016; Rinck & Becker, 2007; Teachman, 2007), we included a step in the BAT which represented a qualitatively difference step (seeing/not seeing) in exposure to the spider threat stimulus by having participants opening the door to the experimental room wherein the spider was kept. Similarly, the last step requiring participants to lean over and stare at the spider also represented a change in the intensity of the exposure to the threat. Consistent with this, our BAT-steps are not equidistant (e.g., step 3 is lengthier than step 6 in Figure 3.9) as we assume that the perception of threat is not precisely linear with respect to physical distance. In fact, the data seems to support this assumption with BAT-steps yielding the highest correlation coefficients and a very strong correlation of r = -.64 between BAT-steps and BAT-anxiety. The aforementioned aspects of the BAT developed for *Experiment 2* thus stand as a significant improvement of this measure.

Self-reported fear, on the other hand, barely missed a significant correlation with the price index. This finding lines up with those reported by Pittig, Brand et al., (2014). Nevertheless, as suggested for *Experiment 1*, induced behavioural switches (from avoidance to approach) due to the nature of the task could be partly responsible for weakening the relationship between self-reported fear and the outcome variable of our AAC-T. Alternatively, this finding could be judged in light of the known weak correlation between explicit and implicit measures of fear (e.g., Kurdi et al., 2018; see also *Study 1*). However, theoretically speaking, implicit tasks aimed at measuring attitudes may not need to relate to deliberate avoidance.

In this regard, the nature of our approach-avoidance task inherently engages deliberate processes involved in decision-making. That is, individuals not only have to compare the response options when deciding, but also the perceived benefits/costs relative to the alternative. This may explain the moderate correlation between the price index and the degree of proximity to the threat during the BAT, which involves deliberate motor regulation. Thus, it would appear that the price index captures processes/features of spider fear that the questionnaire does not. Nonetheless, the fact that the price score did not significantly correlate with the BAT-duration further indicates some specificity in the predictive power of the price index depending on the response dimension. This latter finding contrasts with the reported correlation by Rink and Becker (2006) between their AAC-T score and the BAT-speed. However, the discrepancy between Rink and Becker's (2006) findings and ours is likely due to differences in the measurement unit as these researchers used a composite BAT unit (i.e., time × distance) in their study.

To conclude, a method of limits AAC-T stands as an ecologically valid procedure for measuring fear responses. Further, it represents an effective behaviourally-based method for investigating the strength of approach and avoidance motivations in decision making. Furthermore, avoidance behaviour is sensitive and adaptable to the characteristics of the environment, and being able to assess approach-avoidance processes in a dynamic fashion (i.e., depending on relative pros and cos of a situation) can advance our ability to predict behaviour in realistic settings and improve clinical interventions (Hofmann & Hay, 2018; Krypotos, Arnaudova, Effting, Kindt, & Beckers, 2015).

General Discussion

The objective of the present study was to develop novel methodologies to measure fears[6]. In so doing, we tested two experimental paradigms that enabled us to assess how individuals' tendencies to approach and avoid choice outcomes are dependent on the relative values of their appetitive and aversive properties. The combined results of these experiments not only represent a promising avenue to innovate behavioural assessment procedures, but they also have the potential to inform treatment optimization (Holmes, Craske, Graybiel, 2014). That is, they provide additional support to the power of appetitive contingencies in overriding avoidance tendencies in fearful individuals, and their important role in conceptualising maladjusted avoidance (Costello, 1970; Hayes, 1976; Hayes, Lattal, & Myerson, 1979; Miller, 1944; Pittig, 2019).

In *Experiment 1,* we implemented a staircase procedure in which participants' motivation to avoid was systematically selected from approach contingencies whose reward magnitudes differed substantially (generating low response competition), to contingencies with a small difference between the reward magnitudes (generating high competition). The

[6] As explained in Chapter I, our conceptualization of "fear" differs from mainstream definitions.

difference in the rewards was then converted into a unique index of approach-avoidance motivation ("the price of fear"). In *Experiment 2*, we implemented a somewhat inversed procedure. This second task presented choices starting with a small difference between the reward magnitudes (whilst keeping the aversive consequence constant), and systematically increased such a difference in the rewards until participants decided to approach the aversive consequence; whereupon the procedure reversed until the participants switched back to avoiding. This latter method allowed us to calibrate the boundaries within which participants' approach-avoidance motivations fluctuated due to the conflict from the competing consequences. Based on this behaviour, we were then able to calculate an index of fear of predictive—and potentially clinical—utility.

To date, there are not many studies that have explored the relationship between the performance on approach-avoidance conflict tasks (AAC-Ts) and the self-report measures of fear specific to the threat stimulus used—hence, interpretations in this regard are based on limited data. Nonetheless, one source of comparison is the study carried out by Pittig, Brand, Pawlikowski, and Alpers (2014). These researchers conducted a study in which they adapted the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) so the response options displayed both neutral (butterflies) and aversive (spiders) images. They found that when the spider stimuli were displayed on the advantageous decks, spider-afraid participants chose them less frequently leading to increased "long-term" losses, in comparison to non-afraid participants. In like manner to the current study, Pittig et al. used the balance at the end of the task as a summary index of a participant's decision style. Yet, their analyses did not yield a significant relationship between the FSQ and the final balance of fearful participants.

In contrast, Rinck and Becker (2006) developed a task in which participants are presented with threat images (e.g., spiders) or non-threat ones (e.g., dragonflies). Using a joystick, participants are required to either pull or push the stimuli. In their study, Rink and Becker found that when the response type (pull/push) and the stimuli (threat/non-threat) were compatible, there was a weak but significant relationship with the FSQ (r = -.04), and a moderate strength of association with the speed of approach in a BAT (r = .48). These results are interesting in light of the authors' claim that their task assesses avoidance and, therefore, their index is expected to have "a larger overlap with the BAT than questionnaires" (p. 112). It is important to note though, that they did not report BAT information on the distance dimension (as independent of time), which could have helped to make comparisons with tasks that allow deliberate responses (for which the time dimension may not be the most sensitive unit). In addition, although the task is designed to generate conflict between the stimuli and response required, the task developed by Rinck and Becker (2006) does not include any type of response cost which is characteristic of AAC-Ts.

Nonetheless, Rinck and Becker's (2006) findings align with those from *Experiment 2*, but at the same time—as previously stressed—they further highlight the importance of: (a) complementing the assessment of fear/avoidance with measurements that engage robust behavioural response systems (e.g., BATs), and (b) doing so in a format that makes data directly extrapolatable to contexts of clinical relevance (i.e., having predictive validity). We have argued that BATs are good procedural candidates in this regard. However, depending on the characteristics of the experimental tasks, the relation with performance in BATs may vary along different dimensions (time/space) and measurement units (cm, discrete steps). Taking into account these methodological aspects will help identify crucial behavioural interactions between the different processes and response systems conceptualised as part of the phenomenology of fear (Lang, 1985; Vermilyea, Boice, & Barlow, 1984; Van Bockstaele et al., 2011).

Despite the fact that both experiments suffered from uneven samples (with most individuals having a low "fear price"), *Experiment 1* demonstrated that avoidance in decision-making is sensitive to competing appetitive consequences, in agreement with the available data from an AAC perspective (e.g., Pittig, 2019; Pittig & Dehler, 2019; Pittig, Hengen, Bublatzky, & Alpers, 2018). *Experiment 2* replicated this effect under different conditions and extended its scope to integrate a behavioural measure in a realistic scenario (i.e., BAT), with face validity for clinical research (see Scheveneels, Boddez, Vervliet, & Hermans, 2016; Krypotos, Vervliet, & Engelhard, 2018).

In fact, as alluded to, the high proportion of individuals who approached the spider threat option can be interpreted as an artefact of the paradigms, as these were designed to motivate approach. The rewarding effect of acquiring points, the time spent in the task, coupled with number of additional trials to be completed, could have acted—especially for university students—as a very strong motivator for participants' decisions (ultimately governing self-exposure). Support for this clam comes from participants' answers to the task-related questions asked upon completion of the task (see Appendix H and K, for *Experiment 1* and *2* respectively). For *Experiment 1*, the greatest proportion of participants (83%) agreed to "[having] found going quicker through the task motivating", compared to 24% of participants who "[were] motivated to avoid the spider". These numbers are in spite of the fact that 51% of participants "found that the spider related stimuli made them feel anxious/uncomfortable" (see appendix Figure H1).

A similar pattern in participants' answers to the post-experiment questions was found for *Experiment 2*. Specifically, getting "quicker through the task" seems to have played a major role in motivating participants' approach behaviour, with 95% of people agreeing to the statement inquiring about this. In addition, 74% of participants also reported to have "[chosen] the [threat] because [it implied a higher payment], despite of [their] fear towards the spider stimulus" (see appendix Figure K1).

In light of the foregoing data, ascribing the high number of approachers to the direct effect of the competing consequences present in the tasks is substantiated. This is especially so when contrasted with the empirical data revealing the opposite response pattern under experimental conditions that imply low-cost avoidance (e.g., Vervliet & Indekeu, 2015; Xia, Eyolfson, Lloyd, Vervliet, & Dymond, 2019; cf. Rattel, Miedl, Blechert, & Wilhelm, 2017). Theoretically, presenting individuals with competing contingencies, each of which was simultaneously associated with costs and benefits, created the condition for individuals to experience conflicting approach-avoidance motivations (Miller, 1944; Hovland & Sears, 1937). Namely, progressing through the task meant that the incentive to face the feared stimulus increased and, thereby, participants were being "pushed to their approach-avoidance limits" potentially generating motivational conflict.

This interpretation is in line with empirical data in the area of approach-avoidance (Aupperle et al., 2011; Boyd, Robinson & Fetterman, 2011; Gannon, Roche, Kanter, Forsyth, & Linehan, 2011; Rinck & Becker, 2007; Sierra-Mercado et al., 2015). For example, from a behavioural analytic perspective, Gannon et al., (2011) investigated the effect of conflicting—motivational—stimulus functions via equivalence relations (see Critchfield, Barnes-Holmes, & Dougher, 2018; Sidman, 1994). They trained two sets of stimuli (class 1 and 2), each with four stimuli (A, B, C, and D). One stimulus (B1) was paired with aversive images and another stimulus (B2) was paired with appetitive images; correspondingly avoidance and approach responses were trained to these sets of stimuli. As a result, the stimuli in each set were functionally equivalent, giving rise to avoidance and approach responses (C1, D1 and C2, D2 respectively). In a subsequent phase, one of the stimuli that had acquired aversive functions via class membership (D1) was instead paired with appetitive images, and one of the stimulus (D2) that had acquired appetitive functions was then paired with aversive images. The test consisted of presenting participants with the stimuli in each class that had not received any direct pairing (C1 and C2). Given their class membership, responses to such stimuli were expected to be conflicted, giving rise to both approach and avoidance responses via their association with both B and D stimuli sets. The researchers found that, across participants there was no consistent response pattern (i.e., some people avoided the C stimuli, some approached them). Moreover, the mean response time (in their second experiment) to the C stimuli was greater for all participants after having trained the conflicting functions in the latter phase of the experiment, than earlier when all stimuli in the sets shared the same unique function of approaching or avoiding.

The data ensuing from both experiments provide support to the calculated price method as a scientifically valid method for the assessment of overt avoidance. In this respect, the correlation between explicit and implicit measures of fear reported in the literature ranges between r =.24 and .36 (Hofmann et al., 2005; Nosek, 2005). In contrast, in *Experiment 1* the correlation between our calculated price and the FSQ questionnaire was r = .42 and r = .47 for the images and videos versions respectively. Not only are these coefficients greater than those reported in the literature but they approximate the meta-correlation coefficient found in *Study 1* (r = -.56). Moreover, the correlation between the calculated price and BAT performance in *Experiment 2* (r = -.38) is greater than the meta-correlation that found in *Study 1* (r = -.17).

An advantage of the current experiments is that participants' decision to choose the threat option implied a commitment to observe the aversive stimulus. This was achieved via the use of an eye-tracker device that recorded participants' gaze/fixations. Namely, the stimulus remained on the screen if the participant's foveal vision was outside the stimulus' area, and the task proceeded only after the specified viewing time had been completed. This aspect is of paramount importance given peoples' tendency to engage in passive avoidance such as visual inattention to threat stimuli (see Tolin, Lohr, Lee, & Sawchuk, 1999), an aspect seldom controlled for in ACC-Ts studies. If no constraints are placed on participants' observing behaviour, the aversive visual consequence of looking at an image of a spider can be avoided and the decision would no longer involve such an emotional cost for people who dislike spiders. In fact, there is evidence to suggest that participants quickly divert their gaze away from aversive visual stimuli (Rinck & Becker, 2006). The popularity of eye-tracking for studies directly interested in visual attention to emotional stimuli is increasing (e.g., Mogg, Millar, & Bradley, 2000; Rinck & Becker, 2006; Schofield, Johnson, Inhoff, & Coles, 2012; see Armstrong & Olatunji, 2012 for a review), but—to our knowledge—none of the current AAC paradigms have taken measures to prevent participants from not looking at the stimuli.

Furthermore, the structure and short time that it took to complete the task can be conceived as an advantage in light of the potential clinical applications (e.g., a clinician could have an assessment of fear-avoidance relatively quickly). It could also be the case that the short format of the task might have contributed to a greater proportion of approach behaviour. Avoidance implied a cost (punishment) in terms of additional trials to complete, which coupled with the reward incentive to approach, let to more self-exposure to the aversive, thereby facilitating habituation and extinction. Even though participants were unaware of how long the task would be if they avoided all of the time (specially in *Experiment 2*), the prospect of a long task could have still strengthened the motivation to approach (e.g., via verbal processes in the form of “painful but short”; Hayes, 1989; Hayes, Barnes-Holmes, & Roche, 2001).

Likewise, Rattel, Miedl, Blechert, and Wilhelm (2017; see also Meulders, Franssen, Fonteyne, & Vlaeyen, 2016) devised a task to investigate avoidance costs in terms of additional button presses. In their task, participants had to move an avatar from a specific initial location (top left corner of the computer screen) to its home destination (bottom left corner). During the aversive conditioning phase, on the way to the destination, participants received an electric shock, or not, depending on the stimulus shown at the beginning of the trial. During the experimental trial, however, there was an additional (shock-free) route available and participants could take either of them to reach the destination. Some participants were given an alternative route which was only slightly lengthier than the original threat route, whereas others were given an alternative route which was four times lengthier. The researchers found less avoidance among participants who were given the longest alternative route. Rattel and his team interpreted these results as indicating that higher costs for avoiding the threat (translated in more laboratory time) not only led to a decrease in such behaviours but also facilitated fear extinction (see also Bublatzky, Alpers, & Pittig, 2017; cf. Schlund et al., 2017).

Recent studies are adding empirical support to the role of competing symbolic incentives as conducive to approach response changes in initially reluctant individuals. For example, Pittig, Hengen, Bublatzky and Alpers (2018; see also Bublatzky, Alpers, & Pittig, 2017), conducted two experiments in which they had spider-fearful and non-fearful participants deciding between options yielding different magnitudes of two types of rewards (i.e., hypothetical money: 0.0€, 0.50€, 2.00€; and facial and written social expressions: neutral-"You chose the left deck", mildly happy-"That was okay", strongly happy-"That was great"). During the experimental (approach) trials, choosing the option associated with the threat (i.e., image of a spider) returned a greater reward value (amount of money, or type of affective stimuli) than choosing the alternative non-threat option (displaying an image of a butterfly and a neutral face). Their results showed increased levels of threat approach behaviour when the threat option yielded the greater incentive (whether hypothetical money or facial expressions depending on the group), in comparison to baseline (i.e., trials with no reward difference between the response options). The authors concluded that avoidance behaviour can be counteracted by incentives for approach, and thereby, facilitate fear extinction.

From an AAC theoretical framework, psychopathology can be viewed as the result of persistent context-sensitive imbalances between approach-avoidance motivations (Boyd, Robinson, & Fetterman, 2011; Costello, 1970; Hayes, 1976; Miller, 1944; Rolls, 1999). Investigating decision-making processes from a behavioural perspective as advocated here can shed light on ways to improve our understanding of avoidance behaviours that persist in the face of contradictory consequences; and whose modification via basic conditioning techniques is—judging by the high rate of response resurgence—clinically unpractical (Kelley, Liddon, Ribeiro, Greif, & Podlesnik, 2015).

Hypothetically, part of the observed resistance to change in some individuals suffering from anxiety disorders could lie in the fact that the evaluated costs of facing a threat outweigh the potential gains (Rattel, Miedl, Blechert, & Wilhelm 2017; Vervliet, Lange, & Milad, 2017; Vervliet, & Indekeu, 2015). In a similar vein, for example, some value-oriented therapeutic techniques focus on enhancing the perceived costs of current maladaptive behaviours in relevant areas of the client's life (e.g., Andersen, Ravn, & Roessler, 2015; Hayes, Strosahl, & Wilson, 1999). In this sense, the price of fear could also be considered a measure of *relative response strength,* and an indicator of resistance to change (cf. De Villiers & Herrnstein, 1976; Herrnstein, 1961; Nevin, 1974; Rachlin, 1935).

In spite of the early work by Costello (1970) and Hayes (1976), pointing out that avoidance is of clinical relevance insofar as it is in conflict with approach tendencies, how and when conflicting motivations play a role in "fear-driven" behaviour has not received due attention in psychopathological research (cf. Gannon, Roche, Kanter, Forsyth, & Linehan, 2011; Hofmann & Hay, 2018; Pittig, 2019; Pittig & Dehler, 2019; Pittig, Treanor, LeBeau, & Craske, 2018). In this respect, additional external validity can be provided by observing the extent to which the factors assumed to affect task performance (approach contingencies) are found to lead to changes in behaviour (Scheveneels et al., 2016). Future applied work with clinical samples is needed in this regard, but it could be argued that data from behavioural interventions that focus on the differential reinforcement of incompatible/alternative behaviours might provide an analogue (see Cooper, Heron, & Heward, 2014).

Most of the preceding work in the literature around approach-avoidance conflicts in humans has been theoretical. Although in recent years there has been a renewed interest in the scientific treatment of AACs, many of the experimental paradigms developed to date still rely heavily on response allocation/preference and differences in response times (e.g., Aupperle et al., 2011; Boyd, Robinson & Fetterman, 2011; Gannon et al., 2011; Rinck & Becker, 2007; Sierra-Mercado et al., 2015). Such preference for response-time based analyses means that the “psychological conflict” generated by a simultaneous tendency to respond to competing contingencies remains an inference from traditional units of measurement and dimensions of behaviour. It could be argued that “conflict”, as a measure of relative attraction to or repulsion from sources of stimulation (see Killeen, 1992; Townsend & Busemeyer, 1989), might be better detected by paradigms and visualization techniques that take into account the spatio-temporal characteristics of behaviour as it unfolds (e.g., Buetti, Juan, Rinck, & Kerzel, 2012; Hovland & Sears, 1938).

When faced with a decision (e.g., choosing between two job offers), we do not access all the available information instantaneously, let alone assess and compare all the pros and cons of the possible courses of action. Some features of an option may capture our attention at a first glance, but then, when compared with the alternative, they may become less appealing. This process is naturally accompanied by attentional changes and fluctuations in motivations or behavioural dispositions. Mouse-tracking consists of recording the position of the computer mouse cursor frame-by-frame, and in so doing it provides a continuous measure of one’s response movements. This methodology, thereby, provides a methodological avenue to visualise and analyse the dynamic characteristics of responses en route. Future studies could capitalise on technological developments in this area (see Hehman, Stolier, & Freeman, 2015; Schulte-Mecklenbeck, Kuehberger, & Johnson, 2019; Spivey, 2008).

Chapter IV

The action dynamics of approach-avoidance in decision-making: A mouse-tracking approach.

Many of our daily decisions require us to consider the potential for both positive and negative outcomes, and such evaluations influence whether we decide to engage in or avoid certain activities. For instance, we might consider the pros and cons of leaving a stable job (e.g., "I'll be able to find something that aligns with my current interests, but what if it takes longer than expected or if it doesn't pay well"), or weigh the benefits of taking a medication against its noxious secondary effects. Situations that include both a motivation to approach and avoid are termed approach-avoidance conflicts (Corr, 2013; Elliot, 2006; Lewin, 1935).

The investigation of approach-avoidance conflict has a long history in psychology. Lewin (1935), drawing on field concepts from modern physics, defined motivational conflict as "the opposition of approximately equally strong field forces" (p. 88; see also Kelso, 1995; Killeen 1992; Marr, 1992, for similar contemporary propositions). Lewin identified three types of conflict: (a) *approach-approach,* in the presence of two positive valences (e.g., deciding between two appetitive but mutually exclusive situations such as going to the cinema or a party); (b) *approach-avoidance*, when an object or potential action induces simultaneous positive and negative valences (e.g., a desire for experiencing sky-diving, but also afraid of trying it); and (c) *avoidance-avoidance,* in the presence of two negative valences (e.g., paying for parking to avoid being clamped).

According to Lewin (1935), when an organism encounters an approach-avoidance conflict (henceforth AAC), the potential outcomes exert competing forces on the person's actions until there is a sufficient difference in the forces in favour of one action (or compatible actions). Thus, when conflicts arise, the stronger the conflict is (i.e., the more similar the competing valence forces), the longer a person will remain undecided prior to eventually producing the winning action. Lewin also postulated that the gradient of the strength of the negative valence that repels a person from an option (i.e., induces avoidance) increases more rapidly as one approaches the option (whether in psychological or physical space). That is, the motivation to avoid is more spatially concentrated than the motivation to approach, explaining how we can initially approach a feared object but then stop at a "safe distance".

Lewin's topological conceptualization allowed early behavioural scientists to make empirical predictions and foster a theory of approach and avoidance motivation. For example, Bugelski and Miller (1938) placed rats in an alley at varying distances from a source of shock. They found that the time it took for the animals to start running away from the source of shock (the latency of locomotion) and the speed of locomotion were a function of the distance from it. Moreover, Miller, Brown and Lipofsky (1943; as cited in Miller, 1944) trained rats to approach a source of food and shocked them while they were eating it. Thereafter, the rats would approach the food, but stop before reaching it. Subsequent experimental manipulations revealed that the distance at which the rats stopped was a function of food deprivation; rats stopped closer to the food when they were more deprived. In a similar fashion, Brown (1948) demonstrated that the mechanical force with which rats would pull towards a source of food, and away from a source of shock, was dependent upon the distance from these stimuli.

Recently, there has been a renewed interest in investigating AACs (e.g., Aupperle, Sullivan, Melrose, Paulus, & Stein, 2011; Bublatzky, Alpers, & Pittig, 2017; Meulders, Franssen, Fonteyne, & Vlaeyen, 2016; Pittig, Brand, Pawlikowski, & Alpers, 2014; Pittig, Hengen, Bublatzky, & Alpers, 2018; Schneider et al., 2015; Schlund et al., 2016; Schrooten, Wiech, & Vlaeyen, 2014; Sierra-Mercado et al., 2015) and numerous experimental tasks have been developed to explore these with humans. Approach-avoidance tasks typically establish an appetitive consequence (e.g., following experimenter instructions, earning points or money) and an aversive consequence (e.g., losing points or money, seeing unpleasant stimuli) for the same action. Then, participants are required to decide between initiating the action (e.g., a move towards a stimulus) or an alternative (e.g., move away from a stimulus, remain stationary). The appetitiveness and aversiveness of the consequences vary across trials in order to generate varying degrees of conflict. As a result, participants' responses tend to change such that they would contact a previously avoided aversive consequence if it is in competition with a relatively higher reward (e.g., Meulders et al., 2016; Pittig et al., 2018; Rattel, Miedl, Blechert, & Wilhelm, 2017), and exhibit longer response times for increased approach-avoidance conflict (e.g., Diederich, 2003; Gannon, Roche, Kanter, Forsyth, & Linehan, 2011; Luce, Bettman, & Payne, 1997; Murray, 1975; Schrooten et al., 2014).

Even though response times provide a relatively robust measure of conflict, alternative approaches to estimating relative preference have been developed. For instance, researchers have employed proximity to two available choices as an index of the relative preference of these options. Such tasks typically require participants to press keys in order to move an avatar closer to or away from a choice (e.g., Aupperle et al., 2011; De Houwer, Crombez, Baeyens, & Hermans, 2001; cf. Dibbets & Fonteyne, 2015). For example, Aupperle et al. (2011) employed a task wherein an avatar is located on a runway between two choices, each of which includes a set of positive and/or negative outcomes (e.g., view a positive stimulus vs. view a negative stimulus and earn two points). As the participant moves the avatar along the runway towards a choice, the probability of that choice increases. In this way, the location of the avatar provides an index of the relative preference of these choices and the strength of the competing approach and avoidance motivations.

Tasks requiring greater motor movement than keyboard presses are also becoming popular in the scientific community. For example, in Rinck and Becker's (2007) task, participants respond using a joystick to approach or avoid a stimulus presented on a computer screen (see also Chen & Bargh, 1999). Pushing or pulling arm movements increase or decrease the size of the displayed stimulus, creating the illusion that the stimulus is getting closer or farther away. In their study, spider fearful participants were slower to emit pull ("approach") responses on images of spiders relative to push responses, or in comparison to when asked to pull neutral stimuli towards themselves. This effect has been replicated and explored for a variety of eliciting stimuli (e.g., de la Asuncion, Docx, Sabbe, Morrens, & De Bruijn, 2015; Heuer, Rinck, & Becker, 2007; Khan & Petróczi, 2015; Maccallum, Sawday, Rinck, & Bryant, 2015; Radke, Güths, André, Müller, & de Bruijn, 2014; Snagowski & Brand, 2015; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; see also Laham, Kashima, Dix, & Wheeler, 2015 for a systematic review).

Similarly, Buetti, Juan, Rinck, and Kerzel (2012; see also Gallivan & Chapman, 2014) devised a task in which participants, starting from a point in the middle of the screen, moved their finger to just below one of two visual stimuli (i.e., images of spiders, beetles or dragonflies) located on the sides of the screen. The participant's hand movements from response initiation to completion were recorded. Interestingly, there were no statistically significant differences in response times between spider fearful participants and controls, when approaching or avoiding the threat stimuli. However, analyses of the spatial characteristics of the hand movements revealed greater deviation away from the threat for the spider-fearful participants. Thus, analysing motor response trajectories has the potential to unveil additional intervening processes at play and complement traditional response time measures.

The foregoing research on the effects of AAC on response trajectories bears methodological similarities with computer cursor tracking. Sampling computer-mouse position frame-by-frame (mouse-tracking) during the course of a response trajectory provides a continuous measure of the dynamic influences on that response (see Hehman, Stolier, & Freeman, 2015; Koop & Johnson, 2013; McKinstry, Dale, & Spivey, 2008; O'Hora, Carey, Kervick, Crowley, & Dabrowski, 2016; O'Hora, Dale, Piiroinen, & Connolly, 2013; Scherbaum, Dshemuchadse, & Kalis, 2008; Scherbaum, Dshemuchadse, Fischer, & Goschke, 2010; Song, & Nakayama, 2008; Spivey & Dale, 2004; Spivey, 2008). Koop and Johnson (2013, experiment 1), for example, mouse-tracked the development of participants' preferential choice of visual stimuli taken from the IAPS (International Affective Picture System; Lang & Bradley, 2007). Participants rated the visual stimuli for pleasantness and chose between pairs of stimuli at different levels of arousal difference. As expected, higher arousal difference predicted higher probability of choosing the more pleasant stimuli. Also, curvature analyses of the response trajectories revealed that they were more deviated towards the alternative non-chosen option when arousal difference was lower (i.e., greater approach-approach conflict).

Mouse-tracking provides a fitting testbed for the study of approach and avoidance conflicts. The trajectories of participants' responses are subject to competing approach and avoidance influences as the responses are produced. Indeed, the work of Hovland and Sears (1938) anticipated the development of mouse-tracking and its relevance to the investigation of these phenomena. They asked participants to draw their responses (using a pen) when presented with approach-avoidance conflicts in an attempt to capture the conflict as it unfolded. These response traces provided the basis for their classification of AACs and respective modes of resolution.

One class of models that seems particularly suitable for understanding the problem of integrating the competing effects of approach and avoidance motivations during decision-making is informed by dynamical systems theory (DST; e.g., Busemeyer & Townsend, 1993; Kelso, 1995; Killeen, 1992; Marr, 1992; Scherbaum, Dshemuchadse, & Kalis, 2008; Scherbaum et al., 2016; Spivey & Dale, 2006; van Rooij, Favela, Malone, & Richardson, 2013). DST models of decision making consider the actions available to an organism to be *attractors* in a psychological or *decision state space*, and a decision is made when the current state in this decision space is at one of these attractors. An attractor is simply a set of states of a dynamic physical system toward which that system tends to evolve, regardless of the starting conditions of the system. That is, one can be in a multitude of possible states of indecision, but one will eventually produce one of the available actions (leaving the situation or refusing to move can be construed as actions in this respect). The movement of the mouse cursor during a response trajectory reflects, to some degree, movement in this decision space (O’Hora et al., 2013; Zgonnikov, Aleni, Piiroinen, O'Hora, & di Bernardo, 2017; Zgonnikov, Atiya, O’Hora, Rano, & Wong-Lin, in press). In approach-avoidance decisions, the decision space is updated continuously as the system evaluates the options. According to Lewin and Miller, the strength of attraction towards and repulsion from the available actions will be a function of the approach and avoidance valences, the effects of avoidance valences being more locally concentrated. A potential landscape derived from this decision space would originally depict slopes towards the available choices that are influenced by the relative approach valences of the actions (cf. Townsend & Busemeyer, 1989). A stronger attraction would induce a steeper slope towards the choice, thus greater speed and straighter trajectories in its direction. However, as one approaches a contingency associated with an aversive outcome, the landscape may tip in favour of a previously unfavoured outcome, resulting in a sharp change in direction towards the new choice (see Chapter V, pp. 135-138).

Experiment 3

The current experiment tracked response motion during approach-avoidance decisions. Specifically, we established simple mouse cursor responses that allowed participants to earn points (approach), and then, in a subset of trials (threat trials), earning points required the participant to risk (20% chance of) a mild electric shock (avoidance). We manipulated the amount of points available in each trial in order to vary the approach valence. In this way, it was possible to estimate the relative value of shock aversiveness in terms of points for each participant (the “indifference point”). During threat trials, therefore, approach trajectories implied earning points and a risk of shock, and avoidance trajectories implied losing points and no risk of shock. We hypothesized that threat trials would establish an AAC and, under these conditions, we expected that approach trajectories would be simpler (faster, less deflected and with fewer vacillations) than avoidance trajectories, all other thing being equal. We also hypothesized that approach and avoidance trajectories would be more complex when AAC was highest. That is, when the reward number is close to the indifference point, trajectories should be more complex (slower, more deflected and with more vacillations) for both approach and avoidance responses. We also employed time continuous multiple regression (Scherbaum et al., 2010) to investigate the evolution of experimental influences on approach response trajectories.

For the following experiments mild electric pulses are used as aversive stimuli. Electric stimulation has traditionally been widely used in non-human animal research (Patterson & Kesner, 2013) and the behaviour that it generates is similar to that of the human species (Berkowitz, 1983; Lang, 1995). An advantage of electric shocks, therefore, is that it makes this type of stimulation ideal for research programmes that seek to make inter-species comparisons and generalizations from basic to applied research. Moreover, electric stimulation represents an effective aversive stimulus that generates a reliable withdrawal response (Lang, 1995), which when paired with conditional stimuli, elicits behavioural signs interpretable in terms of fear (LeDoux, 2000; Dillon, Deveney, & Pizzagalli, 2011); thus, generalizable to other types of aversive stimuli of clinical relevance.

In addition, it has been found that electric stimulation generates twice as greater skin conductance and habituates less than visual threat stimuli (Öhman, Eriksson, Fredriksson, Hugdahl, & Olofsson, 1974; cf. Maltzman & Boyd, 1984). More importantly, regardless of its habituation rate, the perception of visual aversive stimuli do not necessarily corresponds with physical behavioural responses as it tends to be the case with electric stimulation; an aspect that has already address in relation to the lack of correspondence between the (cognitive, physiological, behavioural) response channels involved in fear (Lang, 1968; LeDoux, 2017).

Therefore, not only do we implement electric shocks as aversive stimuli, but also we present these in an unpredictable (i.e., probabilistic) manner. Unpredictable and uncontrollable shock delivery has been found to be more resistant to habituation than predictable or self-delivered shocks (Annau & Kamin, 1961; Katz, Webb, & Stotland, 1971) and to yield strong conditioning effects (Grillon, Baas, Cornwell, & Johnson, 2006).

Method

This research was approved by the Research Ethics Committee of the National University of Ireland, Galway (in line with the Helsinki declaration of ethical standards and the Irish Psychological Society).

Sample and Participants Selection

Seventy undergraduate students were recruited for this experiment through a university system (same exclusion criteria as in *Study 1* applied). Students earned class credits and the opportunity to win a voucher worth €45. The latter consisted of a prize draw conducted at the end of the entire data collection phase. For this draw, a participant's ID number was selected (via computerised random sampling functions in *R*) from a dataset which was independent of performance data. The person whose ID number had been drawn, was contacted via email to claim the prize if they had provided their email for this purpose (see consent from; Appendix N). Consent to this procedure was made explicit to all participants prior to taking part in the study and, if preferred, they could opt out of the prize draw. The data of three participants had to be removed due to problems with the synchronization of the recording; consequently, 67 participants were retained (mean age = 23 [18-45], 42 female). This sample was informed by previous literature and also checked against a priori effect size estimates using G*Power (Faul, Erdfelder, Lang & Buchner, 2007).

Experimental setting, Apparatus and Stimuli

Setting and hardware. The data collection took place in a purpose-specific laboratory room with a computer terminal for the participants and one for the experimenter, separated by a standard floor-divider keeping the participant and experimenter visually isolated from each other. Participants sat facing the monitor (80 cm from it), with their heads fixed on an eye-tracker mount. The task was programmed in Python 2.7 using PsychoPy (Peirce, 2007) and PyGaze (Dalmaijer, Mathôt, & Van der Stigchel, 2014) libraries, and was run in a desktop computer with a 24-in digital monitor (1920 x 1080 resolution, refresh rate 60 Hz). A Logitech® Gaming Mouse G403 was used, with sensitivity (resolution) set at 600 dpi, and mouse coordinates were recorded at a sample rate of 99 Hz.

Mild electric stimulation was delivered using a Lafayette Isolated Square Wave Stimulator (ISWS; model 82415-IS), but controlled by the computer, in accordance to programming parameters (see Procedure for details). This device is designed to deliver low voltage and amperage stimulation to living organisms. The stimulation is restricted to a safe maximum output of 100 v, lasting 50 ms. This electric stimulation is similar to that of a sudden burst of static from a car door; hence, in accordance with standard ethical guidelines indicating that the experience of discomfort is not to be greater than those encountered in everyday life (https://www.apa.org/). Disposable electrodes (ECG SKINTACT electrodes FS-50, Vermed EL504 medical sensors), were used to transmit the electric simulation to the participant's skin.

Experimental research in anxiety disorders has typically implemented mild shocks, loud sounds or aversive pictures. However there are reasons to believe that combining auditory stimulation with shocks might work as a stronger elicitor than just shocks or tones in isolation (Britton, Lissek, Grillon, Norcross, & Pine, 2011). Therefore, in this experiment electric stimulation was paired with a beep that averaged 77 dB (70-85 range), with a base room noise of 48 (46-50). This was measured using a Gold Line© sound level meter (Model SPL120, A-weighting as per ANSI S1.4 standards).

Stimuli. An outline of the experimental procedure is presented in Figure 4.1. Prior to each trial (the first panel), a “start” response button was presented at the bottom of the screen (1 cm off the margin) and was 1.5 (width) x 1 (height) cm (subtending θ = 1° [horizontal], 0.7° [vertical] of visual angle). When the trial began (see Procedure for details), the experimental stimuli consisted of a digit from 1 to 9 (2 x 3 cm; θ = 1.4°, 2°) as “target stimulus”, presented in green or red with equal brightness, and located at the bottom quarter of the screen, and two response areas with the letters “T” and “L” located at the top of the screen (5 x 6.5 cm; θ = 3.5°, 4.6°) 2.5 cm off the upper margin of the monitor and 4.5 cm off the side margin.

Assessments and Measures

During the experimental task, eye movement and mouse cursor position were recorded in each trial from the moment of target stimulus presentation to a click response on one of the response areas. Afterwards, participants completed the Behavioural Inhibition System/Behavioural Approach System (BIS/BAS; Carver, & White, 2013) scale, the Brief Experiential Avoidance Questionnaire (BEAQ; Gámez et al., 2014) and the Fear of Pain Questionnaire III (FPQ-III; McNeil & Rainwater, 1998). They also provided basic demographical information and answered some task-related questions (see Appendix M).

The BIS/BAS scale measures motivational/behavioural systems of approach (BAS) and avoidance (BIS), and the BEAQ measures experiential avoidance (see Measures section in Chapter 3 for more details). The FPQ-III is a 30-item questionnaire designed to assess fear and anxiety associated with pain, and it has been demonstrated to have an internal consistency of .92 and a test-retest reliability of .74. The measure consists of three subscales: fear of severe pain (e.g. “Breaking your leg”), fear of minor pain (e.g., “Getting a paper-cut on your finger”) and fear of medical pain (e.g., “Receiving an injection in your hip”). Items are scored on a 5-point Likert scale ranging from 1 (not at all) to 5 (extreme). Only the minor pain scale was implemented in the present study (the reported alpha coefficient and test-retest reliability for this subscale are .87 and .73 respectively).

Procedure and Computer task

After customary consent procedures (see Appendix N), participants were asked to sit in front of the computer whilst the experimental procedure was explained to them. The experimental task was designed to establish approach-avoidance conflicts during decision making. Participants were required to make points-based decisions in the presence or absence of a potential threat. The colour of the target stimulus on each trial informed the participant of the presence (red digit) or absence (green digit) of threat. The value of the target stimulus denoted the number of points that would be gained (“Take”) or lost (“Lose”) by clicking the corresponding response areas (labelled “T” or “L” respectively). In the absence of threat (80% of trials), participants were expected to approach the T response area and avoid the L response area. In the presence of threat, choosing T implied risking a potential shock, presenting a conflict between approaching the points and avoiding the potential shock.

The sequence of events during the participation was as follows: First, participants were briefed about the ISWS whilst the electrodes were being connected to the dorsal surface of the participant’s non-dominant forearm (roughly midway on the *brachioradialis*). The experimenter explained that the objective of this part of the procedure was to experience the graded intensity of the electric stimulation, starting with the lowest. Then, the experimenter gradually increased the level of stimulation until the participant either expressed unwillingness to experience a higher level of stimulation or rated it as “strong” on a perception scale (see Appendix O). The participant was then asked to keep their arm with the electrodes resting on one side of the desk, whilst calibrating the intensity of the electric discharge and during the entire participation (see Appendix O for details about the ISWS setup).

Second, participants read the task instructions (see Appendix O) and had the opportunity to familiarize themselves with the layout and mechanics of the task by responding to two practice blocks (of a maximum of 4 trials each). During this phase, the experimenter talked the participant through the task and she or he was encouraged to ask questions. After, an eye-tracking calibration procedure was conducted and the experimental task began.

At the beginning of each trial-block, participants were informed about the points they needed to accumulate in order to complete it (i.e., 225). Each trial started with participants clicking on the "start" button (see Figure 4.1). Clicking this button resulted in its disappearance and the display of the T/L response areas at the upper corners of the screen (their starting location was randomized and thereafter counterbalanced across trial-blocks). Participants had to move the mouse upwards (90 px) in order to make the *target* number appear (to promote response movement by the time the stimuli came into view; see Scherbaum & Kieslich, 2018). This target number represented the reward value that participants had to decide to "Take" or "Lose". If a participant chose "Take", the amount corresponding to the target number was added to the participant's tally. If a participant chose "Lose", the corresponding amount was deducted from their tally. Each selection was followed by a feedback screen showing the amount of points earned or lost and the updated tally. Clicking again removed this feedback screen and the next trial started. On occasions, the target number appeared in red colour (instead of green), indicating the presence of threat (i.e., 20% probability of receiving a mild electric shock, accompanied by a startling tone) should the participant choose "Take". If participants chose "Take" on all 90 threat trials (20% of 450), they would have experienced a maximum of 18 mild electric pulses (20% of 90).

Participants were exposed to ten blocks, each of which included a minimum of 45 trials. Each of the target numbers (1 to 9) was presented five times, once in the presence of potential shock, establishing a 4:1 ratio of non-threat to threat trials. The 45 possible trials were presented in a quasi-random sequence, constrained such that the same digit could not occur more than twice in a row. If participants chose "Take" on every trial in a block, they earned 225 points and moved to the next block. If participants chose "Lose" in any trial, they completed additional trials to achieve 225 points before moving on. To create the additional trials, participants were exposed to a 45-trial block of the same structure, but this block was terminated as soon as the participant achieved 225 points.

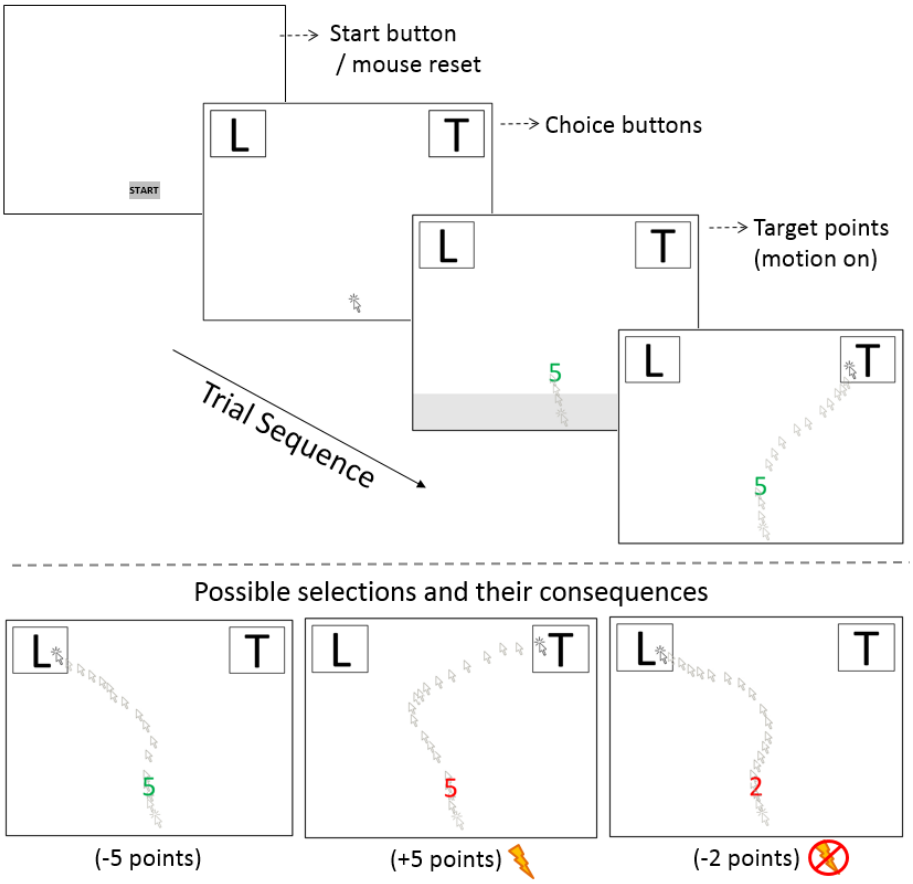


Figure 4.1. Schematic representation of a trial. *Top*: sequence of events from clicking on the "start button" which displays the *L* and *T* response areas, moving the mouse upwards to make the target reward number appear (the shaded area on the lower margin representing this threshold—invisible to the participant) and a click selection. *Below the dashed line*: Possible consequences depending on whether the participant chose *T* or *L* when the target number was green (leftmost frame) or red (middle and rightmost frame). Namely, *T* selections always awarded the target points but, if these were red, it was accompanied by threat (shock and tone on 20% of the times). Alternatively, *L* selections always meant losing the target points but were "threat free". The final screen of a trial (not shown here) provided feedback on earnings/looses, and delivered the aversive stimulation if applicable. The inter-trial break consisted of a black screen for 100 ms.

Therefore, if a participant found the threat stimulation aversive, she or he could always choose to avoid it by selecting the alternative response option "Lose"; bearing in mind that this decision entailed a cost. In any case, the participant could choose depending on whether the amount of points offered in a particular threat trial were "worth the risk". Given that finishing a trial-block was based on a points' criterion, avoiding threat trials also had a cost in terms of time and behaviour, as the participant would have to do extra trials in order to make up for the loss of points and thereby fulfil the points criteria for the block. Thus, the number of trials per block that participants had to complete varied.

After completing the computer task, participants were debriefed about the rationale of the task and asked to answer some questions. In addition, as participants were not explicitly made aware of their mouse-movements being recorded when agreeing to participate, they were asked to sign a retroactive consent upon this disclosure in order for the researchers to retain their data (see Appendix P).

Data processing

Most data analyses were carried out in *R* (Development Core Team, 2017), using the "mousetrap" package (Kieslich & Henninger, 2017; Kieslich, Henninger, Wulff, Haslbeck, & Schulte-Mecklenbeck, in press) for response trajectories, "lme4" (Bates, Maechler, Bolker, & Walker, 2015) for mixed-effects regression models, and "ggplot2" (Wickham, 2016) for plots. Within trial experimental influences were analysed using the TCMR toolbox (Scherbaum, 2018) for MATHLAB.

Preliminary visual inspection of the data indicated that there was a number of points that made taking the 20% risk of shock worthwhile to each participant. Below this value, participants mostly chose "Lose"; above this value, participants mostly chose "Take". To identify the "50/50 approach-avoidance *indifference point*" for each individual, we fitted a logistic regression in which reward values predicted choosing "Take" and extracted the value that corresponded to a probability of point five. Individuals for which this indifference point estimate exceeded the zero-ten range were coerced to these limits (23 cases); similarly with individuals who chose to approach or avoid almost exclusively (i.e., more than 95% of the time), but for whom a few exceptions resulted in inaccurate estimates (10 cases). Since participants varied in their relative evaluation of points and shock, by subtracting the targets from each participant's indifference point, we were able to develop an index of "distance" from subjective equality that provided a more sensitive measure than the raw target value in estimating motivated behaviour. Therefore, we employ the term *target valence* to denote the positive (approach) or negative (avoidance) valence of a target relative to the participants' indifference point, and operationalize the *degree of conflict* as the difference (i.e., distance) between the raw target value and the participant's indifference point.

Data quality checks required for response trajectory analyses involved: removing responses longer than three seconds (approximately 1% of the data). The starting coordinates for all response trajectories were normalized (i.e., mean first position across all trials), as well as their duration (to 101 equally sized time steps through linear interpolation from first to last mouse-coordinates' samples; see Spivey, Grosjean, & Knoblich, 2005). Approximately 2% of all response trajectories were excluded during mouse data cleaning (e.g., erratic movements tracing uninterpretable loops). The remaining dataset consisted of a total of 32.213 response trials.

Approach-avoidance conflict during the decisions was investigated via the following measures: first, duration of the response, from the presentation of the target number to the selection of a response option (response time; RT). Second, the maximum absolute deviation (MAD; i.e., perpendicular deviation from a hypothetical straight line connecting response start- and endpoints) which reflects attraction towards the available choices and as such it is considered a measure of the strength of the competition between them (Koop & Johnson, 2011; Spivey et al., 2005). Third, given the fact that response options are located on one side of the screen or the other, the number of reversals in response direction along the x-axis (x-flips) is considered an indicator of vacillation (e.g., Freeman, 2014; O'Hora et al., 2016; Spivey et al., 2005), response complexity (e.g., Freeman & Ambady, 2010; Freeman, Dale, & Farmer, 2011) and concurrent dynamic attraction towards the alternative response option (e.g., Spivey, 2008; Spivey et al., 2005). Thus, x-flips data could be of particular interest for conceptualizations around approach-avoidance tendencies, relative to available response options. Fourth, sample entropy analyses are considered a measure of how irregular and unpredictable trajectories are (Dale, Kehoe, & Spivey, 2007; Richman & Moorman, 2000). Sample entropy is argued to be a more stringent measure to gauge the complexity of movement trajectories (Calcagnì, Lombardi, & Sulpizio, 2017; Hehman et al., 2015), and potentially a more sensitive measure of response competition among the choice options (Calcagnì et al., 2017; Dale et al., 2007). Fundamentally, sample entropy's undelaying algorithm loops over a specified window (or sample of data points) and computes how much their values differ in the time series. The greater the entropy values the more variability detected, hence, the higher the complexity present in the trajectories. As per Dale et al. (2007), the tolerance for sample entropy calculations was .2 multiplied by the standard deviation of all the x-coordinate fluctuations ($x_{t+1} - x_t$) in normalized trajectories, and a—stringent—sample window of $m = 3$ (see Dale et al., 2007; Richman & Moorman, 2000).

Generalized and linear mixed-effects regression models represent several advantages over traditionally used statistical methods (see Baayen, Davidson, & Bates, 2008; Brauer & Curtin, 2017; and Yang, Zaitlen, Goddard, Visscher, & Price, 2014 for a more thorough discussion), such as lacking the assumption of independence among observations (thereby preventing false positives due to population or relatedness structure) and increased power. Thus, we explored the variables of interest through a variety of these methods. Response times and trial number variables were subject to logarithmic transformations for these analyses, and the number of trials was controlled for in all models. In addition, to reflect the fact that each participant responded differently to the targets, we used the absolute target valences and allowed them to vary across participants (specified as random slope and intercept effects in the models predicting the mouse-tracking metrics; see Appendix Q). Using the absolute target valence eases the comparison of the effects of this variable over approach/avoidance responses, so increases in target valence lead to greater approach or avoidance respectively; consequently, no significant interactions are expected between these variables.

In addition, we applied the time-continuous multiple regression method (TCMR; Scherbaum et al., 2010) to investigate the moment at which the different properties of the task influenced relative approach-avoidance inclinations towards the final decision. This method computes regression analyses per each of the time steps of a trial, yielding time sensitive beta-weights on response direction tendency (i.e., difference in response angle relative to the y-axis between two time-steps, across all normalized steps) as they change within a trial. Thus, it captures response changes as a function of the characteristics of a trial enabling scientists to examine and draw inferences about the underlying psychological processes at play with more precision. For instance, once computed, most mouse-tracking measurements are used for subsequent statistical analyses, but there is an argument that TCMR could be more sensitive to the dynamic effects of the variables of interest on the response movements as this measure is based on differential changes in a unified *xy-plane* (Scherbaum, Gottschalk, Dshemuchadse, & Fischer, 2015).

As a terminological note, we will refer to the variables of interest as follows: *approach*: choosing to "*T*ake" the reward option when there was a probability of receiving the aversive consequence (i.e., shock); *avoidance*: choosing to "*L*ose" the reward during threat trials; *threat*: trials where the target number appeared in red and entailed shock probability; *safe* trials: with no threat (target numbers in green); *aversive* consequence: percutaneous mild electric stimulation.

Results

The current study examined the action dynamics of approaching an emotional threat (i.e., a 1 in 5 chance of experiencing the shock-tone pair) or avoiding it. Participants were exposed to an average of 531 (range 448-753) trials, of which approximately 20% were threat trials. During non-threat trials, participants could obtain points with no probability of shock so we expected that they would quickly choose "Take" on every trial to earn the points available. In non-threat trials, an approach function was induced in "Take" by the potential to earn points and avoidance was induced in "Lose" by the potential to lose points (no approach-avoidance conflict). During threat trials, approach and avoidance functions were induced in "Take" and we hypothesized that responses would be influenced by the participant's relative attraction towards "Take" to earn the points available and repulsion from "Take" induced by a fear of shock. Thus, the following analyses focus on approach-avoidance responses to threat trials only (safe trials did not represent AACs, therefore of no theoretical interest for the current paper other than serving as controls).

As expected, in the absence of threat, participants chose the "Take" response consistently regardless of target value. During threat trials, choosing the threat option was dependent on the target value (see Figure 4.2). This was further corroborated by a binomial mixed-effects model estimating the effects of target value on approach (b = 1.019, SE = 0.098, z = 10.35, p < .001, OR = 2.77 [95% CI: 2.28; 3.36]). Next, we estimated each participant's willingness to pay points to avoid a chance of shock. Logistic regressions were employed to calculate each participant's indifference point; that is, the point value at which participants were 50% likely to choose the "Take" or "Lose" options (see Data processing). Participants were also asked whether during the task they developed a threshold value of points that was the minimum they would accept to choose "Take" during threat trials. Thirty-two participants out of 67 reported such a value: the Pearson's correlation coefficients between participant's self-reported "approach threshold" and their indifference point was r = .70, p < .001 (95% CI: .69, .70), suggesting that these participants had a high degree of awareness of their own performance. Neither the FPQ (r = -.05, p = .67) nor the BEAQ (r = .1, p = .43) or the BIS/BAS scales (BIS r = .05, p = .68; BAS drive r = -.1, p = .41; BAS fun r = .02, p = .89; BAS reward r = .02, p = .84) predicted the indifference point (cf. May, Juergensen, & Demaree, 2016).

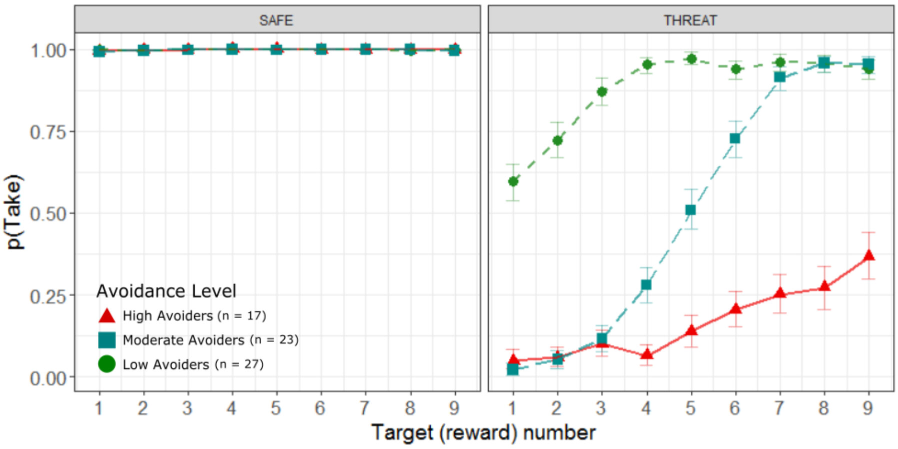


Figure 4.2. Probability of choosing the "take" option as a function of the target reward value (abscissa), for all participants. The left panel shows data when participants responded to non-threat trials ("safe"); the right panel ("threat") shows responses to trials with shock probability. Participants were grouped based on their indifference points (see Data processing). That is, individuals who would only risk receiving the aversive consequence when the payoff was "worth it" (with an indifference point above 7) were on one extreme (categorized as High Avoiders), and individuals for which low targets (indifference point below 3) were sufficiently motivating to take the risk on the other extreme (Low Avoiders).

We expected two primary sources of variation in the dynamics of responding during threat trials. First, approach trajectories should be simpler than avoidance trajectories. Approach responses were much more common (threat trials constituted only 20% of trials), so these responses benefitted from the development of default motor movements ("Take" was presented consistently on one side within blocks) and default decisions. Second, target numbers at greater psychological distance of the target number (higher target valence) from the participant's indifference point should give rise to simpler trajectories than target numbers closer to the participant's threshold for switching from approach to avoidance. That is, if the target was closer to the participant's indifference point (lower target valence) the attraction towards approach and avoidance should be more equal, creating greater approach-avoidance conflict.

Figure 4.3 provides heatmaps of the raw trajectory coordinates for approach and avoidance responses for targets at varying levels of target valence; average interpolated trajectories are also presented. The effect of the default approach response can be clearly seen in the differences between the top row of trajectories and the bottom row. Approach responses moved towards the "Take" option during the whole trial and did not typically change direction towards the "Lose" option. In contrast, avoidance responses initially move towards the "Take" option before switching towards the "Lose" option. The effects of target valence were also as hypothesized. At the extreme right of the figure, target valence is highest and conflict between approach and avoidance motivations is weakest; approach trajectories were quite straight and avoidance trajectories switched earlier and lower on the screen than at lower levels of psychological distance. At the extreme left of the figure, target valence is lowest and the greatest conflict can be observed in both types of responses; approach trajectories were more deflected towards “Lose” and avoidance trajectories switched later and closer to the “Take” option.

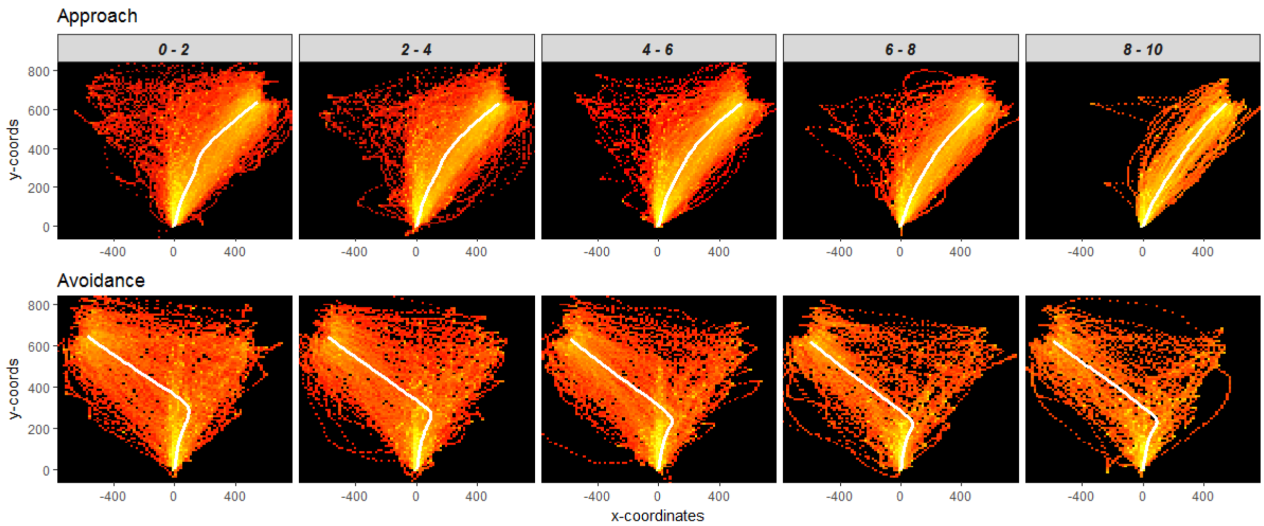


Figure 4.3. Heatmaps (i.e., density plots going from red to yellow) of raw trajectories per index of conflict. The targets have been binned down to five target values, where proximity to zero indicates greater level of psychological conflict (proximity to indifference point). The superimposed white line on each graph is the respective mean trajectory. The “dotted” appearance of the raw trajectories corresponds to their 101 interpolated time steps (see Data processing). Irrespective of the actual location of the response options during the task, approach and avoidance trajectories have been mapped to different sides of the screen (in accordance to Figure 1) for visualization and comparison purposes.

During threat trials, increased approach-avoidance conflict was expected to affect response trajectories such that they would increase in duration (RT), deflection from the final choice (MAD), vacillation (x-flips) and complexity (x-sample entropy; see Data processing). The effects of approach-avoidance and target valence on these indices can be seen in Figure 4.4. In Figure 4a, it can be seen that RT increased as a function of target valence for negative valences, during avoidance; and reduced as a function of target valence for positive valences, during approach. This pattern is also observed for MAD (Figure 4.4b), x-flips (Figure 4.4c) and sample entropy (Figure 4.4d).

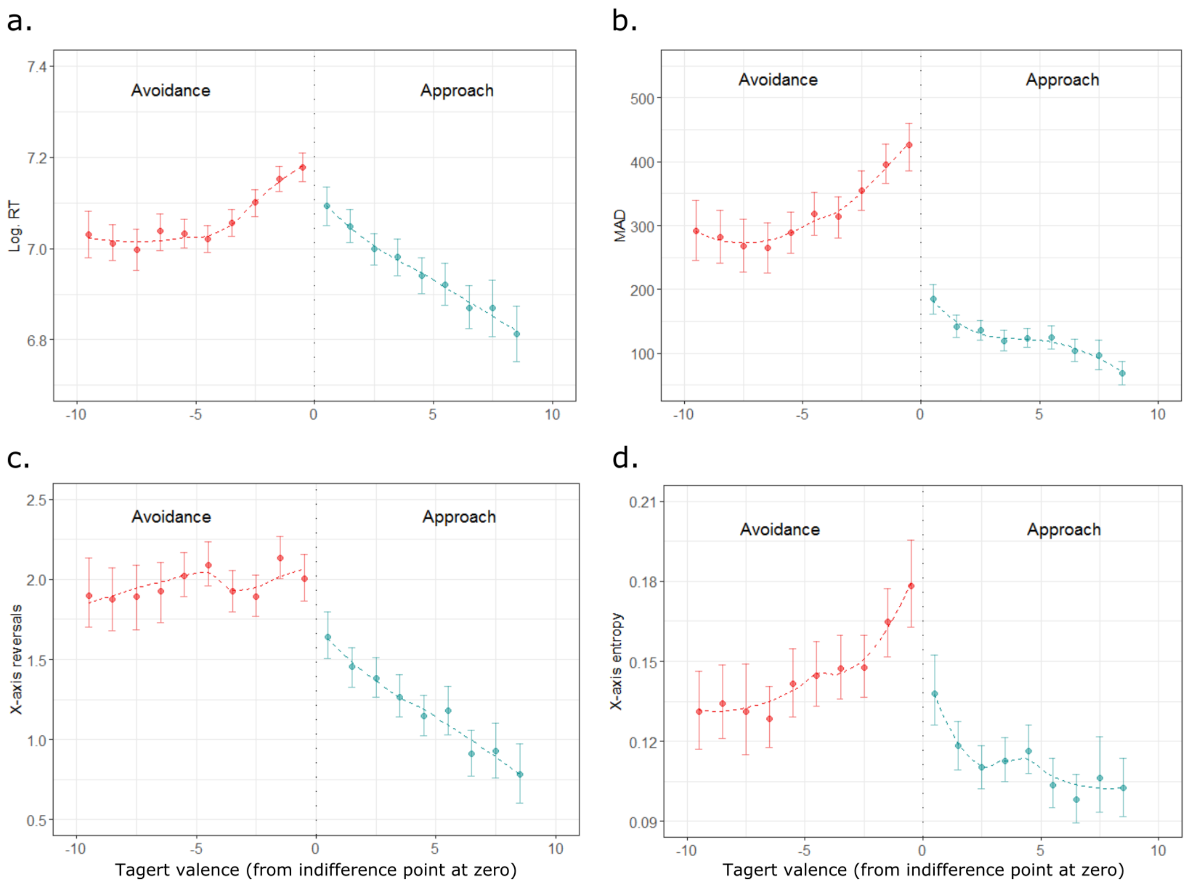


Figure 4.4. Data as a function of psychological conflict (i.e., proximity to the indifference point cantered at zero) for each of the measures of interest: *a*. response time (logarithmically transformed), *b*. maximum absolute deviation, *c*. x-axis reversals, and *d*. x-sample-entropy. The abscissa represents the target values, normalized across participants based on the distance from their indifference points. Avoidance (in red) has been recoded so it consists of negative values to the left of the plot (below zero), and approach (in blue) to the right.

Mixed-effects models estimated the effects of absolute target valence and approach-avoidance on each of the aforementioned measures of conflict (see Table 4.1). The expected effects of approach and target valence mentioned previously were mostly observed in these indices. Except for RT, there was a significant main effect of approach, suggesting that approach trajectories were simpler than avoidance trajectories; approach was characterized by less deflection, vacillation and complexity than avoidance. Across all measures, there was a significant main effect of absolute target valence, corroborating that as absolute target valence increased from the point of subjective indifference, decisions became easier and conflict was reduced. Unexpectedly, when predicting RT and sample entropy, the effect of absolute target valence was moderated by approach-avoidance. Specifically, absolute target valence was a stronger predictor of reduced conflict during approach trajectories than during avoidance (see Figure 4.4a and -d). This was not a very strong effect, but it was likely due to the relative simplicity of approach trajectories (they mostly moved in the same direction) compared to avoidance trajectories.

Table 4.1

Statistical analyses on predictors for conflict variables (Experiment 3).

	Response time		MAD		X-flips		Entropy	
Predictor	*b*	SE	*b*	SE	*b*	SE	*b*	SE
(intercept)	7.105	0.033	389.68	18.99	0.577	0.054	0.165	0.007
Log. Trial	-0.041***	0.004	-20.452***	3.032	-0.077***	0.010	-0.007***	0.001
Target Valence	-0.030***	0.004	-11.672***	2.500	-0.035***	0.009	-0.005***	0.001
Approach	0.019	0.014	-222.15***	10.32	-0.119***	0.037	-0.035***	0.004
Target Val.* Appr	0.010*	0.004	3.426	3.113	0.005	0.012	0.002*	0.001

Note. Significance *p* levels at .05*, .01**, .001***

In order to investigate the degree to which features of the experimental context exerted control over the direction of response trajectories within each response, time continuous multiple regression (TCMR; Scherbaum et al., 2010; see Data processing) was employed. Unlike the previous analyses, both threat (20%) and non-threat (80%) trials were included, but we included only approach responses, since the TCMR method requires a large number of trials and approach trials were considerably more numerous than avoidance responses. TCMR assessed the effects of the response in the previous trial, whether the trial was a threat trial or not, whether the participant had been shocked in the previous trial or not and the reward value of the target stimulus. For each time step, TCMR assessed whether these factors influenced the direction of the trajectory in that step. The TCMR (see Figure 4.5) indicated that these factors exerted influence at different times during the trajectory. The effect of the previous response peaked twice, once at the beginning of the trajectory and once at step 41. The effect of previous shock peaked at step 25 and the effect of current threat peaked at step 50 (see Table 4.2). The effect of current threat was considerably larger than the other factors. Target value had a weak effect on trajectory, which was limited to the middle of the trajectory. In summary, the properties of the previous trial affected trajectory direction early in the trajectory while the properties of the current trial affected the middle and later parts of the trajectory.

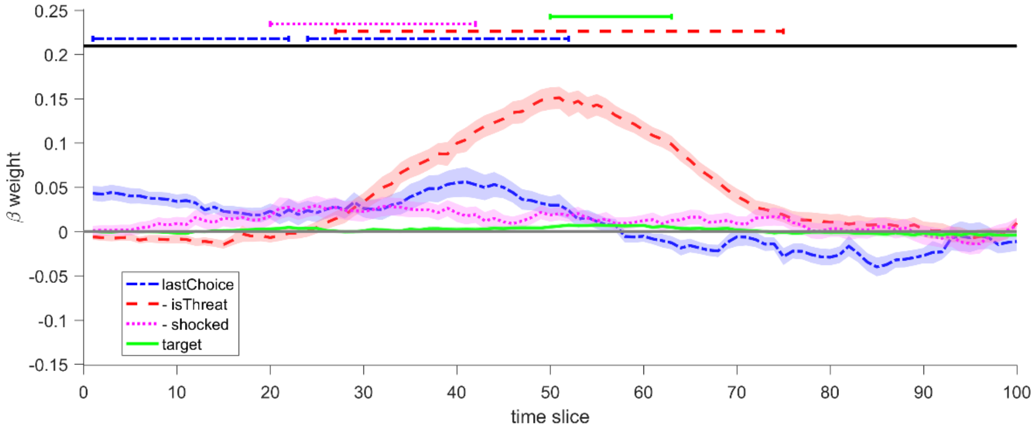


Figure 4.5. Influence of experimental variables on trajectory angle during response movement. The line at zero represents the intercept, where positive values above the line indicate angle towards the final “T” choice (i.e., attraction). Shaded bands around each predictor indicate their respective standard errors. The horizontal lines on the top highlight the regions of significance for the corresponding regressors (i.e., time step during which a regressor influenced response direction) when approaching “T” (familywise estimated error with $p < 0.05$ for ten consecutive t-tests). In each step the angle towards the “Take” response was predicted by the following variables: (a) *lastChoice*: response choice in the previous trial; (b) *lastMove*: response movement of the previous trial; (c) *isThreat*: whether the approach choice entailed threat probability; (d) *shocked*: whether participants received a mild electric pulse in the previous trial; (e) *target*: the amount of the points available as reward. The variables isThreat and shocked are negatively coded indicating movement in the opposite direction (the deflection from isThreat is away from the “T” option).

Table 4.2

Descriptive values for each variable in the TCMR (Experiment 3).

Beta	Start	End	Length	Peak time	Peak strength
lastChoice	1	22	21	41.07 (4.282)	.056 (.015)
	24	52	28	-	-
isThreat	27	75	48	50.98 (.985)	.151 (.012)
Shocked	20	42	22	25.80 (23.494)	.03 (.008)
target	50	63	13	54.71 (9.494)	.007 (.003)

Note. The leftmost column contain the experimental variables—excerting influence on response angle—for which the variables the beta values were explored. *lastChoice*: option chosen in the previous trial; *isThreat*: if the approach choice involve risk of shock; *shocked*: if an electric pulse was delivered in the previous trial; *target*: the points offered as reward. The rest of the columns contain the values for the TCMR parameters (the values shown reached statistical significance). *Length*: duration of the each variable’ influence; *Peak time*: response time-slice at which the influence of each variable reached its highest peak; *Peak strength*: weighing of each experimental variable in terms of beta values.

Discussion

The findings of *Experiment 3* support the main experimental hypotheses concerning approach and avoidance responses under threat conditions (and a strong default expectation of approach). First, approach trajectories were simpler than avoidance trajectories; they were faster, less deflected and less complex than avoidance trajectories. Second, when presented with stimuli that generated very high or very low approach motivations (i.e., target valence), approach-avoidance conflict was reduced and trajectories were simpler. When presented with target numbers farther from the participants' indifference point, participants avoided low numbers more quickly with less deflection and less complexity ("definitely not worth it"), and approached high numbers more quickly with less deflection and less complexity ("definitely worth it"). It is reasonable, thus, to state that such choices seemed "easier" for the participants to make.

Furthermore, the TCMR method allowed us to track the time course of the influence by the experimental variables within a response trajectory. The waxing and waning of these experimental influences suggest a time course of potential psychological processes engaged by the task. In addition, the relative duration and strength of the influences were estimated. The choice in the previous trial influenced early movement, followed by shock recency, presence of threat and reward value which affected the middle phase of the decision. Of these, the effect of current threat was by far the strongest influence on trajectories demonstrating its expected effect of approach-avoidance conflict in these trials.

Response angle TCMRs suggested that persistent activation due to the choice from the preceding trial influenced the beginning of new trajectories, and possibly constituted a bias early in the decision process. This "carry over" effect from the previous choice has been demonstrated previously in simple decision-making paradigms. Two features of *Experiment 3* might have served to establish this effect: (a) the locations of "Take" and "Lose" were consistent within blocks of trials (i.e., always on the left or right), generating a *motor default*; and (b) non-threat trials (in which approaching "Take" was almost always observed) were four times more common than threat trials leading to a *default expectation* of approaching (choosing "Take"; see also Appendix R for related eye movement data). It was not possible to isolate the effects of these defaults in *Experiment 3*, but these were explored in *Experiment 4*.

Experiment 4

A second experiment was carried out in order to replicate the findings from *Experiment 3,* and investigate the effect of two methodological adjustments. The same method was implemented, with the exception of two specific changes: (a) the position of the choice option was quasi-randomly counterbalanced across trials (i.e., constrained to no more than three consecutive repetitions of the response area's location), and (b) the tone accompanying the delivery of shock was removed. The former modification was considered given the limited data in mouse-tracking studies that have implemented trial-based counterbalancing, as well as the potential to dissociate response movement with choice location. Regarding the latter, removing the tone allows to compare whether presenting the shocks without the tone might render such a stimulation less aversive (as assumed in *Experiment 3*).

Participants

Sixty-eight new volunteers were recruited following the protocol of *Experiment 3*. Data from three participants were removed as they were corrupted due to synchronization issues. The remaining sample consisted of 65 participants (mean age = 20 [18-52], 51 females).

Data processing

All data filtering followed the same process as in *Experiment 3*. The indifference point estimate for individuals exceeding the range limits (31 cases) and those requiring estimate adjustment (12 cases) was treated as previously. Exclusion of responses longer than three seconds amounted to approximately 2% of the response trajectories, and an additional 2% of all response trajectories were excluded during quality checks and filtering of the mouse data. The remaining dataset consisted of a total of 32.225 response trials.

Results

The same data analyses were carried out as in *Experiment 3*. Participants completed an average of 495 (450-731) trials. As in the first experiment, the participants always chose "T" in the absence of threat, whereas for threat trials the probability of choosing "T" varied across subgroups (see Figure 4.6). Mixed-effects models (see Appendix Q), once more, corroborated the positive effect of target value on approach (*b* = 1.106, *SE* = .125, *z* = 8.78, *p* < .001, *OR* = 3.02 [95% CI: 2.36; 3.86]). Participants' verbal estimation of their behaviour (n = 42) and the relation with their actual performance is reflected in the correlation between self-reported approach threshold and percentage of approach responses (*r* = -.57 [95% CI: -.58, -.56, *p* < .001]), and between self-report and calculated indifference point (*r* = .55 [95% CI: .54, .56, *p* < .001]). The FPQ scale yielded a significant weak correlation with participants' indifference point (*r* = .26, *p* = .03), as did the BEAQ scale (*r* = .25, *p* = .05). None of the BIS-BAS scales predicted the indifference point (BIS *r* = -.03, *p* = .80; BAS drive *r* = .15, *p* = .23; BAS fun *r* = .05, *p* = .70; BAS reward *r* = -.06, *p* = .66).

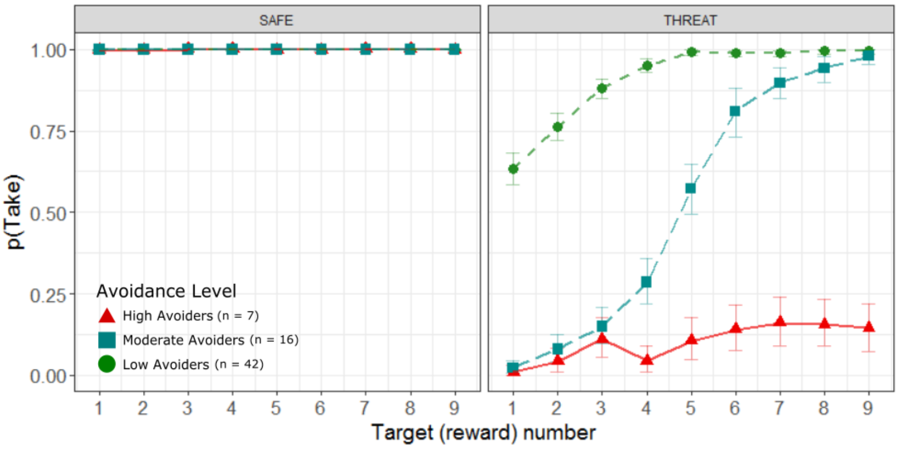


Figure 4.6. Probability of choosing the "take" option as a function of the target reward value (abscissa), for all participants (*Experiment 4*).

Raw trajectory heatmaps of approach and avoidance trajectories as a function of target valence (Figure 4.7) show the impact of the randomization of response location. Specifically, the effect of the default approach response observed in the first experiment was weaker. On some trials, approach responses exhibited a temporary attraction towards the "Lose" option during the trial, and these trials were more common when psychological distance to indifference point was lowest, creating the greatest decision conflict. Avoidance responses were similar to those in the first experiment, showing an initial movement towards the "Take" option and redirecting towards the "Lose" option. On the whole, as observed in *Experiment 3*, approach trajectories were simpler than avoidance trajectories. However, the effects of target valence on response trajectories are less clear in *Experiment 4*. For approach trajectories, we found no evidence of an effect of target valence and, for avoidance trajectories, the effect is the reverse of that expected. That is, higher target valence gave rise to more deflected trajectories rather than less deflected trajectories as would have been expected. It should be noted, however, that there were considerably fewer avoidance trajectories in this experiment than in *Experiment 3*.

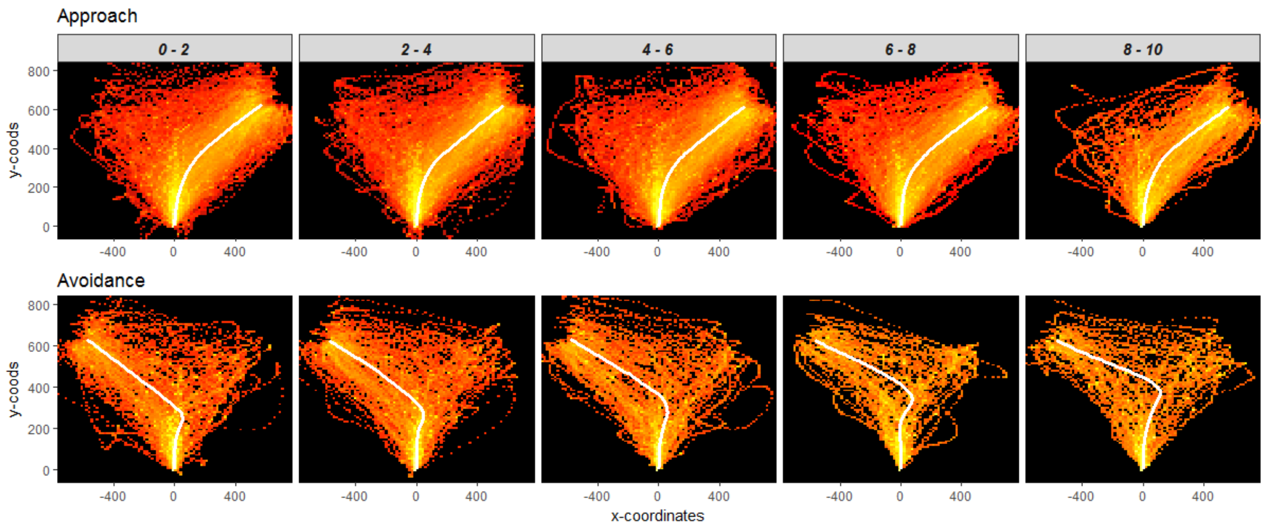


Figure 4.7. Heatmaps of raw trajectories per index of conflict (*Experiment 4*).

Figure 4.8 displays the average effect of approach-avoidance and target valence on the variables of conflict, and Table 4.3 contains their corresponding estimates. Once more, approach yielded simpler trajectories than avoidance; characterized by faster responses, less deflection, vacillation and entropy. In contrast to *Experiment 3*, degree to which approach-avoidance and target valence affected each of the measures of conflict was noisier in this experiment. For example, the effects found for avoidance conflict as indexed by MAD and x-entropy were in disagreement with the observed trends in *Experiment 3*[1]. Mixed-models yielded a main effect of target valence on RT and MAD, suggesting that as target valence distanced from the point of subjective indifference, responses were faster and followed a straighter trajectory towards the chosen option. However, such a relation was not as linear for RT (see Figure 4.8a) and the MADs did not significantly differ for approach (see Figure 4.8b). In addition, increases in target valence neither significantly reduced the number of x-flips (see Figure 4.8c) nor did it result in less x-entropy (see Figure 4.8d). Similar to the first

[1] However, when controlling for within-participant variability the expected trend was observed (i.e., greater MAD for greater AAC).

experiment, target valence was a stronger predictor of reduced conflict during approach than during avoidance for RT, as indicated by the interaction between these variables.

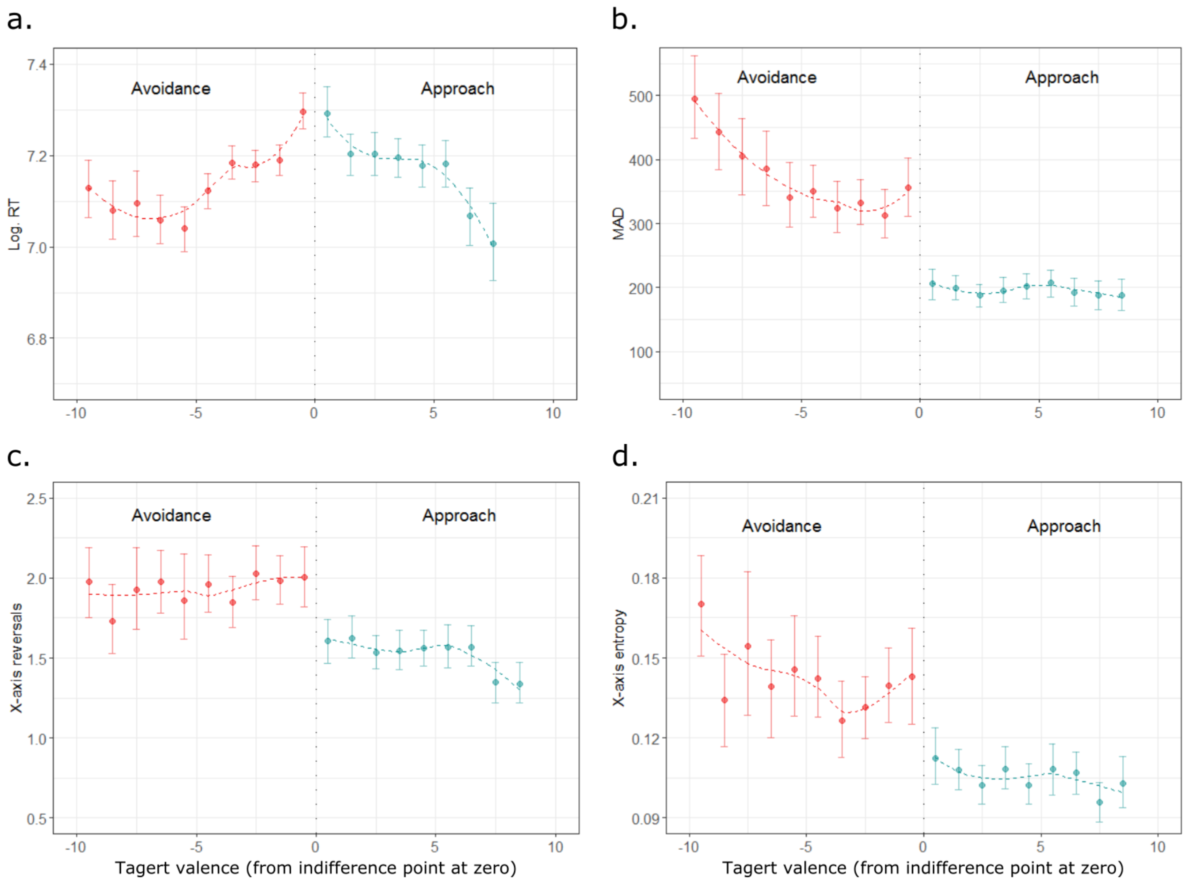


Figure 4.8. Data as a function of psychological conflict for each of the measures of interest (*Experiment 4*).

Table 4.3

Statistical analyses on predictors for conflict variables (Experiment 4).

	Response time		MAD		X-flips		Entropy	
Predictor	*b*	SE	*b*	SE	*b*	SE	*b*	SE
(intercept)	7.151	0.041	336.39	16.04	0.591	0.050	0.137	0.007
Log. Trial	-0.015***	0.004	3.061	3.379	-0.030**	0.011	-0.004***	0.001
Target Valence	-0.040***	0.005	-4.859*	2.248	-0.011	0.008	-0.001	0.001
Approach	-0.077***	0.017	-112.48***	10.00	-0.130***	0.038	-0.023***	0.004
Target Val.* Appr	0.037***	0.005	0.895	2.529	0.004	0.010	0.000	0.001

Note. Significance *p* levels at .05*, .01**, .001***

As before, TCMR analyses of approach responses revealed the factors affecting the angle of the current response at each time step of the trajectory. The same variables as in *Experiment 3* were explored but this time we also recorded the response movement executed during the previous trial as independent from choice (see Figure 4.9). Counterbalancing across trials enabled us to single out the contribution from both the choice and the movement direction of the last trial. The effect of the previous response movement peaked at the beginning of the trajectory whereupon it dropped at a stable rate. Interestingly, the trajectory angle was next affected by the previous response, the effect of which peaked at time step 33 (cf. Figure 4.5 choice 2nd peak). The effect of having experienced a shock during the previous trial peaked at time step 63 and the presence of threat in the current trial peaked at time step 58. Similar to *Experiment 3*, the effect of current threat was the strongest among the variables exerting influence over the trajectory angle, and the effect of target value had a weak effect at time step 56 (see Table 4.4).

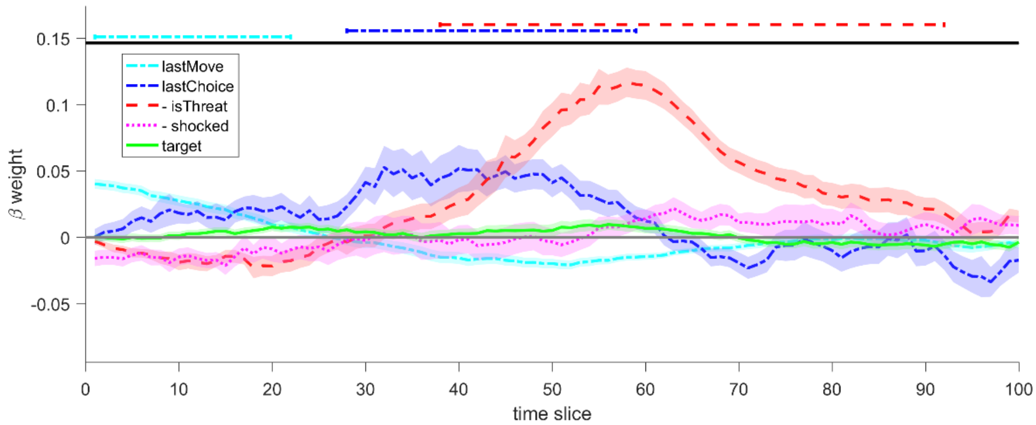


Figure 4.9. Influence of experimental variables on trajectory angle during response movement (*Experiment 4*).

Table 4.4

Descriptive values for each variable in the TCMR (Experiment 4).

Beta	Start	End	Length	Peak time	Peak strength
lastMove	1	22	21	1 (0)	.04 (004)
lastChoice	28	59	31	33.53 (27.423)	.053 (.012)
isTreat	38	92	54	58 (0)	.117 (.011)
Shocked	-	-	-	63 (0)	.022 (.008)
target	53	62	9*	56 (0)	.01 (.004)

* Slightly missing the significance criterion of 10 consecutive significant t-tests.

Discussion

Experiment 4 assessed whether the findings supporting the main experimental hypotheses, concerning approach and avoidance responses under threat conditions, would be replicated in a context that retained a strong default expectation of approach but controlled for the response location. Weakening the connection between the default approach expectation and response location weakened the default motor response established in *Experiment 3*. Approach trajectories were still faster, less deflected and less complex than avoidance trajectories, but approach trajectories in *Experiment 4* were slower, more deflected and more complex than approach trajectories in *Experiment 3*. The effects of target valence on movement were less clear in *Experiment 4* than in *Experiment 3*. Increased target valence clearly reduced response time and marginally reduced MAD, but did not affect vacillation or complexity. The reasons for these differences between experiments are considered later.

TCMR analyses detected similar influences to those found in *Experiment 3*; that is, shock recency, presence of threat and reward value affected the middle phase of the decision, with threat having the strongest effect over trajectory angle, and target value the weakest. Furthermore, by randomizing response location across trials, it was possible to dissociate the influences of a default motor response (move the same direction as the last trial) and a default expectation (approach "Take") within the approach response trajectories. In *Experiment 3*, two peaks were observed in the trial-to-trial influence, one at the very beginning of a movement and one at approximately 40% of the time course of the trajectory. In *Experiment 4*, the peak influence of the default motor response was at the very beginning of the trial, and the peak influence of the default approach expectation was at approximately 40% of the trajectory (and the second strongest effect). This outcome highlights the considerable potential of the TCMR approach in the analysis of the complex interplay of psychological processes during response movement.

General Discussion

In this paper, we set out to explore the action dynamics of behaviour under varying degrees of AAC. Approach-avoidance decision conflict was generated by varying the appetitive consequences of a decision (i.e., point rewards and shorter participation time) in the presence of a simultaneous aversive consequence (i.e., shock probability). We sought to establish whether the time course of the competing influences of approach and avoidance motivations would be reflected in continuous measurements of response movement. We identified typical patterns of approach and avoidance response movement that were sensitive to each participant's subjective level of conflict. Approach responses were simpler than avoidance responses and response trajectories became more complex as approach and avoidance motivations were more equally matched.

The current study contributes to the rich literature on approach-avoidance conflicts that indicates that humans appraise both the appetitive and aversive consequences of a decision. If the appetitive consequences are “worth it”, they will accept aversive consequences or the risk of aversive consequences (Bublatzky et al., 2017; Clark et al., 2012; Mitte, 2007; Pittig et al., 2018; Rattel et al., 2017; Schrooten et al., 2014; Schulreich, Gerhardt, & Heekeren, 2016; Sierra-Mercado et al., 2015; Stocco & Fum, 2008). Though these appraisals are subject to habituation of the aversive consequences across trials, they are often consistent within participants but differ among participants, indicative of differing levels of threat appraisal (or “fear”) across participants (see appendix Figure S1). In the current study, participants’ performance indicated a number of points that were exchangeable for the risk of shock and this was largely reflected in post-hoc descriptions of the participants’ experience of the paradigm. That is, participants identified a number of points that they thought worth the risk of shock (viz., a “price of fear”).

Our findings demonstrated the dynamic continuity of conflict resolution during AACs. Even though participants’ discrete threat appraisals were quite consistent across trials, their response dynamics suggested that the relative appraisals of threat and point losses evolved during each trial. That is, the outcome of the decision-making process was relatively similar from trial to trial, but the conflict was resolved dynamically in each case. In trials that were close to a participant’s indifference threshold point, conflicts took longer to resolve and response trajectories were more complex. For *Experiment 3*, this was evidenced in slower responses, greater deflection, more vacillation and greater entropy when the points available were close to the indifference point threshold. In *Experiment 4*, decisions at higher levels of conflict were longer in duration and exhibited greater deflection, but were not significantly different in vacillation or entropy. Nonetheless, the action dynamics in the data revealed the dynamic competition between approach and avoidance motivation that underlies complex decision making (see Appendix T for average response trajectory profiles).

The time continuous multiple regression approach (TCMR) allowed us to further investigate the relative influences of experimental variables during each response. These analyses focused solely on those responses on which participants decided to gain points, with a subset of these responses occurring under threat conditions. The strongest influence on response trajectories was the presence of threat and this was observed in the middle of the trajectory. This replicates the observation that, even when participants choose to approach, the effects of conflict can be observed in their responses. Prior to the effect of the repulsion from the preferred choice induced by the threat condition, response trajectories were influenced by the motor response (choosing the left or right option) in the previous trial and the decision (approach or avoid) in the previous trial. In *Experiment 3,* the approach and avoid options were presented on the left or the right consistently within blocks of responses. This procedure generated a stable mapping between a particular directional response and a choice, arguably contributing to less noisy patterns of response conflict. Nevertheless, due to this stable mapping, it was not possible to isolate the effects of moving in a particular direction from the decision to approach or avoid. In *Experiment 4,* the locations of the approach and avoid options changed unpredictably across trials, meaning that the mapping between motor response and choice was not consistent. Through TCMR analyses, it was then possible to isolate independent effects on response trajectories due to motor preparation and choice preparation; with the motor preparation effect exerting its influence earliest in the trajectory followed by the choice preparation effect. This choice preparation effect aligns with previous research that has demonstrated that inhibition can be facilitated across trials in a stop-signal reaction time task (Bissett & Logan, 2012). The TCMR approach holds considerable promise for identifying independent effects on response trajectories from various experimental variables in AACs (c.f. Scherbaum, Frisch, & Dshemuchadse, 2017, 2018; Scherbaum, Frisch, Dshemuchadse, Rudolf, & Fischer, 2018; see also Sullivan, Hutcherson, Harris, & Rangel, 2015; but cf. Zhang, Willemsen, & Lakens, 2018).

On the whole, our findings suggest that participants developed expectations across trials that affected their trajectories prior to contact with the conditions established in each trial. This default model was biased towards approaching the "Take" response, but was updated in light of trial properties (i.e., the colour of the target stimulus and the value of the target stimulus). On threat trials, the value of the target stimulus was interpreted in light of each participant's fear of the shock outcome. A dynamical systems account of decision making constitutes one means of accommodating the contributions to each response from the default model (the intrinsic dynamics) and trial properties (behavioural information) which provides a parsimonious explanation of various findings in the current study (e.g., Kelso, 1995; Killeen, 1992; Marr, 1992; Scherbaum et al., 2016). To explain the relative complexity of avoidance trajectories compared to approach trajectories, we consider that, in the default model, there is in effect only one attractor, since participants approach the "Take" stimulus on the vast majority of trials. In threat trials, however, the target value had the potential to compromise this attractor resulting in the creation of a second attractor at "Lose" (a phase transition; cf. Figure 5.2). When the target value was less than the participant deemed worth a shock the “Lose” attractor dominated the decision space. These avoidance responses were more complex due to this competition between attractors. When target values were high and participants continued to approach in spite of the threat, the second attractor was not sufficiently strong to induce this phase transition and trajectories were simpler. The effect of target valence on trajectories suggests that it played a role as a control parameter that tipped the scales towards “Take” or “Lose” (cf. Figure 5.4). Close to a participant’s indifference threshold, the attractors at “Take” and “Lose” approached equipotentiality leading to greater decision conflict, reflected in longer response times, greater trajectory deflection and more vacillations. From this point, as the target valence increased, “Take” responses became more probable and less conflicted; and as target valence decreased, “Lose” responses became more probable and less conflicted. Finally, our TCMR comparative analyses between *Experiment 3* and *4* isolated motor and cognitive biases (i.e., expectation of choosing “Take”) across trials, demonstrating that the default model includes these expectations at the start of a trial.

Many studies of AAC attempt to characterize individual differences in approach or avoidance motivation (e.g., Maccallum et al., 2015; Meulders et al., 2016; Rattel et al., 2017; Rinck & Becker, 2007; Snagowski & Brand, 2015; Stins et al., 2011; Wiers, Rinck, Kordts, Houben, & Strack, 2010; Wittekind, Feist, Schneider, Moritz, & Fritzsche, 2015). Similarly, in the current study, participants varied in their willingness to approach a stimulus associated with a potential shock. For each participant, the indifference approach threshold constituted an estimate of their avoidance motivation, but it was more nuanced than that. The indifference point was the value at which the approach motivation (induced by points leading to completing the study early) matched the avoidance motivation and both these motivations likely varied across participants. That is, some participants were more strongly driven by earning points than others and some were more strongly driven to avoid shocks than others. In each case, the indifference point threshold balanced these motivations. In the context of the current study, the target valence incorporated this value in order to explore behaviour as these motivations tipped in favour of approach or avoidance. Nonetheless, future studies should, whenever possible, include participant’s chosen intensity of the shock as a moderator to explore whether avoidance changes as a function of shock intensity—independent of pain perception.

The current study is among the first to explore the dynamic mechanisms of AACs, and as such there are some limitations and aspects to take into consideration for future studies. For instance, the characteristics of our task meant that approach behaviour predominated over avoidance. This was a result of a disproportionate number of approach trials (i.e., a 1:5 ratio of threat/non-threat), but also the fact that both approach and avoidance response implied an oriented action (as oppose to non-action, cf. go/no-go tasks). Yet, one could argue that approach is indeed the default modus operandi in everyday activity, with avoidance systems being engaged only when necessary (from an evolutionary perspective constant avoidance could hamper vital activities such as foraging, hunting, or mating). This arrangement also made methodological sense, since establishing an approach behaviour first (equivalent to a baseline) enabled us to examine the repelling effect of the threat depending on the degree of conflict present across trials (cf. Schlund et al., 2016; Schlund et al., 2017). In *Experiment 4* there were fewer avoidance responses than in *Experiment 3*, which could have rendered insufficient data to produce as clear an effect as in the first experiment. For instance, this might have also been responsible for the lack of significant changes in x-flips (changes in the response direction) as a function of target valence. It could also be argued that x-flips, although recorded during the continuous stream of response movement, consists of frequency counts and thus might be a less sensitive measure dimension with scarce data than the degree of response curvature.

A characteristic of the experimental arrangement of *Experiment 3* and *4* (e.g., in comparison to *Experiment 1* and *2*), was that the reward magnitude was presented in the centre lower-half of the monitor. This was done in order to isolate eye-movements (involved in detecting and evaluating the reward stimuli) from hand-movements towards the response areas. Future studies involving eye-tracking could benefit from this arrangement to, for example, investigate the interaction/discrepancy between attentional levels and motor preparation in approach-avoidance situations.

Miller (1944; 1951a; 1951b; see also Hovland & Sears, 1938; Sears & Hovland, 1941) put forth the first empirical theory about the conflicts that arise when opportunities for incompatible or competing responses coexist. Hovland and Sears (1938) identified four modes of conflict resolution: (a) *single response*: unilateral movement towards one of the response options; (b) *double reaction*: initial movement towards one of the response options followed by a reversal (sometimes backwards) or redirection towards the alternative response option; (c) *compromise*: upwards movement towards the response options but remaining somewhere (in relatively equal proximity) between the two; and (d) *blocking*: no movement (possibly characterized by an unusually long response time). The decisions in our task only represented double-AACs and the experimental arrangement only allowed for two types of conflict resolution to take place (i.e., a and b). Future studies should accommodate other styles of conflict resolution. It would be interesting to establish whether the observed patterns herein vary depending on the type of AAC (e.g., single approach-avoidance, approach-approach, avoidance-avoidance), and whether data from mouse-tracking approach-avoidance tasks are suitable for modelling in accordance with the theory (e.g., Townsend & Busemeyer, 1989; see also Schall, Palmeri, & Logan, 2017; Talmi & Pine, 2012).

It is our hope that a greater understanding of approach-avoidance conflicts will lead to insights of practical relevance in the field of maladaptive avoidance in order to build a bridge between experimental and applied research (Kirlic, Young, & Aupperle, 2017; Sierra-Mercado et al., 2015). Indeed, it has been argued that approach-avoidance paradigms are more representative of the kind of realistic behaviour that scientists aim to understand (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013; Krypotos, Vervliet, & Engelhard, 2018). Recent research has already begun to shed light on the dynamic processes involved in avoidance (e.g., Bublatzky et al., 2017; Pittig et al., 2018; Schlund et al., 2017). For example, Pittig et al. (2018) demonstrated that competing incentives can instigate approach towards an initially avoided feared stimulus, highlighting how the interaction between approachable and avoidable consequences may be more effective in reducing avoidance than verbally cueing safety in isolation (cf. Garcia-Guerrero, Dickins, & Dickins, 2014). Moreover, it has been suggested that, in clinical anxiety, approach and avoidance contingencies work in parallel, and even in combination with each other (Forsyth, Eifert, & Barrios, 2006) since, without competing approach motivations, avoidance is quite functional (Hayes, 1976; Costello, 1970). Studying the dynamic resolution of AACs may help elucidate some of the factors underlying pathological avoidance which has been resistant to extinction in clinical populations (Luciano et al., 2013; Vervliet & Indekeu, 2015; cf. Volpp et al., 2009).

Chapter V

The present thesis explored the potential of conceiving pathological avoidance as an imbalance of approach and avoidance motivation. First, the utility of current self-report and implicit measures of fears as predictors of behavioural avoidance was assessed in a scoping review and meta-analysis. The intensity of such fears provides an index of pathological avoidance of feared objects such as spiders. Second, two novel measures of spider fear based on balancing approach and avoidance motivations were developed and tested. Third, an experimental investigation of the online resolution of approach-avoidance conflict was conducted using mouse-cursor tracking to highlight the effects of these competing motivations in real-time. On the whole, the three investigations reported herein support the position that there is merit and potential in considering pathological avoidance as an imbalance of approach and avoidance motivation. This chapter revisits selected elements of the findings of these investigations to identify how the present work supports the conclusions. Limitations and considerations of the current investigations are then presented. Some implications around concepts of relevance to the wider context of this work are addressed. In addition, a conceptual model is laid out to accommodate the interrelation between approach-avoidance motivations from a dynamical perspective. The chapter ends with a reflection about the role these findings may play in supporting applied research and psychological clinical practice.

Overview and integrated summary of studies

Pathological avoidance was conceptualised as ensuing from the dynamic interplay between two basic processes: approach and avoidance. In order to contextualise the behavioural measures of fear that would be developed in the thesis, an analysis of the current literature of behavioural fear measures was conducted. Specifically, the relationships between (a) verbal estimations of fears and (b) implicit behavioural measures of fears, and behavioural avoidance were estimated. *Study 1* found that the relationship between self-reports of fear/anxiety and avoidance was greater than that between implicit measures and avoidance; with the former yielding a meta-correlation of $r = -.56$, and the latter of $r = -.17$. Moreover, this study revealed that the protocols used to assess overt avoidance (i.e., Behavioural Approach Tasks; BATs), however regarded as an ideal measure of phobic avoidance (Bellack & Hersen, 1988), lack standardization and operationalization to scientifically desirable standards. This state of affairs calls for amending measures as a prerequisite in research in the area of psychological disorders related to anxiety and maladaptive avoidance.

The subsequent experimental studies consisted of different manipulations of the appetitive and aversive stimuli associated with a participant’s decisions. The current investigation into the dynamic properties of avoidance represented a departure from traditional methodologies. Specifically, two fundamental differences were required in the experimental procedures. First, each decision constituted a dichotomous rather than single choice (which meant that each response was done in the context of another), as well as some task characteristics had to change as a function of the participant’s actions. These elements were thus introduced and tested in two experimental tasks, laying the ground for the subsequent experiments. Second, the layout of the task and data visualization techniques had to facilitate and be able to capture changes in the participants’ responses as these developed. The last two experiments represent a perfected paradigm that allowed us to empirically explore the phenomenon of motivational “conflict” in particular.

The purpose of the experimental studies was to create the necessary conditions for—adaptive—variable avoidance patterns. That is, if approach and avoidance motivations underlie avoidance, pathological avoidance thus represents an imbalance between these, with avoidance motivation being persistently greater than approach motivation in the presence of approach contingencies. Therefore, the common aspect of these tasks was that participants had to choose between two options at a time, each of which contained both positive and negative consequences, the necessary elements to generate an approach-avoidance conflict. More specifically, each of these tasks presented an advantageous option (i.e., with greater payoff) but accompanied by unpleasant emotional elicitors, and a less advantageous option but with neutral stimuli.

For *Experiment 1*, the structure of the task followed a descending staircase procedure in which the approachable consequence of the options (i.e., reward magnitude) was reduced across blocks, depending on participants’ preferential choices (whether they were approaching or avoiding the threat). In addition, two formats of the threat (spider-related) stimuli were tested: photographic and video-clips. The results revealed that, while there was some variability in avoidance decision patterns for some individuals, a great proportion of participants chose the threat option. Furthermore, the format of the threat did not result in significant differences in participants’ decisions. These results hint at potential differences in how aversive (threatening) vs. appetitive stimuli are processed (i.e., differential response patterns). That is, whereas threats might regulate behaviour in robust ways (e.g., approach/avoid, somewhat insensitive to small changes in intensity), appetitive stimuli might lead to more graded behaviour (sensitive to small changes in magnitude). Theoretically, it also suggests that since most individuals in our sample approached the threat when incentivised to do so, their behaviour does not correspond to the one expected from someone "suffering from pathological avoidance". This highlights the need to replicate these experiments using a sample of individuals diagnosed with severe anxiety (or related problems characterised by avoidance). In practice, the use of the current experimental paradigms might help identify "false positives", as individuals diagnosed with anxiety (based on questionnaires) might still respond adaptively to environmental—social—demands.

Experiment 2 implemented a modified procedure in accordance with an adjusting method of limits. Namely, preferring the non-threat option increased the reward magnitude of the threat option in the subsequent block; likewise, preferring the threat option decreased its reward magnitude. This procedure, thereby, provided the upper and lower bounds of the reward magnitude, necessary to motivate changes in overt behaviour (i.e., decision preference) for each participant. These boundaries were a means to index the subjective value (i.e., the price) of the threat consequence present in the decisions, controlling participants' choices. The results were similar to those found in the previous experiment, with a great proportion of participants approaching the threat option, despite high self-reported fear, but demonstrating somewhat more sensitivity in the calculated price. Moreover, building on *Study 1* (on the relationship between indirect measures of fears and the manifestation of avoidance), this study implemented a self-exposure behavioural exercise using a real spider (i.e., BAT). The results showed that while participants' self-reported fear and calculated price did not correlate with each other, both of these measures correlated with overt avoidance. This indicates that the reported fear and calculated price tapped onto distinct psychological processes, both associated with overt avoidance.

The last two studies focused on capturing the action dynamics of approaching and avoiding choice outcomes, and their interpretation in terms of decision conflict. It was envisaged that if competing contingencies exerted similar levels of control over decision-making, such competition (experienced as conflict or indecision) should be reflected in some characteristics of the individual's behaviour. Theoretically, psychopathological behaviour could be accompanied by high conflict, even if such an experience is not obvious or registered in the measures often employed. Such a—motivational—conflict, however, did not need to be distinguishable through traditional discrete measures; in fact, it was assumed that continuous measures were more appropriate. Therefore, a better experimental arrangement for these tasks was to present the reward value (to be approached or avoided) independent of the choice response area. That is, whereas in the previous tasks the reward value of one option was relative to the alternative, in this case the decision entailed winning or losing the reward, coupled with approaching or avoiding the threat. In addition, the continuous motor execution during participants' responses were recorded frame-by-frame, thereby enabling the visualization of response trajectories.

Experiment 3 revealed significant correlations between the calculated participants' indifference point and self-reports. Moreover, the indifference point was related to participants' approach-avoidance conflict, as reflected in the dynamic response measures (i.e., response deflection, vacillation and complexity). In addition, within-trial analyses of approach responses revealed that the previous choice influenced the current response, as well as shock recency and current presence of threat. All the variables, except for "previous choice", exerted the greatest effect on response angle during the middle of the response episode—presumably the time during which most of the decision evaluation took place.

Taking into account differences in their methodologies, the main results from *Experiment 4* differed from those of *Experiment 3*. That is, the indifference point was related to approach-avoidance conflict, but this time it was reflected in response time and response deflection only. These differences are attributed to changes in key features of the experimental task, and in particular to the trial-based counterbalancing of the response areas. The importance of this feature was strikingly evident in average within-trial analyses exploring the angle of participants' responses. These analyses showed that response angle was influenced not only by the previous choice made (as concluded in *Experiment 3*), but also by the previous movement executed as part of the response.

Taken together, this thesis makes a number of contributions to the experimental analysis of approach-avoidance conflicts, as well as to the wider literature on anxiety and clinically relevant avoidance. Overall, the present work merges and updates early conceptualizations of approach-avoidance motivational conflicts with novel techniques used within a dynamical systems approach.

More specifically—and concisely—, the present work puts forward a viable operationalization and procedural standardization to explore overt avoidance via behavioural self-exposure exercises (for feared objects that are suitable for laboratory environments; *Experiment 2*). It also innovates with three different paradigms whereby to investigate the dynamic interplay between approach and avoidance motivations (i.e., AACs) in decision-making (*Experiments 1 – 4*). Correspondingly, we offered three methods to index some of the psychological processes underlying choice behaviour, computed from behaviour recorded directly. The reported data support the premise that avoidance is sensitive to competing approach contingencies (*Experiments 1 – 4*), and avoidance is more complex than approach in this type of conflicted decision-making context (*Experiments 3 & 4*). In so doing, we tested the adequacy of novel methodological and data analytic techniques for this area of research (*Experiments 1 – 4*). In particular, we recommend response-tracing techniques (i.e., mouse-tracking) as particularly useful for capturing the level of conflict generated by—competing—approach and avoidance contingencies (*Experiments 3 & 4*). Moreover, our findings highlight the dynamic nature of avoidance and postulate such a quality as a factor worth exploring further. Acknowledging the potential role of approach motivations, simultaneous to avoidance, may account for the apparent inadequacy of avoidance paradigms to detect mechanisms applicable to real-life contexts. In addition, it may help us discern adaptive from pathological manifestations of avoidance, thus, advancing theoretical and clinical models.

Overall research limitations and recommendations

The fact that our systematic review mostly constituted spider fear limits the generalizability of the findings, especially in areas of clinical research that ascribe to nosological classifications. This was the result of the rigorous application of the eligibility criteria required for a study of this nature. Future research could benefit from a less strict, yet systematic, review such as an empirical synthesis. This approach could also prove fruitful in accommodating a wider range of BATs characterised by increments of “psychological distance” rather than exclusive physical proximity (e.g., Cochrane et al., 2008), or a more discrete fashion (e.g., Koch, O’Neill, Sawchuk, & Connolly, 2002). To our knowledge, a comprehensive review of BATs, their variants and pertinence depending on the areas/goals of research is lacking in the literature. Such an empirical synthesis could represent a solid scaffolding for the renewed interest in tackling maladaptive avoidance as a subject matter in its own right.

Experiments 1 and *2* consisted of short experimental tasks. While this characteristic has its advantages and served the intended purposes, short performances can represent a limitation in terms of the available data to explore some variables typically used in basic research (e.g., response times) that require several data points. In addition, since several possible prices can be calculated (depending on participants' progression through the structure of these tasks), a small or unbalanced sample could represent an issue. In our case this was reflected in the fact that most participants received low prices, causing floor effects which threatened cross validation with psychometric questionnaires.

Despite the relevance of the present work to anxiety disorders, the samples used in these experiments were selected from non-clinical populations. This could have been partly responsible for the observed larger proportion of approachers throughout. In fact, from the theoretical framework adopted herein, a distinctive characteristics of pathological avoidance is the fact that avoidance responses persist in the face of conditions that would normally motivate approach responses. While the observed performance in our experiments show participants who can be defined as "approachers", "switchers" and "avoiders", there were proportionally few extreme avoiders. Therefore, future studies would benefit from comparing performance in these tasks using clinical populations.

There are quite a few types of approach-avoidance conflicts in the literature and a multitude of ways in which their key variables can be manipulated depending on the focus of each AAC paradigm. For the scope of the present thesis, the tasks designed for each study represented one class of conflicts characterised by involving opposite motivations (as distinct from approach-approach or avoidance-avoidance). As explained, selecting approach-avoidance conflicts made theoretical sense since the balance between these two motivations underlie adaptive avoidance, and we could induce imbalances between these motivations by manipulating external consequential stimuli. However, in our tasks the threat consequence was kept constant and only the approachable consequence was systematically varied. While deciding to manipulate directly only the reward consequence somewhat simplified the procedure and provided a focused methodology, there could be differences in how people balance approach-avoidance motivations when threats of different magnitude are presented. Additional studies are necessary that include trade-offs in the probability/magnitude of both the appetitive and aversive consequence. Implementing—and further validating—the task developed by Aupperle and her team (2011) in future studies could be a step in this direction. Likewise, future studies could implement other kind of threats (e.g., unpleasant images) and rewards (e.g., financial), or even introduce hypothetical conflicts (cf. Pittig, Hengen et al., 2018; Murray, 1975).

One of the aspects around the conceptualization of avoidance that we set out to explore was the fact that, in order for it to be adaptive, it needs to be dynamic and change depending on changes in the environment. In particular, *Experiments 3* and *4* capitalised on recent methodological and technological developments which, however promising and theoretically appropriate in line with dynamical accounts, are still pending scientific standardization and validation. Future replications of the present work will have to introduce any developments in this area. Nonetheless, conducting studies that make use of mouse-tracking will contribute to this process and help identify weaknesses as well as strengths. For example, response acceleration profiles might prove to be highly valuable in highlighting fear/avoidance processes in this dimension (e.g., detecting a transitory freezing phase before deploying active escape responses), but no studies exist to date in this regard. The combined results of all the studies presented as part of this thesis lead us to conclude that avoidance is indeed sensitive to approachable consequences. Furthermore, we posit that the implementation of tasks designed to capture the dynamic nature of avoidance and its interrelation with approach can advance the scientific study of anxiety disorders. However, developments within the area of approach-avoidance conflicts is still a very nascent enterprise. The use of clinical samples and AAC-Ts targeting different fears, as well as including different arrangements, are necessary.

Conceptual Implications

Fear (and anxiety) research has traditionally been based on the inferred functionality of the behavioural correlates from exposing an organism to aversive stimulation (or stimuli associated with it). There exists a plethora of procedures to study avoidance in the laboratory, but the basic elements of the most common procedure include the presentation of an aversive stimulus (US+; e.g., electric shock) following a specific non-aversive stimulus (CS+; e.g., a beep). After a few pairings of these stimuli, the emission of a specific response by the organism (whilst in the presence of the non-aversive stimulus) will cancel the presentation of the impending aversive stimulus and terminate the non-aversive one (see Krypotos et al., 2015 for an overview of other procedures commonly used in research).

Over the decades, avoidance paradigms following this basic formulae have allowed researchers to learn a great deal about how animals learn to respond to threats (Dymond, 2019), and it continues to be a fruitful procedures widely used in experimental psychology and the neurosciences; not to mention the numerous theories emerging from these paradigms (Krypotos et al., 2015).

As stressed in Chapter III, there are advantages in investigating behavioural processes via paradigms in which appetitive contingencies are presented in competition with threat contingencies and, thereby, take into account the constant interplay between approach and avoidance tendencies. This approach provides a methodological and conceptual model to differentiate adaptive avoidance from maladaptive. That is, AAC paradigms help distinguish adaptive avoidance responses to noxious stimulation from avoidance in situations where strong appetitive contingencies are present but do not control behaviour (i.e., lead to approach). Thus, the insensitivity of avoidant behaviour to approach—competing—contingencies is a defining characteristic of pathological avoidance.

The basic premise behind the present work is that we respond to events in relation to other events, which is, in turn, affected by the state of the organism (i.e., motivation). This means that the aversiveness or appetitiveness of an event is relative. For example, when an individual avoids a potentially dangerous situation (e.g., staying at home during a storm), and the potential costs of the avoided action (e.g., physical harm) outweigh the benefits of doing otherwise (e.g., outdoors exercising, interacting with friends), such avoidance behaviour is regarded to be functional. However, when the perceived costs/benefits ratio is inverted (i.e., approaching incurs less costs or greater benefits than avoiding), avoidance may be regarded as dysfunctional and of clinical importance.

The same logic should thus be expected of approaching contingencies. Approach behaviour that implies greater danger (or is perceived by the community as incurring greater costs) than avoiding is considered pathological. An example of this would be the case of addictions in which the physical and social costs of such a class of behaviours are perceived to outweigh the benefits thereof (e.g., temporal euphoria, relaxation, inhibition etc.). An example in non-human animals would be when mice chase after cats as the result of parasites (Berdoy, Webster, & Macdonald, 2000), a behaviour clearly considered dysfunctional.

In fact, “desirable” cases of conflicted contingencies in which approaching aversive consequences is controlled (outweighed) by ulterior appetitive consequences are commonplace (e.g., withstanding muscle pain in the service of bodybuilding). This kind of behaviour was also commonly observed in the animal models of approach-avoidance conflicts during the late 50s and 60s (see Olds, 1956; Geller & Seifter, 1960; Olds & Milner 1954). In a modification of the Vogel Conflict Test (see Vogel, Beer, & Clody, 1971), for example, water-deprived rats are trained to run along a metallic grid from one end of a chamber to the other where they have access to water. Subsequently, the grid floor was electrified, and (given this experimental arrangement) rats exposed themselves to such an aversive stimulation in order to drink water. It important to note that, although similar dynamic motivational processes exists between non-human and human animals, human behaviour is also regulated by verbal processes (see Hayes, 1989; Hayes, Barnes-Holmes, & Roche, 2001; cf. Berry & Broadbent, 1984) and thus requires yet more complex models.

The AAC-Ts developed for the present work produced an outcome variable (e.g., "the price of fear"), based on the degree to which approach and avoidance contingencies took control over participants' behaviour. Estimating the—subjective—value of a consequence in this manner, could be considered a measure of *relative* response strength. That is, instead of response strength being a function of the frequency of reinforcement from approach or avoidance contingencies independently (De Villiers & Herrnstein, 1976; Herrnstein, 1961; Nevin, 1974; Rachlin, 1935), the response strength of conflicting contingencies could be proportional to the frequency of *differential* reinforcement from these (e.g., avoidance persists if the surplus corresponds to the avoidance contingencies). Although this proposal is, matter-of-factly, very incipient, it represents an alternative way to measure an individuals' coexisting (approach and avoidance) motivations in a unified index.

We have placed emphasis on motivation as allusive to the state of the organism given a history of reinforcement/punishment, and deprivation/satiation [1]. Thus, the concept of motivation becomes a convenient short-cut term. Yet, such a convenience is far from being an excuse for ignoring the variables of which behaviour is a function. As introduced, considering motivation, defined in terms that are scientifically sound (e.g., Michael, 2000), can lead to a better understanding of behaviour, its prediction and control. In our case, for instance, it could be assumed that increasing the value of approachable consequences acted as

[1] It is important to note that verbal behaviour is expected to be a factor in motivation given contemporary advances around relational responding. As Skinner (1953) also recognised, "[t]he probability of response may be due to many different kinds of variables where deprivation plays a minor role. For example, the strong 'drive' of the gambler… may not be primarily due to a condition of deprivation at all, since a carefully arranged schedule of variable-ratio of reinforcement will lead to a high probability of responding at a relatively low level of deprivation." (p. 144).

an abolishing operation (abating the punishing function of the aversive stimulation) resulting in reduced avoidance (for as long as the approachable consequence was more valuable than the avoidable consequence).

Other theoretical frameworks advocated here (based on dynamical systems theory, e.g., Kelso, 1995; Killeen, 1992; see next section) seem scientifically more viable for dynamic responding in the sense that they can accommodate behavioural phenomena across a wider range of dimensions, but more research is needed. As demonstrated with the present work, contemporary process-tracing methodologies (i.e., mouse-tracking) represent an opportunity to scientifically substantiate dynamic motivational conflicts that may underlie approach/avoidance behaviour at one given point.

Furthermore, from a conceptual viewpoint, talking about "approach-avoidance conflict", instead of "fear", emphasises the interactive nature of behaviour, and has a basis in observable phenomena. Unlike traditional assessment protocols of anxiety based on self-reports (e.g., Mischel, Grusec, & Masters, 1968) or implicit measures (e.g., Bradley, Mogg, Falla, & Hamilton, 1998), assessing avoidance allows researchers to examine the relationships between threat assessment and behavioural outputs directly; which, given the crucial role that avoidance plays in psychopathology and anxiety disorders (Arnaudova et al., 2017; Woods & Kanter, 2007), this approach can significantly contribute to the literature of applied clinical psychology.

Methodologically, capturing the dynamics of the competition generated by the available alternatives, and how they may evolve or change over time, is not something that traditional discrete measures are suited for. Even though appetitive or aversive stimuli prepares the organism for approaching or withdrawing (Arnold, 1960), this readiness does not necessarily have a behavioural manifestation (Lang et al. 1997) or is observable to the naked eye. For example, two decisions that caused different levels of conflict may still result in the same final recorded response (approached/avoided; e.g., see Appendix T). Differences in response time has traditionally been the preferred method to distinguish among responses and assumed underlying processes (e.g., Diederich, 2003).

Yet, response times are single data points that summarise a complex environment-behaviour interaction that is extended in time. For instance, two decisions may result in the same response times but have distinct characteristics in the time course of the response (e.g., transient engagement of defensive systems could yield different response acceleration profiles). In conflicting situations, this is most likely to occur at different stages of a response episode: initial freeze due to threat detection, and, if the course of action is avoidance, subsequent speeding up (cf. Stins, van Gelder, Oudenhoven, & Beek, 2015). Approach-avoidance paradigms, coupled with continuous response measurements, represent an alternative to circumvent this limitation.

A dynamical systems stance on approach-avoidance conflicts

Dynamical Systems Theory (DST) models of decision making (e.g., Kelso, 1995; O'Hora, Dale, Piiroinen, & Connolly, 2013; Scherbaum et al., 2016; Townsend & Busemeyer, 1989; van Rooij, Favela, Malone, & Richardson, 2013) offer a framework to describe (and test) the nonlinear and continuous nature of complex human processes. In these models, actions are conceived as the result of *attraction forces* represented by depressions in the surface of a potential/energy landscape. In a dynamical system this landscape is reshaped continuously as the system evaluates the options. Thus, a moving marble on this landscape (representing the state of the system at any given point) would gravitate towards the "attractor fields" (or decision choices); with the strength of the attraction being a function of the distance from these attractors, and its continuous dynamical change reflected in the trajectory made from a starting state. The deeper the field, the greater the probability of moving towards it. In the context of a task that includes pure aversive and appetitive outcomes, such potential landscape would include not only *attractors* (concave fields) but also *repellers* (convex fields— indicating the system's tendency to evolve into neighbouring states), as illustrated in Figure 5.1 for earning or losing varying amount of points respectively.

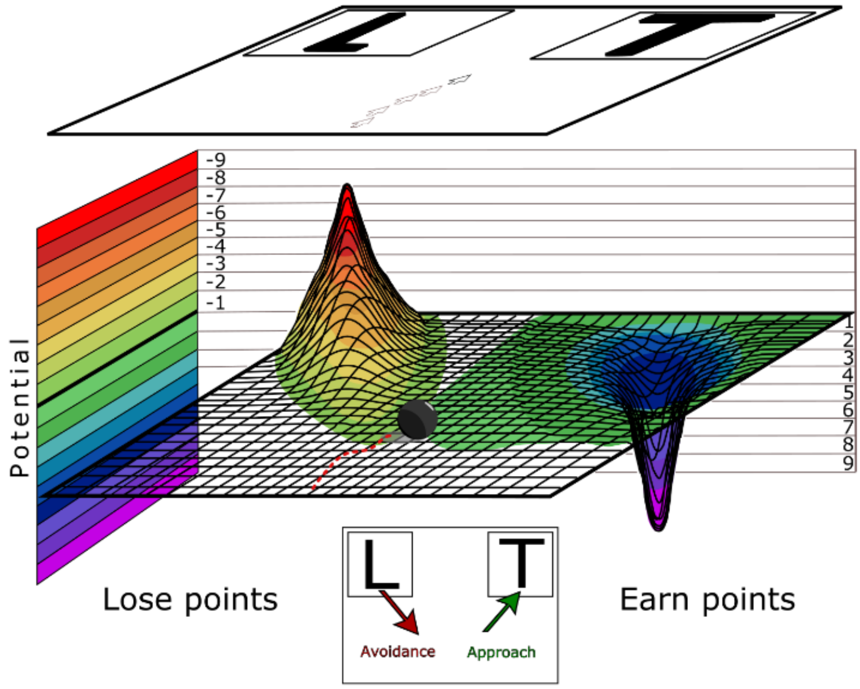


Figure 5.1. Hypothetical representation of a multi-state potential decision landscape with only aversive (avoidable) or appetitive (approachable) consequences. This illustration is based on the experimental layout corresponding to the tasks in Chapter IV. The magnitude of the rewards (1 – 9) are indicated on the background, and the assumed attraction exerted by them (i.e., fields' shape) is colour-coded ("elevation/depression" of the field).

In an approach-avoidance paradigm like the one implemented in our experiments, however, this potential decision landscape is best represented by two attractors: one for non-threat trials; and one for the approach-avoidance threat trials, whose degree of attraction—depth—is moderated by the relative values of the approachable and avoidable consequences of the choice (see Figure 5.2). When the current state of the decision is in one of these attractors the probability of the decision to resolve (or the tendency to settle) in that direction increases (put in discrete terms, ending up in approach or avoidance behaviour).

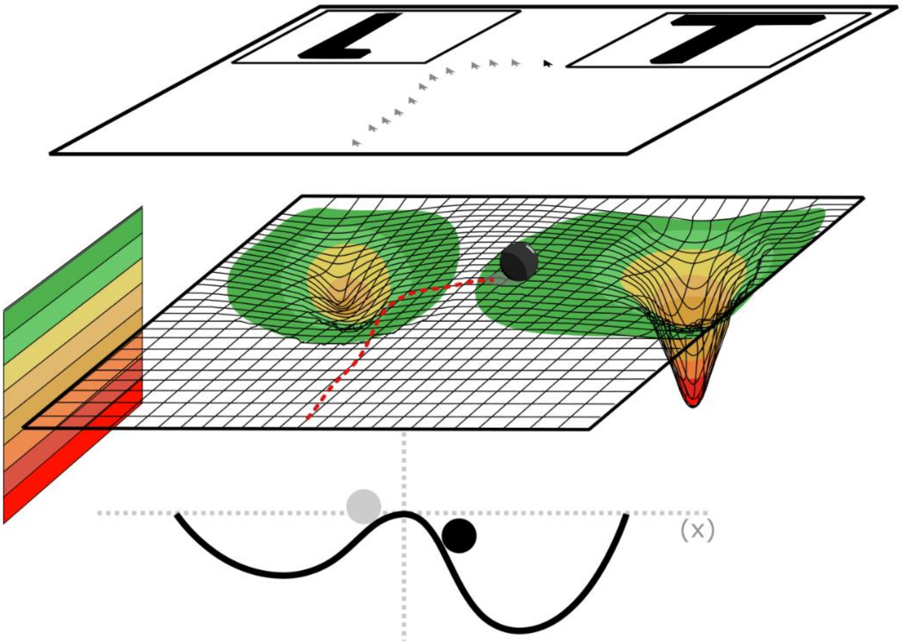


Figure 5.2. Illustration of a multi-state decision landscape showing two attractors, and below its respective depiction in a single plane.

This potential decision landscape can also be hypothetically mapped in time to correspond with the sequence in which an individual might evaluate the available choices (see Figure 5.3). For example, the right hand-side of Figure 5.3 illustrates the moment in time at which the attractors exert their influence during the decision-making process, and how tracking the movement of the mouse cursor constitutes an "online" measure of these psychological processes.

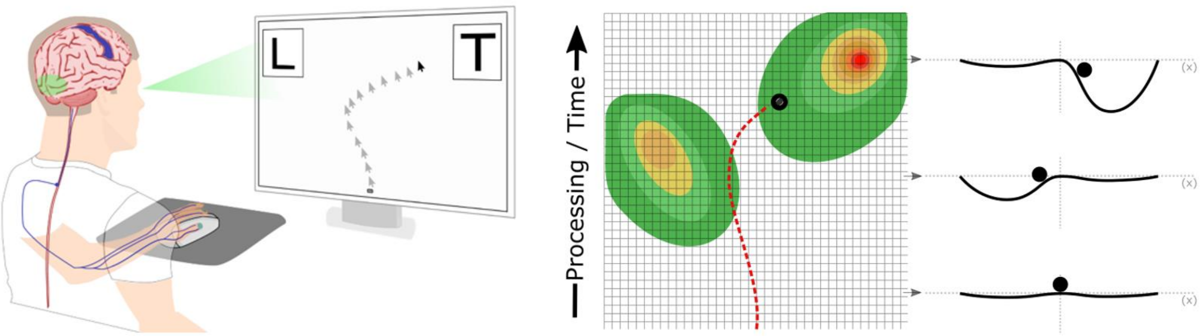


Figure 5.3. Left: Illustration of how the mouse-trajectory made during a decision relates to the continuous evaluation of the response options. Right: Depiction of the trajectory of the system (red dashed line) as it changes through time, as a function of the existing potential fields or attractors. The extreme right shows ("cross-section") slices of this potential decision landscape at three different points (system states) in time.

In our AAC task (*Experiments 3* and *4*), participants could decide whether to "Take" a specified reward with a risk of shock (threat), or not; the latter case resulting in the reward value being discounted from the participant's tally. During the task, participants soon developed choice preferences and adopted—sometimes explicitly—a rule (i.e., a minimum value below which they would not risk experiencing a shock) in order for them to opt to approach the threat option; we referred to such value as the "point of subjective equality" (PSE).

Thus, in our paradigm, the interaction between a reward value and an individual's PSE (i.e., their relative evaluation) determined the depth of the attractors (i.e., how strongly they influenced the terminal decision). Figure 5.4 below is a hypothetical representation of how this evaluation would determine the probability of approaching (Ap) or avoiding (Av).

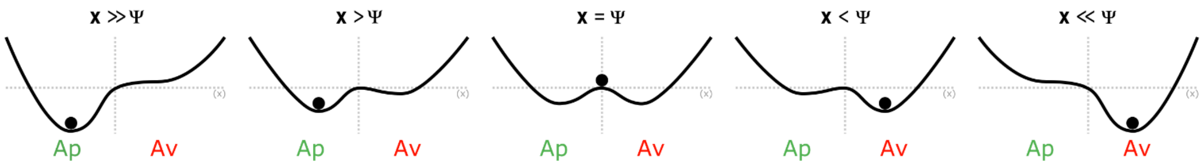


Figure 5.4. Single-plane potential landscapes with two possible choices corresponding to approach (choosing threat) or avoiding (choosing the non-threat option). Varying levels of attractiveness for each choice are depicted, depending on the relative value of a reward (X) with respect to the subjective point of indifference or the individual's approach threshold (Ψ).

Each individual's PSE threshold is indicated by "Ψ", and "x" is any reward value greater or smaller (or much greater/smaller depending on the number of available values) than that individual's PSE. It follows that when the reward for approaching the threat option is greater than an individual's threshold, s/he is expected to be attracted to it (the strength of which is a function of how much the reward exceeds that individual's PSE). Contrariwise, when the reward is below the individual's PSE, s/he is expected to avoid the threat and choose the alternative option. In other words, the relative positive or negative difference between "x" and "Ψ" (e.g., our operationalised *target valence* in *Experiment 3* and *4*) tilts the landscape in such a way that either approach or avoidance becomes more "attractive", leading to *stability* (the systems' tendency—indicated by the dot—to settle in one side or the other for as long as the attractor remains unperturbed). Deep attractors are manifested in straighter and faster speed response trajectories in their direction. However, when the reward value is equal to the individual's PSE (indifference point) two equipotential attractors coexist (Figure 5.4, middle panel), giving rise to oscillations between them (e.g., as reflected in x-flips or vacillation in mouse-tracking metrics) representing an equal probability that the individual will choose either option. This, in turn, is manifested in greater variability in the data (e.g., sample entropy metrics), slower responses, and greater deflections towards the alternative option in mouse-tracked response trajectories.

Applied implications

As addressed in Chapter II, there is a discrepancy between self-report, implicit and overt behavioural measures as it concerns fear-motivated avoidance. We have argued that, while constructs of fear might be fundamental to understand the cognitive and biological processes that accompany the perception of threat, focusing on avoidance remains the most direct scientific strategy to improve the face and predictive validity of clinical treatments.

A variety of psychological vulnerability factors have been proposed to explain the shift from a normal experience of fear to pathological anxiety. Among these, we can find genetics, temperament, uncontrollability, unpredictability, apprehension, threat biases, catastrophic thinking, fear of fear, anxiety sensitivity, etc. A complication with many of these concepts is that they are usually tackled as problematic for their own sake. For example, let's consider a tendency to catastrophize (viz. verbalizations around high risk of harm). Suppose a person who thinks airplanes are highly prone to malfunction, with little chance of escape or control should something go wrong. If the person engages in this sort of behaviour without the intention or need to approach the catastrophized situation (e.g., flying somewhere), such responding is not problematic (it might even be enjoyable as in watching films that evoke the related fear responses but in the comfort of a safe environment).

Catastrophic behaviour only becomes relevant if the person is motivated to (i.e., has been exposed to contingencies that increase the likelihood of) approaching the situation giving rise to such catastrophization. A strong motivation to approach could be the product of financial, time related, or social costs of travelling by land as a form of avoidance. Moreover, the clinical judgement around the degree to which such motivational conflict "significantly impairs an individual's life" is subject to particular circumstances. For example, having experienced a panic attack whilst in a bus, an individual whose job require him to use public transport might experience greater levels of anxiety under these circumstances than somebody who can always work from home should the "the emotions get the best of him".

Being able to establish a link between evaluative processes and action tendencies has clear advantages for applications where bringing about behavioural change is necessary. One could argue that, as effective as exposure therapy has been proven to be, such an intervention still depends on an individual's decision to take appropriate actions to tackle a particular problematic behaviour. Such a decision will, in turn, be heavily influenced by the perceived need to treat it or the costs of not doing something about it, regardless of its pathological nature.

As alluded to in the introduction of this thesis, conceptualising emotions as causes, rather than as effects, brings with it methodological limitations in terms of the locus of control of the phenomenon under investigation: behaviour. Skinner (1953) wrote extensively on this topic, "It does not help in the solution of a practical problem to be told that some feature of a man's behaviour is due to frustration or anxiety; we also need to be told how the frustration or anxiety has been induced and how it may be altered. In the end, we find ourselves dealing with two events—the emotional behaviour and the manipulable conditions of which that behaviour is a function—which comprise the proper matter of the study of emotion." (p. 167).

Emotions or motivational variables are justified in scientific psychology only insofar as they increase the prediction of behaviour. This sets the challenge of identifying the conditions under which these variables actually give rise to specific forms of behaviour and the conditions under which the absence thereof would reliably produce different behaviours. We have advocated that the concept of motivating operations (Michael, 2000; Laraway et al., 2014) is a promising avenue in this respect, but research within this framework is still scant and, so far, exclusive to traditional applied behavioural analysis.

Nevertheless, the notion of fear and related physiological and neuronal correlates, are the focus of much attention in psychopathology, whereas avoidance is not even included in nation-wide programmes aimed to integrate and standardise nosological research (e.g., see Lonsdorf et al., 2017). A reason for this may lie in the fact that there has not been much conceptual work around the concept of avoidance (Servatius, 2016). This is an aspect that might have delayed translational research on avoidance with direct implications for clinical research, but recent work addressing this gap has started to appear (e.g., Arnaudova et al., 2017; Dymond, 2019; Hofmann & Hay, 2018).

As a final remark, evolutionary theory suggests that behaviour needs to be flexible and variable in order to adapt to changes in the environment. Our biological endowment has systems in place to optimise survival (e.g., nociception serves to minimise tissue damage), but at the same time it has an intricate structure and the connectivity necessary to compute and evaluate multiple features of the environment (e.g., decision-making). Such computation gives rise to complex forms of behaviour that helps us respond to environments with greater levels of interrelation.

Perhaps the conceptual crisis in the area of anxiety-related disorders and maladaptive avoidance (Arnaudova et al., 2017; LeDoux, 2017) is an invitation to migrate from simple empirical paradigms to more interactive ones, and dynamical formulations of behaviour. As argued in this thesis, approach-avoidance paradigms might prove to be a fruitful scientific endeavour. For example, strong competing approach contingencies can lead individuals to start contacting the thus far avoided aversive contingency (Hayes, 1976). If this is repeated over time and across contexts, such an exposure could weaken conditioned stimulus functions (viz. habituation to the aversive) leading to a more permanent behavioural change. Moreover, the mere presence of competing approach contingencies can facilitate contacting extinguished aversive contingencies, thereby weakening avoidance (Pittig, 2019).

Conclusions

A central objective of this PhD was to determine if avoidance processes could be investigated within methodological approaches that take into consideration the dynamic nature of behaviour (via AACs).

Consideration of avoidance as a dynamic behaviour and its relevance within a clinical context is of crucial importance. However, preliminary basic experimental work in this area has been scarce. In order to develop a testable model of avoidance, conceived dynamically, experimental tasks need to include—to some possible extent—dynamic features (i.e., which change depending on the individuals' responses) and record behaviour as it occurs and it transitions between discretely defined responses. It is hoped that the studies undertaken as part of this PhD programme represent a first step in this direction.

Psychology has long benefited from operationalising its subject matter in terms of overt behavioural reactions to experimentally controlled stimuli. Approach-avoidance research began adhering to this experimental tradition with the pioneering work by Brown

(1948) and Miller (1948). The present work revisited some of the postulates in approach-avoidance conflicts capitalising on current technologies with the hope to find new insights and instigate investigative opportunities in this field.

Although there have been some studies using humans within the classical approach-avoidance theory presented here (e.g., Boyd et al., 2011; Förster, Higgins, & Idson, 1998), we believe mouse-tracking paradigms represent a richer promising research tool to further development in this area (cf. O'Hora et al., 2013). The continuous recording of participants' responses during decisions enabled us to scientifically investigate the theorised conflict/competition exerted by the simultaneous presentation of approach and avoidance contingencies via AAC-Ts.

Further work in this area can significantly contribute to related therapeutic practices. It appears that a fundamental issue that has not received enough attention among clinical researchers is the overemphasis on extinction procedures and reduction of autonomous activation as the prime therapeutic strategy to foster functional—socially adjusted—behaviour. Although the effectiveness of extinction procedures in experimental research on fear conditioning is robust and reliable, therapeutic interventions based solely on these kind of paradigms are, in the best of cases, short-lived as evidenced by the high levels of recurrence (Craske, 1999; see Vervliet et al., 2013 for a review; cf. Golkar, Bellander, Olsson, & Öhman, 2012).

Fear responses and our ability to establish associations between stimuli and qualify them as potentially harmful is an integral part of our phylogeny, not to mention their evolutionary advantage (Costello, 1970; Öhman, 1986, 2009; Öhman, Dimberg, Esteves, 2014; Mineka, & Öhman, 2002; Mobbs et al., 2015; Öhman & Wiens, 2004; cf. LeDoux, 2012). Thus, more emphasis should be placed on improving a clients' ability to respond in accordance with dynamic additional features of the (threatening) environment (Ginat-Frolich, Klein, Aderka, & Shechner, 2019). This PhD represents a preliminary exploration into the feasibility of some theoretical and methodological approaches for such an endeavour.

References

As per APA guidelines, the entries indicated with "*" correspond to the sampled papers for the systematic review (*Study 1*).

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin*, *84*(5), 888. http://dx.doi.org/10.1037/0033-2909.84.5.888

Alpers, G. W., Gerdes, A. B., Lagarie, B., Tabbert, K., Vaitl, D., & Stark, R. (2009). Attention and amygdala activity: an fMRI study with spider pictures in spider phobia. *Journal of Neural Transmission*, *116*(6), 747-757. https://doi.org/10.1007/s00702-008-0106-8

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* - V (5th ed.). Washington, D.C.: American Psychiatric Association.

Andersch, S., & Hetta, J. (2003). A 15-year follow-up study of patients with panic disorder. *European Psychiatry, 18*(8), 401-408. https://doi.org/10.1016/j.eurpsy.2003.03.007

Andersen, T. E., Ravn, S. L., & Roessler, K. K. (2015). Value-based cognitive-behavioural therapy for the prevention of chronic whiplash associated disorders: protocol of a randomized controlled trial. *BMC Musculoskeletal Disorders*, *16*(1), 232. doi: 10.1186/s12891-015-0687-y.

Annau, Z., & Kamin, L. J. (1961). The conditioned emotional response as a function of intensity of the US. *Journal of Comparative Physiological Psychology, 54*, 428-432. https://doi.org/10.1037/h0042199

Armony, J. L., Servan-Schreiber, D., Cohen, J. D., & LeDoux, J. E. (1995). An anatomically constrained neural network model of fear conditioning. *Behavioral Neuroscience, 109*(2), 246-257. http://dx.doi.org/10.1037/0735-7044.109.2.246

Arnaudova, I., Kindt, M., Fanselow, M., & Beckers, T. (2017). Pathways towards the proliferation of avoidance in anxiety and implications for treatment. *Behaviour Research and Therapy*, *96*, 3-13. https://doi.org/10.1016/j.brat.2017.04.004

Arnold, M. (1960). *Emotion and Personality*. NY, New York: Columbia University Press.

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review*, *32*(8), 704-723. https://doi.org/10.1016/j.cpr.2012.09.004

*Asnaani, A., Rinck, M., Becker, E., & Hofmann, S. G. (2014). The effects of approach-avoidance modification on social anxiety disorder: A pilot study. *Cognitive Therapy and Research*, *38*(2), 226. https://doi.org/10.1007/s10608-013-9580-x

Augustson, E. M., & Dougher, M. J. (1997). The transfer of avoidance evoking functions through stimulus equivalence classes. *Journal of Behavior Therapy and Experimental Psychiatry*, *28*(3), 181-191. https://doi.org/10.1016/S0005-7916(97)00008-6

Aupperle, R. L., Sullivan, S., Melrose, A. J., Paulus, M. P., & Stein, M. B. (2011). A reverse translational approach to quantify approach-avoidance conflict in humans. *Behavioral Brain Research*, *225*(2), 455-463. https://doi.org/10.1016/j.bbr.2011.08.003

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390-412. https://doi.org/10.1016/j.jml.2007.12.005

Bardeen, J. R., Fergus, T. A., & Orcutt, H. K. (2014). The moderating role of experiential avoidance in the prospective relationship between anxiety sensitivity and anxiety. *Cognitive Therapy and Research*, *38*(4), 465-471.

https://doi.org/10.1007/s10608-014-9614-z

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological bulletin*, *133*(1), 1-24. http://dx.doi.org/10.1037/0033-2909.133.1.1

Barker, T. V., Buzzell, G. A., & Fox, N. A. (2019). Approach, avoidance, and the detection of conflict in the development of behavioral inhibition. *New Ideas in Psychology*, *53*, 2-12. https://doi.org/10.1016/j.newideapsych.2018.07.001

Barlow, D. H. (2000). Unraveling the mysteries of anxiety and its disorders from the perspective of emotion theory. *American Psychologist*, *55*(11), 1247-1263. http://dx.doi.org/10.1037/0003-066X.55.11.1247

Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic*. NY: Guilford.

Barnes, D., & Roche, B. (1997). Relational frame theory and the experimental analysis of human sexuality. *Applied and Preventive Psychology*, *6*(3), 117-135. https://doi.org/10.1016/S0962-1849(97)80001-7

Barnes-Holmes, D., Barnes-Holmes, Y., Stewart, I., & Boles, S. (2010). A sketch of the Implicit Relational Assessment Procedure (IRAP) and the Relational Elaboration and Coherence (REC) model. *The Psychological Record*, *60*(3), 527. https://doi.org/10.1007/BF03395726

Barnes-Holmes, D., Hayden, E., Barnes-Holmes, Y., & Stewart, I. (2008). The Implicit Relational Assessment Procedure (IRAP) as a response-time and event-related-potentials methodology for testing natural verbal relations: A preliminary study. *The Psychological Record, 58*(4), 497. https://doi.org/10.1007/BF03395634

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, P. M., & Luciano, C. (2004). A derived transfer of mood functions through equivalence relations. *The Psychological Record*, *54*(1), 95-113. https://doi.org/10.1007/BF03395464

Barrett, P. M., Duffy, A. L., Dadds, M. R., & Rapee, R. M. (2001). Cognitive–behavioral treatment of anxiety disorders in children: Long-term (6-year) follow-up. *Journal of Consulting and Clinical Psychology*, *69*(1), 135. http://dx.doi.org/10.1037/0022-006X.69.1.135

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software, 67*(1), 1-48 (R package version version: 1.1-17). doi:10.18637/jss.v067.i01

Baujat, B., Mahé, C., Pignon, J. P., & Hill, C. (2002). A graphical method for exploring heterogeneity in meta-analyses: application to a meta-analysis of 65 trials. *Statistics in Medicine*, *21*(18), 2641-2652. https://doi.org/10.1002/sim.1221

Baum, M. (1970). Extinction of avoidance responding through response prevention (flooding). *Psychological Bulletin*, *74*(4), 276-284. http://dx.doi.org/10.1037/h0029789

Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do conscious thoughts cause behavior?. *Annual Review of Psychology, 62,* 331-361. https://doi.org/10.1146/annurev.psych.093008.131126

Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007). Psychology as the science of self-reports and finger movements: Whatever happened to actual behavior?. *Perspectives on Psychological Science*, *2*(4), 396-403. https://doi.org/10.1111/j.1745-6916.2007.00051.x

Beatty, G. F., Cranley, N. M., Carnaby, G., & Janelle, C. M. (2016). Emotions predictably modify response times in the initiation of human motor actions: A meta-analytic review. *Emotion*, *16*(2), 237.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1-3), 7–15. https://doi.org/10.1016/0010-0277(94)90018-3

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science*, *275*(5304), 1293-1295. doi: 10.1126/science.275.5304.1293

Beck, A. T., Epstein, N., Brown, G., Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology, 56*, 893-897. http://dx.doi.org/10.1037/0022-006X.56.6.893

Beckers, T., & Craske, M. G. (2017). Avoidance and decision making in anxiety: An introduction to the special issue. *Behaviour Research and Therapy*, *96*, 1. doi: 10.1016/j.brat.2017.05.009

Beckers, T., Krypotos, A. M., Boddez, Y., Effting, M., & Kindt, M. (2013). What's wrong with fear conditioning?. *Biological psychology*, *92*(1), 90-96. https://doi.org/10.1016/j.biopsycho.2011.12.015

Bednarek, D. B., Tarnowski, A., & Grabowska, A. (2006). Latencies of stimulus-driven eye movements are shorter in dyslexic subjects. *Brain and Cognition*, *60*(1), 64-69.

Begg, C. B., & Mazumdar, M. (1994). Operating characteristics of a rank correlation test for publication bias. *Biometrics*, 1088-1101. http://www.jstor.org/stable/2533446

Bellack, A. S., & Hersen, M. (1988). *Behavioral assessment*. New York, NY: Pergamon Press.

Berdoy, M., Webster, J. P., & Macdonald, D. W. (2000). Fatal attraction in rats infected with Toxoplasma gondii. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *267*(1452), 1591-1594. https://doi.org/10.1098/rspb.2000.1182

Berkowitz, L. (1983). Aversively stimulated aggression: Some parallels and differences in research with animals and humans. *American Psychologist, 38*(11), 1135–1144. https://doi.org/10.1037/0003-066X.38.11.1135

Berry, D. C., & Broadbent, D. E. (1984). On the relationship between task performance and associated verbalizable knowledge. *The Quarterly Journal of Experimental Psychology, Section A*, *36*(2), 209-231. https://doi.org/10.1080/14640748408402156

Berry, D. C., & Broadbent, D. E. (1988). Interactive tasks and the implicit-explicit distinction. *British Journal of Psychology*, *79*(2), 251-272. https://doi.org/10.1111/j.2044-8295.1988.tb02286.x

Biscaldi, M., Fischer, B., & Aiple, F. (1994). Saccadic eye movements of dyslexic and normal reading children. Perception, 23(1), 45-64.

Biscaldi, M., Fischer, B., & Hartnegg, K. (2000). Voluntary saccadic control in dyslexia. Perception, 29(5), 509-521.

Biscaldi, M., Gezeck, S., & Stuhr, V. (1998). Poor saccadic control correlates with dyslexia. Neuropsychologia, 36(11), 1189-1202.

Bissett, P. G., & Logan, G. D. (2012). Post-stop-signal adjustments: inhibition improves subsequent inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(4), 955-966. doi: 10.1037/a0026778

Bonanno, G. A. (2004). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events?. *American Psychologist*, *59*(1), 20.

Boyd, R. L., Robinson, M. D., & Fetterman, A. K. (2011). Miller (1944) revisited: Movement times in relation to approach and avoidance conflicts. *Journal of Experimental Social Psychology*, *47*(6), 1192-1197. https://doi.org/10.1016/j.jesp.2011.04.017

Bradley, B. P., Mogg, K., Falla, S. J., & Hamilton, L. R. (1998). Attentional bias for threatening facial expressions in anxiety: Manipulation of stimulus duration. *Cognition & Emotion*, *12*(6), 737-753.

Bramer, W. M. & de Jonge, G. B. (June, 2015). *Improving efficiency and confidence in systematic literature searching* [Workshop notes]. EAHIL+ICAHIS+ICLC, Edinburgh (UK), June 11th–12th. http://www.docs.is.ed.ac.uk/mvm/eahil2015/Workshop_sessions_detailed_descriptions.pdf

Brauer, M., & Curtin, J. J. (2017). Linear mixed-effects models and the analysis of nonindependent data: A unified framework to analyze categorical and continuous independent variables that vary within-subjects and/or within-items. *Psychological Methods, 23*(3), 389-411. http://dx.doi.org/10.1037/met0000159

Brehmer, B. (2007). Reasonable decision making in complex environments. In P. Juslin & H. Montgomery. (Eds.), *Judgment and Decision Making* (pp. 17-30). NY, New York: Psychology Press. (Original work published 1999)

Brehmer, B., & Allard, R. (1991). Dynamic decision making: The effects of task complexity and feedback delay. In J. Rasmussen, B. Brehmer, & J. Leplat (Eds.), *New technologies and work. Distributed decision making: Cognitive models for cooperative work* (pp. 319-334). Oxford, England: John Wiley & Sons.

Breidert, C., Hahsler, M., & Reutterer, T. (2006). A review of methods for measuring willingness-to-pay. *Innovative Marketing*, *2*(4), 8-32. Retrieved from https://pdfs.semanticscholar.org/6645/b7b08ec530f1201211dee550d045d3318e3d.pdf

Breiner, M. J., Stritzke, W. G., & Lang, A. R. (1999). Approaching avoidance. *Alcohol Research & Health*, *23*, 197-206.

Britton, J. C., Lissek, S., Grillon, C., Norcross, M. A., & Pine, D. S. (2011). Development of anxiety: The role of threat appraisal and fear learning. *Depression and anxiety*, *28*(1), 5-17. doi: 10.1002/da.20733

Broadbent, D. E., & Aston, B. (2007). Human control of a simulated economic system. *Ergonomics*, *21*(12), 1035-1043. (Original work 1978) https://doi.org/10.1080/00140137808931810

Broadbent, D. E., FitzGerald, P., & Broadbent, M. H. (1986). Implicit and explicit knowledge in the control of complex systems. *British Journal of Psychology*, *77*(1), 33-50. https://doi.org/10.1111/j.2044-8295.1986.tb01979.x

Brown, J. S. (1948). Gradients of approach and avoidance responses and their relation to level of motivation. *Journal of Comparative and Physiological Psychology*, *41*(6), 450-465. http://dx.doi.org/10.1037/h0055463

Bruce, S. E., Yonkers, K. A., Otto, M. W., Eisen, J. L., Weisberg, R. B., Pagano, M., ... & Keller, M. B. (2005). Influence of psychiatric comorbidity on recovery and recurrence in generalized anxiety disorder, social phobia, and panic disorder: a 12-year prospective study. *American Journal of Psychiatry*, *162*(6), 1179-1187. https://doi.org/10.1176/appi.ajp.162.6.1179

Bublatzky, F., Alpers, G. W., & Pittig, A. (2017). From avoidance to approach: The influence of threat-of-shock on reward-based decision making. *Behaviour Research and Therapy*, *96*, 47-56. https://doi.org/10.1016/j.brat.2017.01.003

Buetti, S., Juan, E., Rinck, M., & Kerzel, D. (2012). Affective states leak into movement execution: Automatic avoidance of threatening stimuli in fear of spider is visible in reach trajectories. *Cognition & Emotion*, *26*(7), 1176-1188. https://doi.org/10.1080/02699931.2011.640662

Bugelski, R. & Miller, N. E. (1938). A spatial gradient in the strength of avoidance responses. *Journal of Experimental Psychology*, *23*(5), 494 -505. http://dx.doi.org/10.1037/h0058936

Burghardt, G M. (Ed.) (1985). Foundations of animal behavior: Benchmark papers in ethology and comparative psychology. A review of foundations of ethology. NY, New York: Van Nostrand Reinhold.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: a dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review*, *100*(3), 432- 459. doi: 10.1037/0033-295X.100.3.432

Cacioppo, J. T. & Gardner, W. L. (1999). Emotion. *Annual Review of Psychology, 50*, 191-214. https://doi.org/10.1146/annurev.psych.50.1.191

Cacioppo, J. T., Berntson, G. G., Larsen, J. T., Poehlman, K. M., & Ito, T. A. (2000). The psychophysiology of emotion. In M. Lewis & J. M. Haviland-Jones (Eds.), *The handbook of emotions (3rd Ed.)*. New York, NY: Guilford Press.

Calcagnì, A., Lombardi, L., & Sulpizio, S. (2017). Analyzing spatial data from mouse tracker methodology: An entropic approach. *Behavior Research Methods*, *49*(6), 2012-2030. https://doi.org/10.3758/s13428-016-0839-5

Campbell-Sills, L., & Barlow, D. H. (2007). Incorporating Emotion Regulation into Conceptualizations and Treatments of

Anxiety and Mood Disorders. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 542-559). New York, NY, US: Guilford Press.

Cannon, W. B. (1927). The James-Lange theory of emotions: a critical examination and an alternative theory. *The American Journal of Psychology, 39,* 106-124. http://dx.doi.org/10.2307/1415404

Carleton, R. N., Collimore, K. C., & Asmundson, G. J. G. (2007). Social anxiety and fear of negative evaluation: Construct validity of the BFNE-II. *Journal of Anxiety Disorders, 21*, 131-141. doi:10.1016/j.janxdis.2006.03.010

Carleton, R. N., McCreary, D. R., Norton, P. J., & Asmundson, G. J. G. (2006). Brief Fear of Negative Evaluation Scale-Revised. *Depression and Anxiety, 23*, 297-303. doi:10.1002/ da. 20142

Carleton, R. N., Norton, M. P. J., & Asmundson, G. J. (2007). Fearing the unknown: A short version of the Intolerance of Uncertainty Scale. *Journal of anxiety disorders, 21*(1), 105-117.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioural activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology, 67* (2), 319-333. doi: 10.1037/0022-3514.67.2.319

Castriotta, N. N. (2013). *Anxiety and Avoidance: The Relationship, Function, and Measurement*. University of California, Los Angeles. Retrieved from ProQuest Digital Dissertations. (UMI Number: 3594097).

Chalmers, A. F. (1999). *What is this thing called science?* (3rd edition, pp. 213-225). Cambriedge, UK: Hackett Publishing Company, Inc.

Charpentier, C. J., De Neve, J. E., Li, X., Roiser, J. P., & Sharot, T. (2016). Models of affective decision making: how do feelings predict choice?. *Psychological Science*, *27*(6), 763-775. https://doi.org/10.1177/0956797616634654

Chen, F. K., Patel, P. J., Xing, W., Crossland, M. D., Bunce, C., Rubin, G. S., et al. (2011). Intrasession repeatability of fixation stability assessment with the Nidek MP-1. Optometry and Vision Science, 88(6), 742-750. doi: 710.1097/OPX.1090b1013e3182167641

Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and social psychology bulletin*, *25*(2), 215-224. https://doi.org/10.1177/0146167299025002007

Clark, D. A., & Beck, A. T. (2011). *Cognitive therapy of anxiety disorders: Science and practice*. Guilford Press.

Clark, L., Li, R., Wright, C. M., Rome, F., Fairchild, G., Dunn, B. D., & Aitken, M. R. (2012). Risk‐avoidant decision making increased by threat of electric shock. *Psychophysiology*, *49*(10), 1436-1443. https://doi.org/10.1111/j.1469-8986.2012.01454.x

Cochran, W. G. (1954). Some methods for strengthening the common χ2 tests. *Biometrics, 10,* 417–451. doi:10.2307/3001616

*Cochrane, A., Barnes-Holmes, D., & Barnes-Holmes, Y. (2008). The perceived-threat behavioral approach test (PT-BAT): Measuring avoidance in high-, mid-, and low-spider-fearful participants. *The Psychological Record*, *58*(4), 585. https://doi.org/10.1007/BF03395639

Cohen, D. C. (1977). Comparison of self-report and overt-behavioral procedures for assessing acrophobia. *Behavior Therapy*, *8*(1), 17-23. https://doi.org/10.1016/S0005-7894(77)80116-0

Connor, K. M., Davidson, J. R., Churchill, L. E., Sherwood, A., Weisler, R. H., & Foa, E. (2000). Psychometric properties of the Social Phobia Inventory (SPIN): New self-rating scale. *The British Journal of Psychiatry*, *176*(4), 379-386. https://doi.org/10.1192/bjp.176.4.379

Cooper, J. O., Heron, T. E., & Heward, W. L. (2014). *Applied Behavior Analysis* (2nd Ed.). London: Pearson Education Limited.

Cooper, M. L., Talley, A. E., Sheldon, M. S., Levitt, A., & Barber, L. L. (2008). A dyadic perspective on approach and avoidance motives for sexual behaviour. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 615-631). New York, NY: Psychology Press.

Corr, P. J. (2013). Approach and avoidance behaviour: Multiple systems and their interactions. *Emotion Review*, *5*(3), 285-290. https://doi.org/10.1177/1754073913477507

Costello, C. G. (1970). Dissimilarities between conditioned avoidance responses and phobias. *Psychological Review*, *77*(3), 250-254. http://dx.doi.org/10.1037/h0029228

Craske, M. G. (1999). *Anxiety disorders: psychological approaches to theory and treatment*. Boulder, CO, US: Westview Press.

Critchfield, T. S., Barnes-Holmes, D., & Dougher, M. J. (2018). What Sidman Did--Historical and Contemporary Significance of Research on Derived Stimulus Relations. *Perspectives on Behavior Science*, 41, 9–32. https://doi.org/10.1007/s40614-018-0154-9

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*(4), 281-302. http://dx.doi.org/10.1037/h0040957

Dale, R., Kehoe, C., & Spivey, M. J. (2007). Graded motor responses in the time course of categorizing atypical exemplars. *Memory & Cognition*, *35*(1), 15-28. https://doi.org/10.3758/BF03195938

Dalmaijer, E. S., Mathôt, S., & Van der Stigchel, S. (2014). PyGaze: An open-source, cross-platform toolbox for minimal-effort programming of eyetracking experiments. *Behavior Research Methods*, *46*(4), 913-921. https://doi.org/10.3758/s13428-013-0422-2

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *351*(1346), 1413-1420. https://doi.org/10.1098/rstb.1996.0125

Dan-Glauser, E. S., & Scherer, K. R. (2011). The Geneva affective picture database (GAPED): a new 730- picture database focusing on valence and normative significance. *Behavior Research Methods*, *43*(2), 468-477.

Darwin, C. (1965). *The expression of the emotions in man and animals*. London, UK: John Marry. (Original work published 1872).

Davey, G. C. (1994). Self-reported fears to common indigenous animals in an adult UK population: the role of disgust sensitivity. *British Journal of Psychology*, *85*(4), 541-554. doi: 10.1111/j.2044-8295.1994.tb02540.x

Davison, G. C. (1968). Systematic desensitization as a counterconditioning process. *Journal of Abnormal Psychology*, *73*(2), 91. http://dx.doi.org/10.1037/h0025501

De Houwer, J. (2003). The extrinsic affective Simon task. *Experimental Psychology*, *50*(2), 77. http://dx.doi.org/10.1026//1618-3169.50.2.77

De Houwer, J. (2006). What are implicit measures and why are we using them? In R. W. Wiers & A. W. Stacy (Eds.), *The handbook of implicit cognition and addiction* (pp. 11-28). Thousand Oaks, CA: Sage.

De Houwer, J. (2009). Comparing measures of attitudes at the functional and procedural level: Analysis and implications. In R. E. Petty, R. H. Fazio, & P. Brinol (Eds.), *Attitudes: Insights from the new implicit measures* (pp. 361-390). NY: Erlbaum.

De Houwer, J., Crombez, G., Baeyens, F., & Hermans, D. (2001). On the generality of the affective Simon effect. *Cognition & Emotion*, 15(2), 189-206. https://doi.org/10.1080/02699930125883

De Houwer, J., Teige-Mocigemba, S., Spruyt, A., & Moors, A. (2009). Implicit measures: A normative analysis and review. *Psychological Bulletin*, *135*(3), 347. doi:10.1037/a0014211

de Jong, P., van den Hout, M., Rietbroek, H., & Huijding, J. (2003). Dissociations between implicit and explicit attitudes toward phobic stimuli. *Cognition & Emotion*, *17*(4), 521-545. doi: 10.1080/02699930302305

de la Asuncion, J., Docx, L., Sabbe, B., Morrens, M., & De Bruijn, E. R. (2015). Converging evidence of social avoidant behavior in schizophrenia from two approach-avoidance tasks. *Journal of Psychiatric Research*, *69*, 135-141.

https://doi.org/10.1016/j.jpsychires.2015.08.008

De Villiers, P. A., & Herrnstein, R. J. (1976). Toward a law of response strength. *Psychological Bulletin, 83(6), 1131–1153*. http://dx.doi.org/10.1037/0033-2909.83.6.1131

de Vries, G. J., & Olff, M. (2009). The lifetime prevalence of traumatic events and posttraumatic stress disorder in the Netherlands. *Journal of Traumatic Stress: Official Publication of The International Society for Traumatic Stress Studies*, *22*(4), 259-267. doi: 10.1002/jts.20429.

Delprato, D. J. (1973). An animal analogue to systematic desensitization and elimination of avoidance. *Behaviour Research and Therapy*, *11*(1), 49-55. https://doi.org/10.1016/0005-7967(73)90068-5

Department of Social Protection. (2016) *Pct benef dep/anxiety RoI 2015* [Online]. Available from: http://publichealthwell.ie/node/1022469

Dertwinkel-Kalt, M., & Köhler, K. (2014). Exchange asymmetries for bads? Experimental evidence. *Experimental Evidence (February 2014)*. The Open Access Publication Server of the ZBW – Leibniz Information Centre for Economics.

Dibbets, P., & Fonteyne, R. (2015). High spider fearfuls can overcome their fear in a virtual approach-avoidance conflict task. *Journal of Depression & Anxiety*, *4*(2), 1-7. http://dx.doi.org/10.4172/2167-1044.1000182

Dickinson, A., & Pearce, J. M. (1977). Inhibitory interactions between appetitive and aversive stimuli. *Psychological Bulletin, 84*(4), 690-711. http://dx.doi.org/10.1037/0033-2909.84.4.690

Diederich, A. (2003). Decision making under conflict: Decision time as a measure of conflict strength. *Psychonomic Bulletin & Review, 10*(1), 167-176. https://doi.org/10.3758/BF03196481

Dillon, D. G., Deveney, C. M., & Pizzagalli, D. A. (2011). From Basic Processes to Real-World Problems: How Research on Emotion and Emotion Regulation Can Inform Understanding of Psychopathology, and Vice Versa. *Emotion Review, 3(1), 74–82*. doi:10.1177/1754073910380973

Dolan, R. J. (2002). Emotion, cognition, and behaviour. *Science, 298*(1191). doi: 10.1126/science.1076358

Dougher, M. J., & Hackbert, L. (2000). Establishing operations, cognition, and emotion. *The Behavior Analyst*, *23*(1), 11-24. https://doi.org/10.1007/BF03391996

*Dour, H. J., Brown, L. A., & Craske, M. G. (2016). Positive valence reduces susceptibility to return of fear and enhances approach behavior. *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 277-282. https://doi.org/10.1016/j.jbtep.2015.09.010

Dovidio, J. F., Kawakami, K., & Beach, K. R. (2001). Implicit and explicit attitudes: Examination of the relationship between measures of intergroup bias. *Blackwell handbook of social psychology: Intergroup processes*, *4*, 175-197.

Dymond, S. (2019). Overcoming avoidance in anxiety disorders: The contributions of Pavlovian and operant avoidance extinction methods. *Neuroscience & Biobehavioral Reviews*. https://doi.org/10.1016/j.neubiorev.2019.01.007

Dymond, S., & Roche, B. (2009). A contemporary behavior analysis of anxienty and avoidance. *The Behavior Analyst, 32*(1), 7-27. https://doi.org/10.1007/BF03392173

Dymond, S., Bennett, M., Boyle, S., Roche, B., & Schlund, M. (2018). Related to anxiety: Arbitrarily applicable relational responding and experimental psychopathology research on fear and avoidance. *Perspectives on Behavior Science*, *41*(1), 189-213. https://doi.org/10.1007/s40614-017-0133-6

Eder, A. B., Rothermund, K., & Proctor, R. W. (2010). The prepared emotional reflex: Intentional preparation of automatic approach and avoidance tendencies as a means to regulate emotional responding. *Emotion, 10*(4), 593. doi:10.1037/a0019009

Edwards, A. L. (1957). *The social desirability variable in personality assessment and research*. Ft Worth, TX: Dryden Press.

*Effting, M., Salemink, E., Verschuere, B., & Beckers, T. (2016). Implicit and explicit measures of spider fear and avoidance behavior: Examination of the moderating role of working memory capacity. *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 269-276. https://doi.org/10.1016/j.jbtep.2015.10.003

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *Behavioral Medicine Journal*, *315*(7109), 629-634. https://doi.org/10.1136/bmj.315.7109.629

Eifert, G. H., & Forsyth, J. P. (2007). From normal anxiety to anxiety disorders: An experimental avoidance perspective. In D.W. Woods & J. W. Kanter (Eds.), *Understanding behavior disorders: A contemporary behavioural perspective* (pp. 81-116). Reno, NV: Context Press.

Ekman, P. (1994) All emotions are basic. In P. Ekman & R. J. Davidson (Eds.). *The Nature of Emotion: Fundamental Questions* (pp. 128-133). New York, NY: Oxford University Press.

Elliot, A. J. & Covington, M. V. (2001). Approach and avoidance motivation. *Educational Psychology Review, 13(2),* 73-92. doi: 1040-726X/01/0600-0073

Elliot, A. J. (2006). The hierarchical model of approach-avoidance motivation. *Motivation and Emotion*, *30*(2), 111-116. https://doi.org/10.1007/s11031-006-9028-7

Elliot, A. J. (2008). Approach and avoidance motivation. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 3-14). New York, NY: Psychology Press.

Elliot, A. J., Gable, S. L., & Mapes, R. R. (2006). Approach and avoidance motivation in the social domain. *Personality and Social Psychology Bulletin*, *32*(3), 378-391. https://doi.org/10.1177/0146167205282153

Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General*, *136*(1), 154-168.

*Ellwart, T., Rinck, M., & Becker, E. S. (2006). From fear to love: individual differences in implicit spider associations. *Emotion*, *6*(1), 18.

Engelhard, I. M., Van Den Hout, M. A., Weerts, J. O. S., Arntz, A., Hox, J. J., & McNally, R. J. (2007). Deployment-related stress and trauma in Dutch soldiers returning from Iraq: Prospective study. *The British Journal of Psychiatry*, *191*(2), 140-145. https://doi.org/10.1192/bjp.bp.106.034884

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, *49*(8), 709.

Epstein, S., & Fenz, W. D. (1965). Steepness of approach and avoidance gradients in humans as a function of experience: Theory and experiment. *Journal of Experimental Psychology, 70,* 1–12. http://dx.doi.org/10.1037/h0021990

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007) [version used: 3.1.9.4]. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavioral Research Methods*, *39*(2), 175-91. https://doi.org/10.3758/BF03193146

Fazio, R. H., Sanbonmatsu, D. M., Powell, M. C., & Kardes, F. R. (1986). On the automatic activation of attitudes. *Journal of Personality and Social Psychology*, *50*(2), 229.

Fazio, R. H., Williams, C. J., & Sanbonmatsu, D. M. (1990). Toward an unobtrusive measure of attitude. *Unpublished manuscript, Department of Psychology, Indiana University, Bloomington, IN*.

Fechner, G. T. (1860). *Elemente der Psychophysik* (Vol. 1). Leipzig: Breitkopf & Härtel. [Also available as Fechner, G. T., Howes, D. H., & Boring, E. G. (1966). *Elements of psychophysics* (Vol. 1). New York, NY: Holt, Rinehart and Winston.]

Fergus, T. A. (2015). I really believe I suffer from a health problem: Examining an association between cognitive fusion and healthy anxiety. *Journal of Clinical Psychology, 71*(9), 920-934. https://doi.org/10.1002/jclp.22194

Field, A. P. (2003a). The problems of using fixed-effects models of meta-analysis on real-world data. *Understanding Statistics, 2*, 77-96. doi:10.1207/S15328031US0202_02

Field, A. P. (2003b). Can meta-analysis be trusted? *Psychologist*, *16*(12), 642-645.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, *13*(1), 1-17. https://doi.org/10.1002/(SICI)1099-0771(200001/03)13:1<1::AID-BDM333>3.0.CO;2-S

Finucane, M. L., Peters, E., & Slavic, P. (2003). Judgment and Decision Making: The Dance of Affect and Reason. In S. L. Schneider & J. Shanteau (Eds.), *Emerging Perspectives on Judgment and Decision Research* (pp. 327-364). Cambridge; UK: University Press.

Fisher, Z., & Tipton, E. (2015). robumeta: An R-package for robust variance estimation in meta-analysis. *arXiv preprint arXiv:1503.02220*.

Foa, E. B., Zinbarg, R., & Rothbaum, B. O. (1992). Uncontrollability and unpredictability in post-traumatic stress disorder: an animal model. *Psychological Bulletin*, *112*(2), 218-238. http://dx.doi.org/10.1037/0033-2909.112.2.218.

Forsyth, J. P. (1999). A process-Oriented Behavioral Approach to the Etiology, Maintenance, and Treatment of Anxiety-Related Disorders. In M. J. Dougher (Ed.), *Clinical Behavior Analysis* (pp. 153-180). Reno, Nevada, USA: Context Press.

Forsyth, J. P., Eifert, G. H., & Barrios, V. (2006). Fear conditioning research as a clinical analog: What makes fear learning disordered? In M. G. Craske, D. Hermans, & D. Vansteenwegen (Eds.), *Fear and learning: From basic processes to clinical implications* (pp. 133-153). Washington, DC, US: American Psychological Association.

Fox, A. S., Lapate, R. C., Davidson, R. J. & Shackman, A. J. (in press). Epilogue—The nature of emotion: A research agenda for the 21st century. In Fox, A. S., Lapate, R. C., Shackman, A. J. & Davidson, R. J. (Eds.). *The nature of emotion: Fundamental questions* (2nd ed.). NY: Oxford University Press.

Fredrikson, M., Annas, P., Fischer, H., & Wik, G. (1996). Gender and age differences in the prevalence of specific fears and phobias. *Behaviour Research and Therapy*, *34*(1), 33-39. https://doi.org/10.1016/0005-7967(95)00048-3

Freeman, J. B., & Ambady, N. (2010). MouseTracker: Software for studying real-time mental processing using a computer mouse-tracking method. *Behavior Research Methods*, *42*(1), 226-241. https://doi.org/10.3758/BRM.42.1.226

Freeman, J., Dale, R., & Farmer, T. (2011). Hand in motion reveals mind in motion. *Frontiers in Psychology*, *2*, 59. https://doi.org/10.3389/fpsyg.2011.00059

Frijda, N. H (1986). *The Emotions*. London: Cambridge University Press.

Frijda, N. H. (1988). The laws of emotion. *American Psychologist*, *43*(5), 349.

Frijda, N. H. (2017). *The laws of emotion*. New York, NY: Psychology Press. https://doi.org/10.4324/9781315086071

Frijda, N. H., & Scherer, K. R. (2009). Emotion definitions (psychological perspectives). In D. Sander & K. R. Scherer (Eds.), *Oxford companion to emotion and the affective sciences*. NY, New York: Oxford University Press.

Gallivan, J. P., & Chapman, C. S. (2014). Three-dimensional reach trajectories as a probe of real-time decision-making between multiple competing targets. *Frontiers in Neuroscience*, *8*, 215. https://doi.org/10.3389/fnins.2014.00215

Gámez, W., Chmielewski, M., Kotov, R., Ruggero, C., Suzuki, N., & Watson, D. (2014). The brief experiential avoidance questionnaire: development and initial validation. *Psychological Assessment, 26*(1), 35. doi: 10.1037/a0034473

Gannon, S., Roche, B., Kanter, J. W., Forsyth, J. P., & Linehan, C. (2011). A derived relations analysis of approach-avoidance conflict: Implications for the behavioral analysis of human anxiety. *The Psychological Record*, *61*(2), 227-252. https://doi.org/10.1007/BF03395758

Garcia-Guerrero, S., Dickins, T. E., & Dickins, D. W. (2014). The gradual extinction of transferred avoidance stimulus functions. *The Psychological Record*, *64*(3), 581-599.

https://doi.org/10.1007/s40732-014-0062-7

Garcia-Palacios, A., Hoffman, H., Carlin, A., Furness III, T. A., & Botella, C. (2002). Virtual reality in the treatment of spider phobia: a controlled study. *Behaviour Research and Therapy*, *40*(9), 983-993.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: an integrative review of implicit and explicit attitude change. *Psychological Bulletin*, *132*(5), 692.

Geller, I., & Seifter, J. (1960). The effects of meprobamate, barbiturates, d-amphetamine and promazine on experimentally induced conflict in the rat. Psychopharmacologia, 1(6), 482-492. https://doi.org/10.1007/BF00429273

Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time. *Department of Statistics, Columbia University*. Retrieved from http://www.stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf

Gerdes, A. B., Alpers, G. W., & Pauli, P. (2008). When spiders appear suddenly: Spider-phobic patients are distracted by task-irrelevant spiders. *Behaviour Research and Therapy*, *46*(2), 174-187. https://doi.org/10.1016/j.brat.2007.10.010

Ginat-Frolich, R., Klein, Z., Aderka, I. M., & Shechner, T. (2019). Reducing avoidance in adults with high spider fear using perceptual discrimination training. *Depression and anxiety*. https://doi.org/10.1002/da.22930

Ginsburg, G. S., Kendall, P. C., Sakolsky, D., Compton, S. N., Piacentini, J, Albano, A. M., Walkup, J. T., Sherrill, J., Coffey, K. A., Rynn, M. A., Keeton, C. P., McCracken, J. T., Bergman, L., Iyengar, S., Birmaher, B., & March, J. (2011). Remission after acute treatment in children and adolescents with anxiety disorders: findings from the CAMS. *Journal of Consulting and Clinical Psychology*, *79*(6), 806-813. http://dx.doi.org/10.1037/a0025933

Golkar, A., Bellander, M., Olsson, A., & Öhman, A. (2012). Are fear memories erasable?–reconsolidation of learned fear with fear-relevant and fear-irrelevant stimuli. *Frontiers in Behavioral Neuroscience*, *6*, 80. https://doi.org/10.3389/fnbeh.2012.00080

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour research and therapy*, *8*(3), 249-266. https://doi.org/10.1016/0005-7967(70)90069-0

Gray, J. A. (1975). *Elements of a two-process theory of learning*. Oxford, England: Academic Press.

Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: attitudes, self-esteem, and stereotypes. *Psychological Review*, *102*(1), 4. doi:10.1037/0033-295X.102.1.4

Greenwald, A. G., & Nosek, B. A. (2001). Health of the Implicit Association Test at age 3. *Zeitschrift für Experimentelle Psychologie*, *48*(2), 85-93.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464-1480. doi: 10.1037/0022-3514.74.6.1464

Grillon, C., Baas, J. M., Cornwell, B., & Johnson, L. (2006). Context conditioning and behavioral avoidance in a virtual reality environment: effect of predictability. *Biological Psychiatry*, *60*(7), 752-759. https://doi.org/10.1016/j.biopsych.2006.03.072

Gross, J. J. (Ed.) (2007). *Handbook of emotion regulation*. New York, NY: Guilford Press.

Guion, R. M. (1980). On Trinitarian doctrines of validity. *Professional Psychology*, *11*(3), 385-398. http://dx.doi.org/10.1037/0735-7028.11.3.385

Hahn, A., Judd, C. M., Hirsh, H. K., & Blair, I. V. (2014). Awareness of implicit attitudes. *Journal of Experimental Psychology: General*, *143*, 1369-1392. doi:10.1037/a0035028

Hare, R. D. (1966). Preference for delay of shock as a function of its intensity and probability. *Psychonomic Science*, *5*(10), 393-394. https://doi.org/10.3758/BF03328456

Hartley, C. A., Gorun, A., Reddan, M. C., Ramirez, F., & Phelps, E. A. (2014). Stressor controllability modulates fear extinction in humans. *Neurobiology of Learning and Memory*, *113*, 149-156. https://doi.org/10.1016/j.nlm.2013.12.003

Hayes, N. A., & Broadbent, D. E. (1988). Two modes of learning for interactive tasks. *Cognition*, *28*(3), 249-276. https://doi.org/10.1016/0010-0277(88)90015-7

Hayes, S. C. (1976). The role of approach contingencies in phobic behavior. *Behavior Therapy, 7(1), 28-36.* http://dx.doi.org/10.1016/S0005-7894(76)80216-X

Hayes, S. C. (1989). *Rule-governed behavior: Cognition, contingencies, and instructional control*. New York, NY, US: Plenum Press.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. New York, NY, US: Kluwer Academic/Plenum Publishers.

Hayes, S. C., Lattal, K. A., & Myerson, W. A. (1979). Strength of experimentally induced phobic behavior in rats: Avoidance versus dual-component formulations. *Psychological Reports*, *44*(3), 891-894. https://doi.org/10.2466/pr0.1979.44.3.891

Hayes, S. C., Strosahl, K., & Wilson, K. G. (1999). *Acceptance and Commitment Therapy: An experiential approach to behavior change*. New York, NY: Guilford Press.

Hayes, S. C., Wilson, K. G., Gifford, E. V., Follette, V. M., & Strosahl, K. (1996). Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of consulting and clinical psychology*, *64*(6), 1152-1168. http://dx.doi.org/10.1037/0022-006X.64.6.1152

Haynes, S. N., & Lench, H. C. (2003). Incremental Validity of New Clinical Assessment Measures. *Psychological Assessment*, *15*(4), 456-466. http://dx.doi.org/10.1037/1040-3590.15.4.456

Health Service Executive - HSE. (2018) *National Service Plan 2019*. Report available from: http://publichealthwell.ie/node/1232167

Hehman, E., Stolier, R. M., & Freeman, J. B. (2015). Advanced mouse-tracking analytic techniques for enhancing psychological science. *Group Processes & Intergroup Relations*, *18*(3), 384-401. https://doi.org/10.1177/1368430214538325

Heiberger, R. M. (2018). HH: Statistical Analysis and Data Display: Heiberger and Holland. R package version 3.1-35. URL https://CRAN.R-project.org/package=HH

Heiberger, R. M., & Robbins, N. B. (2014). Design of diverging stacked bar charts for Likert scales and other applications. *Journal of Statistical Software*, *57*(5), 1-32. http://www.jstatsoft.org/v57/i05/

Herrnstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of the Experimental Analysis of Behavior, 4(3), 267–272.* doi:10.1901/jeab.1961.4-267

Heuer, K., Rinck, M., & Becker, E. S. (2007). Avoidance of emotional facial expressions in social anxiety: The approach–avoidance task. *Behaviour Research and Therapy*, *45*(12), 2990-3001. https://doi.org/10.1016/j.brat.2007.08.010

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine*, *21*, 1539–1558. doi:10.1002/sim.1186

Hinde, R. A. (1966). *Animal Behaviour*. NY, New York: McGraw-Hill Book Company.

Hoad T. F. (2003). *The Concise Oxford Dictionary of Etymology*. Oxford University Press. Available from http://www.oxfordreference.com/view/10.1093/acref/9780192830982.001.0001/acref-9780192830982

Hodges, W. F. (1976). The psychophisiology of anxiety. In M. Zuckerman & C. D. Spielberger (Eds.), *Emotions and anxiety: New concepts, methods, and applications* (pp. 175-194). Hillsdale, HJ: Erlbaum.

Hodgson, R., & Rachman, S. (1974). II. Desynchrony in measures of fear. *Behaviour Research and Therapy*, *12*(4), 319-326. https://doi.org/10.1016/0005-7967(74)90006-0

Hofmann, S. G. (2008). Cognitive processes during fear acquisition and extinction in animals and humans: Implications for exposure therapy of anxiety disorders. *Clinical Psychology Review*, *28*(2), 199-210. https://doi.org/10.1016/j.cpr.2007.04.009

Hofmann, S. G., & Hay, A. C. (2018). Rethinking avoidance: Toward a balanced approach to avoidance in treating anxiety disorders. *Journal of Anxiety Disorders*, *55*, 14-21. https://doi.org/10.1016/j.janxdis.2018.03.004

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the Implicit Association Test and explicit self-report measures. *Personality and Social Psychology Bulletin*, *31*(10), 1369-1385. https://doi.org/10.1177/0146167205275613

Hofmann, W., Gschwendner, T., Friese, M., Wiers, R. W., & Schmitt, M. (2008). Working memory capacity and self-regulatory behavior: toward an individual differences perspective on behavior determination by automatic versus controlled processes. *Journal of Personality and Social Psychology*, *95*(4), 962. doi:10.1037/a0012705

Holmes, E. A., Craske, M. G., & Graybiel, A. M. (2014). Psychological treatments: A call for mental-health science. *Nature News*, *511*(7509), 287.

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & van de Weijer, J. (2011). Eye Tracking - A Comprehensive Guide to Methods and Measures (1 ed.). New York: Oxford University Press.

Horowitz, J. K., & McConnell, K. E. (2002). A review of WTA/WTP studies. *Journal of Environmental Economics and Management*, *44*(3), 426-447. https://doi.org/10.1006/jeem.2001.1215

Hovland, C. I. & Sears, R. R. (1937). Experiments on motor conflict I: Types of conflict and their modes of resolution. Paper presented at the *Meetings of the American Psychological Association at Minnesapolis, Sept*, 1937.

Hovland, C. I. & Sears, R. R. (1938). Experiments on motor conflict I: Types of conflict and their modes of resolution. *Journal of Experimental Psychology*, *23*(5), 477-494.

*Huijding, J., & de Jong, P. J. (2005). A pictorial version of the Extrinsic Affective Simon Task: Sensitivity to generally affective and phobia-relevant stimuli in high and low spider fearful individuals. *Experimental Psychology*, *52*(4), 289-295. http://dx.doi.org/10.1027/1618-3169.52.4.289

*Huijding, J., & de Jong, P. J. (2006). Specific predictive power of automatic spider-related affective associations for controllable and uncontrollable fear responses toward spiders. *Behaviour Research and Therapy*, *44*(2), 161-176. https://doi.org/10.1016/j.brat.2005.01.007

Huijding, J., & de Jong, P. J. (2007). Beyond fear and disgust: The role of (automatic) contamination-related associations in spider phobia. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(2), 200-211. https://doi.org/10.1016/j.jbtep.2006.10.009

*Huijding, J., & De Jong, P. J. (2009). Implicit and explicit attitudes toward spiders: Sensitivity to treatment and predictive value for generalization of treatment effects. *Cognitive Therapy and Research*, *33*(2), 211-220. https://doi.org/10.1007/s10608-007-9167-5

IntHout, J., Ioannidis, J. P., Borm, G. F., & Goeman, J. J. (2015). Small studies are more heterogeneous than large ones: a meta-meta-analysis. *Journal of Clinical Epidemiology*, *68*(8), 860-869. https://doi.org/10.1016/j.jclinepi.2015.03.017

James, W. (1884). What is an Emotion? *Mind*, 9(34), 188-205. https://doi.org/10.1093/mind/os-IX.34.188

Jones, A. C. & Gosling, S. D. (2008). Individual differences in approach and avoidance motivation in animals. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 165-185). New York, NY: Psychology Press.

Jorm, A. F., Christensen, H., Henderson, A. S., Jacomb, P. A., Korten, A. E., & Rodgers, B. (1999). Using the BIS/BAS scales to measure behavioural inhibition and behavioural activation: Factor structure, validity and norms in a large community sample. *Personality and Individual Differences, 26*(1), 49-58. http://dx.doi.org/10.1016/S0191-8869(98)00143-3

Judd, F., & Burrows, G. (2001). The nature of anxiety. In S. Bloch & B. S. Singh (Eds.), *Foundations of Clinical Psychiatry*, (pp. 128-148). Melbourne, Australia: Melbourne University Press.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263-292. doi: 10.2307/1914185. https://www.jstor.org/stable/1914185

Kahneman, D., Slovic, S. P., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge: UK: University Press.

Katz, A., Webb, L., & Stotland, E. (1971). Cognitive influences on the rate of GSR extinction. *Journal of Experimental Research in Personality, 5*(3), 208–215.

Kazdin, A. E., & Kagan, J. (1994). Models of dysfunction in developmental psychopathology. *Clinical Psychology: Science and Practice*, *1*(1), 35-52. https://doi.org/10.1111/j.1468-2850.1994.tb00005.x

Kelley, M. E., Liddon, C. J., Ribeiro, A., Greif, A. E., & Podlesnik, C. A. (2015). Basic and translational evaluation of renewal of operant responding. *Journal of Applied Behavior Analysis*, *48*(2), 390-401. https://doi.org/10.1002/jaba.209

Kelso, J. A. S. (1995). *Dynamic Patterns: The self-organization of brain and behavior.* London, UK: A Bradford Book, The MIT Press.

Kennedy, D. P., Gläscher, J., Tyszka, J. M., & Adolphs, R. (2009). Personal space regulation by the human amygdala. *Nature Neuroscience*, *12*(10), 1226-1227. doi:10.1038/nn.2381

Kenrick, D. T. & Shiota, M. N. (2008). Approach and avoidance motivation(s): An evolutionary perspective. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 273-288). New York, NY: Psychology Press.

Kessler, R. C., McGonagle, K. A., Zhao, S., Nelson, C. B., Hughes, M., Eshleman, S., ... & Kendler, K. S. (1994). Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States: results from the National Comorbidity Survey. *Archives of General Psychiatry*, *51*(1), 8-19. doi:10.1001/archpsyc.1994.03950010008002

Khan, S., & Petróczi, A. (2015). Stimulus-response compatibility tests of implicit preference for food and body image to identify people at risk for disordered eating: a validation study. *Eating behaviors*, 16, 54-63. https://doi.org/10.1016/j.eatbeh.2014.10.015

Kieslich, P. J., & Henninger, F. (2017). Mousetrap: An integrated, open-source mouse-tracking package. *Behavior Research Methods*, *49*(5), 1652-1667 (R package version version: 3.1.0). https://doi.org/10.3758/s13428-017-0900-z

Kieslich, P. J., Henninger, F., Wulff, D. U., Haslbeck, J. M. B., & Schulte-Mecklenbeck, M. (in press). Mouse-tracking: A practical guide to implementation and analysis. In M. Schulte-Mecklenbeck, A. Kühberger, & J. G. Johnson (Eds.), *A Handbook of Process Tracing Methods*. New York: Taylor & Francis.

Killeen, P. R. (1992). Mechanics of the animate. *Journal of the experimental Analysis of Behavior, 57*(3), 429-463. https://doi.org/10.1901/jeab.1992.57-429

Kim, B. W., Kennedy, D. N., Lehár, J., Lee, M. J., Blood, A. J., Lee, S., ... & Breiter, H. C. (2010). Recurrent, robust and scalable patterns underlie human approach and avoidance. *PLoS One*, *5*(5), e10613. https://doi.org/10.1371/journal.pone.0010613

Kimmel, H. D. (1971). *Experimental psychopathology: Recent research and theory*. New York, NY: Academic Press.

Kircanski, K., Lieberman, M. D., & Craske, M. G. (2012). Feelings into words: contributions of language to exposure therapy. *Psychological Science*, *23*(10), 1086-1091. https://doi.org/10.1177/0956797612443830

Kirlic, N., Young, J., & Aupperle, R. L. (2017). Animal to human translational paradigms relevant for approach avoidance conflict decision making. *Behaviour Research and Therapy*, *96*, 14-29. https://doi.org/10.1016/j.brat.2017.04.010

Klorman, R., Weerts, T. C., Hastings, J. E., Melamed, B. G., & Lang, P. J. (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy*, *5*(3), 401-409. https://doi.org/10.1016/S0005-7894(74)80008-0

Koch, M. D., O'Neill, H. K., Sawchuk, C. N., & Connolly, K. (2002). Domain-specific and generalized disgust sensitivity in blood-injection-injury phobia: The application of behavioral approach/avoidance tasks. *Journal of Anxiety Disorders*, *16*(5), 511-527. https://doi.org/10.1016/S0887-6185(02)00170-6

Koop, G. & Johnson, J. G. (2011). Response dynamics: A new window on the decision process. *Judgment and Decision Making*, *6*(8), 750–758.

Koop, G. J., & Johnson, J. G. (2013). The response dynamics of preferential choice. *Cognitive Psychology*, *67*(4), 151-185. https://doi.org/10.1016/j.cogpsych.2013.09.001

Kozak, M. J., & Cuthbert, B. N. (2016). The NIMH research domain criteria initiative: background, issues, and pragmatics. *Psychophysiology*, *53*(3), 286-297. doi:10.1111/psyp.12518

Krizan, Z., & Suls, J. (2008). Are implicit and explicit measures of self-esteem related? A meta-analysis for the Name-Letter Test. *Personality and Individual Differences*, *44*(2), 521-531. https://doi.org/10.1016/j.paid.2007.09.017

Krypotos, A. M., Arnaudova, I., Effting, M., Kindt, M., & Beckers, T. (2015). Effects of approach-avoidance training on the extinction and return of fear responses. *PloS One*, *10*(7), e0131581. https://doi.org/10.1371/journal.pone.0131581

Krypotos, A. M., Effting, M., Kindt, M., & Beckers, T. (2015). Avoidance learning: a review of theoretical models and recent developments. *Frontiers in Behavioral Neuroscience, 9*. doi:10.3389/fnbeh.2015.00189

Krypotos, A. M., Vervliet, B., & Engelhard, I. M. (2018). The validity of human avoidance paradigms. *Behaviour Research and Therapy*, *111*, 99-105. https://doi.org/10.1016/j.brat.2018.10.011

Kurdi, B., Seitchik, A. E., Axt, J. R., Carroll, T. J., Karapetyan, A., Kaushik, N., & Banaji, M. R. (2018). Relationship between the Implicit Association Test and intergroup behavior: A meta-analysis. *American psychologist*. doi: 10.1037/amp0000364 Retrived from: https://www.researchgate.net/publication/329666147

Laham, S. M., Kashima, Y., Dix, J., & Wheeler, M. (2015). A meta-analysis of the facilitation of arm flexion and extension movements as a function of stimulus valence. *Cognition and Emotion*, *29*(6), 1069-1090. https://doi.org/10.1080/02699931.2014.968096

Lang, P. (1984). Cognition in emotion: Concept and action. In C. Izard, J. Kagan, & R. Zajonc (Eds.), *Emotion, Cognition, and Behavior* (pp. 196–226). NY, New York: Cambridge University Press.

Lang, P. J. (1968). Fear reduction and fear behavior: Problems in treating a construct. In J. M. Shlien (Ed.), *Research in Psychotherapy*, (pp.90-102). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/10546-004

Lang, P. J. (1978). Anxiety: Toward a psychophysiological definition. In H. S. Akiskal & W. L. Webb (Eds.), *Psychiatric diagnosis: Exploration of biological predictors* (pp. 365–389). NY: Spectrum.

Lang, P. J. (1985). The cognitive psychophysiology of emotion: Fear and anxiety. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the Anxiety Disorders* (pp. 131-170). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Lang, P. J. (1988). What are the data of emotion? In V. Hamilton, G. H. Bower & N. Frijda (Eds.), *Cognitive perspectives on emotion and motivation*. Amsterdam: Martinus Nijhoff Publishers.

Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist, 50(5), 372–385*. doi:10.1037/0003-066x.50.5.372

Lang, P. J. (2010). Emotion and motivation: Toward consensus definitions and a common research purpose. *Emotion Review*, *2*(3), 229-233. doi: 10.1177/1754073910361984

Lang, P. J., & Lazovik, A. D. (1963). Experimental desensitization of phobia. *The Journal of Abnormal and Social Psychology*, *66*(6), 519. http://dx.doi.org/10.1037/h0039828

Lang, P., & Bradley, M. M. (2007). The International Affective Picture System (IAPS) in the study of emotion and attention. In J. A. Coan & J. J. B. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 29-46). New York, NY: Oxford University Press.

Lang, P.J., Bradley, M. M., Cuthbert, B. N. (1997) Motivated attention: affect, activation, and action. In: P. J. Lang, R.F. Simons, M. T. Balaban (Eds.), *Attention and Orienting: Sensory and Motivational Processes* (pp. 97–135). New Jersey, NJ: Erlbaum, Hillsdale.

Lang, P.J., Bradley, M. M., Cuthbert, B. N. (1998). Emotion, motivation and anxiety: Brain mechanisms and psychophysiology. *Biological psychiatry*, *44*(12), 1248-1263. https://doi.org/10.1016/S0006-3223(98)00275-3

Laraway, S., Snycerski, S., Olson, R., Becker, B., & Poling, A. (2014). The motivating operations concept: current status and critical response. *The Psychological Record*, *64*(3), 601-623. https://doi.org/10.1007/s40732-014-0080-5

Lazarus, R. S. (1991). *Emotion and adaptation*. New York, NY: Oxford University Press.

Leary, M. R. (1983). A brief version of the Fear of Negative Evaluation Scale. *Personality and Social Psychology Bulletin, 9*, 371-375. doi:10.1177/0146167283093007

LeDoux, J. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience*, *23*, 155–184. https://doi.org/10.1146/annurev.neuro.23.1.155

LeDoux, J. E. (2012). Evolution of human emotion: a view through fear. *Progress in Brain Research*, *195*,431-442. doi: 10.1016/B978-0-444-53860-4.00021-0

LeDoux, J. E. (2014). Coming to terms with fear. *Proceedings of the National Academy of Sciences*, *111*(8), 2871-2878. https://doi.org/10.1073/pnas.1400335111

LeDoux, J. E. (2017). Semantics, surplus meaning, and the science of fear. *Trends in Cognitive Sciences*, *21*(5), 303-306. https://doi.org/10.1016/j.tics.2017.02.004

LeDoux, J. E., & Pine, D. S. (2016). Using neuroscience to help understand fear and anxiety: a two-system framework. *American Journal of Psychiatry*, *173*(11), 1083-1093. https://doi.org/10.1176/appi.ajp.2016.16030353

LeDoux, J. E., Moscarello, J., Sears, R., & Campese, V. (2017). The birth, death and resurrection of avoidance: a reconceptualization of a troubled paradigm. *Molecular Psychiatry*, *22*(1), 24-36. doi:10.1038/mp.2016.166

*Leech, A., Barnes-Holmes, D., & Madden, L. (2016). The Implicit Relational Assessment Procedure (IRAP) as a measure of spider fear, avoidance, and approach. *The Psychological Record*, *66*(3), 337-349. https://doi.org/10.1007/s40732-016-0176-1

Leek, M. R. (2001). Adaptive procedures in psychophysical research. *Perception & Psychophysics*, *63*(8), 1279-1292. https://doi.org/10.3758/BF03194543

Levitt, E. E. (1967). *The psychology of anxiety*. New York, NY: Bobbs-Merill.

Levy, D. L., Holzman, P. S., Matthysse, S., & Mendel, N. R. (1993). Eye Tracking Dysfunction and Schizophrenia: A Critical Perspective. *Schizophrenia Bulletin, 19*, (3), 461-536.

Levy, D. L., Holzman, P. S., Matthysse, S., & Mendel, N. R. (1994). Eye Tracking and Schizophrenia: A Selective Review. *Schizophrenia Bulletin, 20*, (1), 47-62.

Lewin, K. (1935). *A dynamic theory of personality*. New York, NY: McGraw-Hill.

Lewis, S. J., Arseneault, L., Caspi, A., Fisher, H. L., Matthews, T., Moffitt, T. E., ... & Danese, A. (2019). The epidemiology of trauma and post-traumatic stress disorder in a representative cohort of young people in England and Wales. *The Lancet Psychiatry*, *6*(3), 247-256. https://doi.org/10.1016/S2215-0366(19)30031-8

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., ... & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Medicine*, *6*(7), e1000100. https://doi.org/10.1371/journal.pmed.1000100

Liebowitz, M. R. (1987). Social phobia. In D. F. Klein (Ed.), *Anxiety*. (pp. 141-173). New York, NY: Karger Publishers.

Lipsitz, J. D., Mannuzza, S., Klein, D. F., Ross, D. C., & Fyer, A. J. (1999). Specific phobia 10–16 years after treatment. *Depression and Anxiety*, *10*(3), 105-111. https://doi.org/10.1002/(SICI)1520-6394(1999)10:3<105::AID-DA3>3.0.CO;2-X

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological bulletin*, *127*(2), 267-286. doi: 10.1037/0033-2909.127.2.267

Lonsdorf, T. B., & Merz, C. J. (2017). More than just noise: Inter-individual differences in fear acquisition, extinction and return of fear in humans-Biological, experiential, temperamental factors, and methodological pitfalls. *Neuroscience & Biobehavioral Reviews*, *80*, 703-728. https://doi.org/10.1016/j.neubiorev.2017.07.007

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., ... & Drexler, S. M. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience & Biobehavioral Reviews*, *77*, 247-285. https://doi.org/10.1016/j.neubiorev.2017.02.026

Løvborg, L., & Brehmer, B. (1991). *NEWFIRE-A flexible system for running simulated fire-fighting experiments*. Risø National Laboratory for Sustainable Energy, Technical University of Denmark, Denmark.

Luce, M. F., Bettman, J. R., & Payne, J. W. (1997). Choice processing in emotionally difficult decisions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(2), 384.

Luciano, C., Valdivia-Salas, S., Ruiz, F. J., Rodríguez-Valverde, M., Barnes-Holmes, D., Dougher, M. J., ... & Gutierrez, O. (2013). Extinction of aversive eliciting functions as an analog of exposure to conditioned fear: Does it alter avoidance responding?. *Journal of Contextual Behavioral Science*, *2*(3-4), 120-134. https://doi.org/10.1016/j.jcbs.2013.05.001

Maccallum, F., Sawday, S., Rinck, M., & Bryant, R. A. (2015). The push and pull of grief: Approach and avoidance in bereavement. *Journal of Behavior Therapy and Experimental Psychiatry*, *48*, 105-109. https://doi.org/10.1016/j.jbtep.2015.02.010

MacCorquodale, K., & Meehl, P. E. (1948). On a distinction between hypothetical constructs and intervening variables. *Psychological Review*, *55*(2), 95. http://dx.doi.org/10.1037/h0056029

Maltzman, I., & Boyd, G. (1984). Stimulus significance and bilateral SCRs to potentially phobic pictures. *Journal of Abnormal Psychology*, *93*(1), 41-46. https://doi.org/10.1037/0021-843X.93.1.41

Mandler, G., Mandler, J. M., Kremen, I., & Sholiton, R. D. (1961). The response to threat: Relations among verbal and physiological indices. *Psychological Monographs: General and Applied*, *75*(9), 1-22. http://dx.doi.org/10.1037/h0093803

Marks, I. (1981). Behavioural concepts and treatments of neuroses. *Behavioural and Cognitive Psychotherapy*, *9*(2), 137-154. https://doi.org/10.1017/S0141347300007321

Marr, M. J. (1992). Behavior dynamics: One perspective. *Journal of the Experimental Analysis of Behavior*, *57*(3), 249-266. https://doi.org/10.1901/jeab.1992.57-249

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion*, *23*(2), 209-237. https://doi.org/10.1080/02699930802204677

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion*, *5*(2), 175-190. doi: 10.1037/1528-3542.5.2.175

Maxwell, J. S., & Davidson, R. J. (2007). Emotion as motion: Asymmetries in approach and avoidant actions. *Psychological Science*, *18*(12), 1113-1119. https://doi.org/10.1111/j.1467-9280.2007.02033.x

May, C. N., Juergensen, J., & Demaree, H. A. (2016). Yum, cake! How reward sensitivity relates to automatic approach motivation for dessert food images. *Personality and Individual Differences, 90*, 265-268. https://doi.org/10.1016/j.paid.2015.11.022

McConnell, A. R., & Leibold, J. M. (2001). Relations among the Implicit Association Test, discriminatory behavior, and explicit measures of racial attitudes. *Journal of Experimental Social Psychology*, *37*(5), 435-442. https://doi.org/10.1006/jesp.2000.1470

McCroskey, J. C. (1970) . Measures of communication-bound anxiety. *Speech Monographs, 37*, 269-277.

McFarland, D. (1987). *The Oxford Companion to Animal Behaviour*. Oxford, UK: Oxford University Press.

McKinstry, C., Dale, R., & Spivey, M. J. (2008). Action dynamics reveal parallel competition in decision making. *Psychological Science*, *19*(1), 22-24. https://doi.org/10.1111/j.1467-9280.2008.02041.x

McNally, R. J. (1995). Automaticity and the anxiety disorders. *Behaviour Research and Therapy*, *33*(7), 747-754. https://doi.org/10.1016/0005-7967(95)00015-P

McNaughton, N., & Corr, P. J. (2008). The neuropsychology of fear and anxiety: A foundation for reinforcement sensitivity theory. In P. J. Corr., (Ed.). *The reinforcement sensitivity theory of personality* (pp. 44-94). New York, NY, US: Cambridge University Press.

McNaughton, N., DeYoung, C. G., & Corr, P. J. (2016). Approach/avoidance. In J. R. Absher & J. Cloutier. (Eds.), *Neuroimaging personality, social cognition, and character* (pp. 25-49). London: Academic Press.

McNeil, D. W., & Rainwater, A. J. (1998). Development of the fear of pain questionnaire-III. *Journal of Behavioral Medicine*, *21*(4), 389-410. https://doi.org/10.1023/A:1018782831217

Mehta, R., & Zhu, R. J. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science*, *323*(5918), 1226-1229. doi: 10.1126/science.1169144

Mellers, B., Schwartz, A., & Ritov, I. (1999). Emotion-based choice. *Journal of Experimental Psychology: General*, *128*(3), 332. http://dx.doi.org/10.1037/0096-3445.128.3.332

Messick, S. (1980). Test validity and the ethics of assessment. *American psychologist*, *35*(11), 1012-1027. http://dx.doi.org/10.1037/0003-066X.35.11.1012

*Meulders, A., Franssen, M., Fonteyne, R., & Vlaeyen, J. W. (2016). Acquisition and extinction of operant pain-related avoidance behavior using a 3 degrees-of-freedom robotic arm. *Pain*, *157*(5), 1094-1104. doi: 10.1097/j.pain.0000000000000483

Michael, J. (1982). Distinguishing between discriminative and motivational functions of stimuli. *Journal of the Experimental Analysis of Behavior, 37*(1), 149-155. https://doi.org/10.1901/jeab.1982.37-149

Michael, J. (1993). Establishing operations. *The Behavior Analyst*, *16*(2), 191-206. https://doi.org/10.1007/BF03392623

Michael, J. (2000). Implications and refinements of the establishing operation concept. *Journal of Applied Behavior Analysis, 33*(4), 401-410. https://doi.org/10.1901/jaba.2000.33-401

Milad, M. R., & Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: ten years of progress. *Annual Review of Psychology, 63*, 129-151. https://doi.org/10.1146/annurev.psych.121208.131631

Miller, K. M., Hofstetter, R., Krohmer, H., & Zhang, Z. J. (2011). How should consumers’ willingness to pay be measured? An empirical comparison of state-of-the-art approaches. *Journal of Marketing Research*, *48*(1), 172-184. https://doi.org/10.1509/jmkr.48.1.172

Miller, N. E. (1944). Experimental studies of conflict. In J. McV. Hunt (Ed.), *Personality and the Behavioral Disorders* (vol. 1, pp. 431-465). New York, NY: Wiley.

Miller, N. E. (1951a). Learnable drives and rewards. In S. S. Stevens (Ed.), *Handbook of experimental psychology* (pp. 435-472). Oxford, England: Wiley.

Miller, N. E. (1951b). Illustrated by the Development of a Theory of Conflict

Behavior. *Journal of Personality, 20*(1), 82-100. https://doi.org/10.1111/j.1467-6494.1951.tb01514.x

Miller, N. E., Brown, J. S., & Lipofsky, H. (1943). A theoretical and experimental analysis of conflict behaviour: III. Approach-avoidance conflict as a function of strength of drive and strength of shock. (unpublished).

Miller, W. R., & Rollnick, S. (1991). *Motivational interviewing: Preparing people to change addictive behavior*. New York, NY: The Guilford Press.

Mineka, S., & Oehlberg, K. (2008). The relevance of recent developments in classical conditioning to understanding the etiology and maintenance of anxiety disorders. *Acta Psychologica*, *127*(3), 567-580. https://doi.org/10.1016/j.actpsy.2007.11.007

Mineka, S., & Öhman, A. (2002). Phobias and preparedness: The selective, automatic, and encapsulated nature of fear. *Biological Psychiatry*, *52*(10), 927-937. https://doi.org/10.1016/S0006-3223(02)01669-4

Mineka, S., Cook, M., & Miller, S. (1984). Fear conditioned with escapable and inescapable shock: Effects of a feedback stimulus. *Journal of Experimental Psychology: Animal Behavior Processes*, *10*(3), 307. http://dx.doi.org/10.1037/0097-7403.10.3.307

Mischel, W., Grusec, J., & Masters, J. C. (1968). Effects of expected delay time on the subjective value of rewards and punishments. *Journal of Personality and Social Psychology, 11*(4), 363-373.

Mitte, K. (2007). Anxiety and risky decision-making: The role of subjective probability and subjective costs of negative events. *Personality and Individual Differences*, *43*(2), 243-253. http://www.sciencedirect.com/science/article/pii/S0191886906004843

Miu, A. C., Heilman, R. M., & Houser, D. (2008). Anxiety impairs decision-making: psychophysiological evidence from an Iowa Gambling Task. *Biological Psychology*, *77*(3), 353-358. http://www.sciencedirect.com/science/article/pii/S0301051107001962

Mobbs, D., Hagan, C. C., Dalgleish, T., Silston, B., & Prévost, C. (2015). The ecology of human fear: survival optimization and the nervous system. *Frontiers in Neuroscience*, *9*, 55. https://doi.org/10.3389/fnins.2015.00055

Mobbs, D., Marchant, J. L., Hassabis, D., Seymour, B., Tan, G., Gray, M., ... & Frith, C. D. (2009). From threat to fear: the neural organization of defensive fear systems in humans. *Journal of Neuroscience*, *29*(39), 12236-12243. https://doi.org/10.1523/JNEUROSCI.2378-09.2009

Monestès, J. L., Karekla, M., Jacobs, N., Michaelides, M. P., Hooper, N., Kleen, M., ... & Villatte, M. (2016). Experiential avoidance as a common psychological process in European cultures. *European Journal of Psychological Assessment*, *34*, 247-257. https://doi.org/10.1027/1015-5759/a000327

Mowrer, O. H. (1960). *Learning Theory and Behavior*. New Jersey, NJ: John Wiley & Sons Inc.

Mühlberger, A., Sperber, M., Wieser, M. J., & Pauli, P. (2008). A virtual reality behavior avoidance test (VR-BAT) for the assessment of spider phobia. *Journal of CyberTherapy and Rehabilitation*, *1*(2), 147-158.

Muris, P., & Merckelbach, H. (1996). A comparison of two spider fear questionnaires. *Journal of Behavior Therapy and Experimental Psychiatry*, *27*(3), 241-244. https://doi.org/10.1016/S0005-7916(96)00022-5

Muris, P., Van Zuuren, F. J., De Jong, P. J., De Beurs, E., & Hanewald, G. (1994). Monitoring and blunting coping styles: The Miller Behavioural Style Scale and its correlates, and the development of an alternative questionnaire. *Personality and Individual Differences*, *17*(1), 9-19. https://doi.org/10.1016/0191-8869(94)90257-7

Murray, E. J. (1975). Resolution of complex decisional conflicts as a function of degree of avoidance. *Journal of Research in Personality*, *9*(3), 177-190. https://doi.org/10.1016/0092-6566(75)90014-8

Murray, E. J., & Miller, N. E. (1952). Displacement; steeper gradient of generalization of avoidance than of approach with age of habit controlled. *Journal of Experimental Psychology*, *43*(3), 222-226. http://dx.doi.org/10.1037/h0062579

Naqvi, N., Shiv, B., & Bechara, A. (2006). The role of emotion in decision making a cognitive neuroscience perspective. *Current Directions in Psychological Science*, *15*(5), 260-264. http://cdp.sagepub.com/content/15/5/260.short

Nevin, J. A. (1974). Response strength in multiple schedules. *Journal of the Experimental Analysis of Behavior*, *21*(3), 389-408. https://doi.org/10.1901/jeab.1974.21-389

*Nicholson, E., & Barnes-Holmes, D. (2012). The Implicit Relational Assessment Procedure (IRAP) as a measure of spider fear. *The Psychological Record*, *62*(2), 263. https://doi.org/10.1007/BF03395801

Nilsson, D., Gustafsson, P. E., & Svedin, C. G. (2010). Self-reported potentially traumatic life events and symptoms of post-traumatic stress and dissociation. *Nordic Journal of Psychiatry*, *64*(1), 19-26. https://doi.org/10.3109/08039480903264846

Nosek, B. A., & Banaji, M. R. (2001). The go/no-go association task. *Social Cognition*, *19*(6), 625-666.

Nyström, M., Hooge, I. & Andersson, R. (2016). Pupil size influences the eye-tracker signal during saccades. *Vision research*, *121*, 95-103.

O'Hora, D., Carey, R., Kervick, A., Crowley, D., & Dabrowski, M. (2016). Decisions in motion: decision dynamics during intertemporal choice reflect subjective evaluation of delayed rewards. *Scientific Reports*, *6*, 20740. Retrieved from https://www.nature.com/articles/srep20740

O'Hora, D., Dale, R., Piiroinen, P. T., & Connolly, F. (2013). Local dynamics in decision making: The evolution of preference within and across decisions. *Scientific Reports*, *3*, 2210. doi: 10.1038/srep02210

Oatley, K., & Jenkins, J. M. (1996). *Understanding emotions*. Oxford, UK: Blackwell.

Öhman, A. (1986). Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology*, *23*(2), 123-145. https://doi.org/10.1111/j.1469-8986.1986.tb00608.x

Öhman, A. (2008). Fear and Anxiety: Overlaps and distinctions. In M. Lewis, J. M., Haviland-Jones, & L. F. Barrett (Eds), *Handbook of emotions*, 3rd Edition (pp. 709-729). New York, NY: The Guilford Press.

Öhman, A. (2009). Of snakes and faces: An evolutionary perspective on the psychology of fear. *Scandinavian Journal of Psychology*, *50*(6), 543-552. https://doi.org/10.1111/j.1467-9450.2009.00784.x

Öhman, A., Eriksson, A., Fredriksson, M., Hugdahl, K., & Olofsson, C. (1974). Habituation of the electrodermal orienting reaction to potentially phobic and supposedly neutral stimuli in normal human subjects. *Biological Psychology, 2(2), 85–93.* doi:10.1016/0301-0511(74)90017-9

Öhman, A., & Wiens, S. (2004). The concept of an evolved fear module and cognitive theories of anxiety. In A. S. R. Manstead, N. Frijda, & A. Fischer (2004), *Feelings and emotions: The Amsterdam symposium* (pp. 58-80). Cambridge, UK: Cambridge University Press.

Öhman, A., Dimberg, U., Esteves, F. (2014). Preattentive activation of aversive emotions. In T., Archer & L. G., Nilsson (Eds.), *Aversion, avoidance, and anxiety: Perspectives on aversively motivated behavior* (pp. 169-190). London: Psychology Press.

Olds, J. (1956). Pleasure centers in the brain. *Scientific American*, *195*(4), 105-117.

Olds, J., & Milner, P. (1954). Positive reinforcement produced by electrical stimulation of septal area and other regions of rat brain. *Journal of comparative and physiological psychology*, *47*(6), 419. http://dx.doi.org/10.1037/h0058775

Onat, S., & Büchel, C. (2015). The neuronal basis of fear generalization in humans. *Nature Neuroscience*, *18*(12), 1811–1818. doi:10.1038/nn.4166

Organisation for Economic Co-operation and Development - OECD/EU (2018). *Health at a Glance: Europe 2018. State of Health* *in the EU Cycle*. Paris, OECD Publishing. Retrieved from: https://ec.europa.eu/health/sites/health/files/state/docs/2018_healthatglance_rep_en.pdf

Osman, M. (2010). Controlling uncertainty: A review of human behavior in complex dynamic environments. *Psychological Bulletin*, *136*(1), 65-86. http://dx.doi.org/10.1037/a0017815

Oswald, F. L., Mitchell, G., Blanton, H., Jaccard, J., & Tetlock, P. E. (2013). Predicting ethnic and racial discrimination: A meta-analysis of IAT criterion studies. *Journal of Personality and Social Psychology*, *105*(2), 171. doi:10.1037/a0032734

Ottenbreit, N. D., & Dobson, K. S. (2004). Avoidance and depression: the construction of the Cognitive–Behavioral Avoidance Scale. *Behaviour Research and Therapy*, *42*(3), 293-313. https://doi.org/10.1016/S0005-7967(03)00140-2

Ottenbreit, N. D., Dobson, K. S., & Quigley, L. (2014). An examination of avoidance in major depression in comparison to social anxiety disorder. *Behaviour Research and Therapy*, *56*, 82-90. https://doi.org/10.1016/j.brat.2014.03.005

Pachur, T., Hertwig, R., & Wolkewitz, R. (2014). The affect gap in risky choice: Affect-rich outcomes attenuate attention to probability information. *Decision*, *1*(1), 64 -78. http://dx.doi.org/10.1037/dec0000006.

Panksepp, J., Fuchs, T., & Iacobucci, P. (2011). The basic neuroscience of emotional experiences in mammals: The case of subcortical FEAR circuitry and implications for clinical anxiety. *Applied Animal Behaviour Science*, *129*(1), 1-17.

Patterson, M. M., & Kesner, R. P. (Eds.). (2013). *Electrical stimulation research techniques* (Vol. 3). New York, NY: Elsevier.

Pavlov, I. P. (1927). *Conditioned Reflexes*. Oxford, UK: Oxford University Press.

Pavlov, I. P. (1928). Experimental psychology and psychopathology in animals. Herald of the Military Medical Academy, 7 109-121. In W. H. Gantt, (Ed.), *Lectures on Condition Reflexes* (vol 1, pp. 47-60). London, UK : Lawrence & Wishart. (Original work published 1903).

Peira, N., Golkar, A., Öhman, A., Anders, S., & Wiens, S. (2012). Emotional responses in spider fear are closely related to picture awareness. *Cognition & Emotion*, *26*(2), 252-260. https://doi.org/10.1080/02699931.2011.579087

Peirce, J. W. (2007). PsychoPy—psychophysics software in Python. *Journal of Neuroscience Methods*, *162*(1-2), 8-13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Pellis, S. M. (1985). What is 'fixed' in a fixed action pattern? A problem of methodology. *Bird Behavior*, *6*(1), 10-15. https://doi.org/10.3727/015613885792335293

Pennebaker, J. W. (1982). *The psychology of physical symptoms*. NY: Springer.

Perna, G. (2013). Understanding anxiety disorders: the psychology and the psychopathology of defence mechanisms against threats. *Rivista di Psichiatria*, *48*(1), 73-75. Doi: 10.1708/1228.13618

Peterson, R. A., & Heilbronner, R. L. (1987). The anxiety sensitivity index: Construct validity and factor analytic structure. *Journal of Anxiety Disorders*, *1*(2), 117-121. https://doi.org/10.1016/0887-6185(87)90002-8

Pham, M. T., Lee, L., & Stephen, A. T. (2012). Feeling the future: The emotional oracle effect. *Journal of Consumer Research*, *39*(3), 461-477. https://doi.org/10.1086/663823

Pigott, T. (2012). *Advances in meta-analysis*. Springer Science & Business Media.

Pittig, A. (2019). Incentive-based extinction of safety behaviors: Positive outcomes competing with aversive outcomes trigger fear-opposite action to prevent protection from fear extinction. *Behaviour Research and Therapy*, *121*, 103463. doi: 10.1016/j.brat.2019.103463

Pittig, A., & Dehler, J. (2019). Same fear responses, less avoidance: Rewards competing with aversive outcomes do not buffer fear acquisition, but attenuate avoidance to accelerate subsequent fear extinction. *Behaviour Research and Therapy*, *112*, 1-11. https://doi.org/10.1016/j.brat.2018.11.003

Pittig, A., Alpers, G. W., Niles, A. N., & Craske, M. G. (2015). Avoidant decision-making in social anxiety disorder: a laboratory task linked to in vivo anxiety and treatment outcome. *Behaviour Research and Therapy*, *73*, 96-103. https://doi.org/10.1016/j.brat.2015.08.003

Pittig, A., Brand, M., Pawlikowski, M., & Alpers, G. W. (2014). The cost of fear: avoidant decision making in a spider gambling task. *Journal of Anxiety Disorders*, *28*(3), 326-334. https://doi.org/10.1016/j.janxdis.2014.03.001

Pittig, A., Hengen, K., Bublatzky, F., & Alpers, G. W. (2018). Social and monetary incentives counteract fear-driven avoidance: Evidence from approach-avoidance decisions. *Journal of Behavior Therapy and Experimental Psychiatry*, *60*, 69-77. https://doi.org/10.1016/j.jbtep.2018.04.002

Pittig, A., Schulz, A. R., Craske, M. G., & Alpers, G. W. (2014). Acquisition of behavioral avoidance: task-irrelevant conditioned stimuli trigger costly decisions. *Journal of Abnormal Psychology*, *123*(2), 314.

Pittig, A., Treanor, M., LeBeau, R. T., & Craske, M. G. (2018). The role of associative fear and avoidance learning in anxiety disorders: Gaps and directions for future research. *Neuroscience & Biobehavioral Reviews*, *88*, 117-140. https://doi.org/10.1016/j.neubiorev.2018.03.015

Poythress, N. G., Skeem, J. L., Weir, J., Lilienfeld, S. O., Douglas, K. S., Edens, J. F., & Kennealy, P. J. (2008). Psychometric properties of Carver and White's (1994) BIS/BAS scales in a large sample of offenders. *Personality and Individual Differences*, *45*(8), 732-737. doi: 10.1016/j.paid.2008.07.021

R Development Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria (version 3.3.3). ISBN 3-900051-07-0, URL http://www.R-project.org/

R Development Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria (version 3.4.3). ISBN 3-900051-07-0, URL http://www.R-project.org/

Rachlin, H. (1935). *Behavior and Learning*. San Fransico, USA: W. H. Freeman and Compay.

Rachman, S. (1977). The conditioning theory of fear acquisition: A critical examination. *Behaviour research and therapy*, *15*(5), 375-387. https://doi.org/10.1016/0005-7967(77)90041-9

Rachman, S., & Hodgson, R. (1974). I. Synchrony and desynchrony in fear and avoidance. *Behaviour research and therapy*, *12*(4), 311-318. https://doi.org/10.1016/0005-7967(74)90005-9

Radke, S., Güths, F., André, J. A., Müller, B. W., & de Bruijn, E. R. (2014). In action or inaction? Social approach–avoidance tendencies in major depression. *Psychiatry Research*, *219*(3), 513-517. https://doi.org/10.1016/j.psychres.2014.07.011

Raghunathan, R., & Pham, M. T. (1999). All negative moods are not equal: Motivational influences of anxiety and sadness on decision making. *Organizational Behavior and Human Decision Processes*, *79*(1), 56-77. http://www.sciencedirect.com/science/article/pii/S0749597899928388

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741-756. https://doi.org/10.1016/S0005-7967(97)00022-3

Rattel, J. A., Miedl, S. F., Blechert, J., & Wilhelm, F. H. (2017). Higher threat avoidance costs reduce avoidance behaviour which in turn promotes fear extinction in humans. *Behaviour Research and Therapy*, *96*, 37-46. https://doi.org/10.1016/j.brat.2016.12.010

*Reese, H. E., McNally, R. J., Najmi, S., & Amir, N. (2010). Attention training for reducing spider fear in spider-fearful individuals. *Journal of Anxiety Disorders*, *24*(7), 657-662. https://doi.org/10.1016/j.janxdis.2010.04.006

Richman, J. S., & Moorman, J. R. (2000). Physiological time-series analysis using approximate entropy and sample entropy. *American Journal of Physiology-Heart and Circulatory Physiology*, *278*(6), H2039-H2049.

https://doi.org/10.1152/ajpheart.2000.278.6.H2039

Rimm, D. C., & Mahoney, M. J. (1969). The application of reinforcement and participant modeling procedures in the treatment of snake-phobic behavior. *Behaviour Research and Therapy*, *7*(4), 369-376. https://doi.org/10.1016/0005-7967(69)90066-7

Rinck, M., & Becker, E. S. (2006). Spider fearful individuals attend to threat, then quickly avoid it: evidence from eye movements. *Journal of Abnormal Psychology*, *115*(2), 231. https://doi.org/10.1037/0021-843X.115.2.231

*Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(2), 105-120. https://doi.org/10.1016/j.jbtep.2006.10.001

Rinck, M., Rörtgen, T., Lange, W. G., Dotsch, R., Wigboldus, D. H., & Becker, E. S. (2010). Social anxiety predicts avoidance behavior in virtual encounters. *Cognition and Emotion*, *24*(7), 1269-1276.

Ringen, J. D. (1993). Adaptation, teleology, and selection by consequences. *Journal of the Experimental Analysis of Behavior*, *60*(1), 3-15. https://doi.org/10.1901/jeab.1993.60-3

Robinson, M. D., & Clore, G. L. (2002). Episodic and semantic knowledge in emotional self-report: evidence for two judgment processes. *Journal of Personality and Social Psychology*, *83*(1), 198-215. http://dx.doi.org/10.1037/0022-3514.83.1.198.

Roefs, A., Huijding, J., Smulders, F. T., MacLeod, C. M., de Jong, P. J., Wiers, R. W., & Jansen, A. (2011). Implicit measures of association in psychopathology research. *Psychological Bulletin*, *137*(1), 149-193. http://dx.doi.org/10.1037/a0021729

Ross, S. R., Benning, S. D., Patrick, C. J., Thompson, A., & Thurston, A. (2009). Factors of the Psychopathic Personality Inventory: Criterion-related validity and relationship to the BIS/BAS and Five-Factor Models of Personality. *Assessment*, *16*(1), 71-87. https://doi.org/10.1177/1073191108322207

Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., North, M., & Tasman, A. (1996). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry, 152(1), 626-28.*

Rottenstreich, Y., & Hsee, C. K. (2001). Money, kisses, and electric shocks: On the affective psychology of risk. *Psychological science*, *12*(3), 185-190. https://doi.org/10.1111/1467-9280.00334

Roy-Byrne, P. P., & Cowley, D. S. (1994). Course and outcome in panic disorder: A review of recent follow-up studies. *Anxiety*, *1*(4), 151-160. https://doi.org/10.1002/anxi.3070010402

Saunders, B. E., & Adams, Z. W. (2014). Epidemiology of traumatic experiences in childhood. *Child and Adolescent Psychiatric Clinics*, *23*(2), 167-184. doi: 10.1016/j.chc.2013.12.003

Schall, J. D., Palmeri, T. J., & Logan, G. D. (2017). Models of inhibitory control. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1718), 1-9 (20160193). https://doi.org/10.1098/rstb.2016.0193

Scherbaum, S., & Kieslich, P. J. (2018). Stuck at the starting line: How the starting procedure influences mouse-tracking data. *Behavior Research Methods*, *50*, 1-14. doi: 10.3758/s13428-017-0977-4

Scherbaum, S., Dshemuchadse, M., & Kalis, A. (2008). Making decisions with a continuous mind. *Cognitive, Affective, & Behavioral Neuroscience*, *8*(4), 454-474. https://doi.org/10.3758/CABN.8.4.454

Scherbaum, S., Dshemuchadse, M., Fischer, R., & Goschke, T. (2010). How decisions evolve: The temporal dynamics of action selection. *Cognition*, *115*(3), 407-416. https://doi.org/10.1016/j.cognition.2010.02.004

Scherbaum, S., Frisch, S., & Dshemuchadse, M. (2017). Step by step: Harvesting the dynamics of delay discounting decisions. *The Quarterly Journal of Experimental Psychology*, (just-accepted), 1-53. https://doi.org/10.1080/17470218.2017.1307863

Scherbaum, S., Frisch, S., & Dshemuchadse, M. (2018). A Bird in the Hand Isn't Good for Long. *Experimental Psychology*, 65. https://doi.org/10.1027/1618-3169/a000385

Scherbaum, S., Frisch, S., Dshemuchadse, M., Rudolf, M., & Fischer, R. (2018). The test of both worlds: Identifying feature binding and control processes in congruency sequence tasks by means of action dynamics. *Psychological Research*, *82*(2), 337-352. https://doi.org/10.1007/s00426-016-0823-9

Scherbaum, S., Frisch, S., Leiberg, S., Lade, S. J., Goschke, T., & Dshemuchadse, M. (2016). Process dynamics in delay discounting decisions: An attractor dynamics approach. *Judgment and Decision Making*, *11*(5), 472. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=a9h&AN=118664054&site=ehost-live&authtype=sso&custid=s6172330

Scherbaum, S., Gottschalk, C., Dshemuchadse, M., & Fischer, R. (2015). Action dynamics in multitasking: the impact of additional task factors on the execution of the prioritized motor movement. *Frontiers in Cognition*, *6*, 934. https://doi.org/10.3389/fpsyg.2015.00934

Scherer, K. R. (2009). The dynamic architecture of emotion: Evidence for the component process model. *Cognition and Emotion*, *23*(7), 1307-1351. https://doi.org/10.1080/02699930902928969

Scheveneels, S., Boddez, Y., Vervliet, B., & Hermans, D. (2016). The validity of laboratory-based treatment research: Bridging the gap between fear extinction and exposure treatment. *Behaviour Research and Therapy*, *86*, 87-94. https://doi.org/10.1016/j.brat.2016.08.015

Schlinger, H. D., & Poling, A. (1998). *Introduction to scietific psychology*. New York, NY: Plenum Press.

Schlund, M. W., Brewer, A. T., Magee, S. K., Richman, D. M., Solomon, S., Ludlum, M., & Dymond, S. (2016). The tipping point: Value differences and parallel dorsal–ventral frontal circuits gating human approach–avoidance behavior. *NeuroImage*, *136*, 94-105. https://doi.org/10.1016/j.neuroimage.2016.04.070

Schlund, M. W., Treacher, K., Preston, O., Magee, S. K., Richman, D. M., Brewer, A. T., ... & Dymond, S. (2017). “Watch out!”: Effects of instructed threat and avoidance on human free-operant approach–avoidance behavior. *Journal of the Experimental Analysis of Behavior*, *107*(1), 101-122. https://doi.org/10.1002/jeab.238

Schneider, I. K., van Harreveld, F., Rotteveel, M., Topolinski, S., van der Pligt, J., Schwarz, N., & Koole, S. L. (2015). The path of ambivalence: tracing the pull of opposing evaluations using mouse trajectories. *Frontiers in Psychology*, *6*, 996. https://doi.org/10.3389/fpsyg.2015.00996

Schofield, C. A., Johnson, A. L., Inhoff, A. W., & Coles, M. E. (2012). Social anxiety and difficulty disengaging threat: Evidence from eye-tracking. *Cognition & emotion*, *26*(2), 300-311. https://doi.org/10.1080/02699931.2011.602050

Schrooten, M. G., Wiech, K., & Vlaeyen, J. W. (2014). When pain meets… pain-related choice behavior and pain perception in different goal conflict situations. *The Journal of Pain*, *15*(11), 1166-1178. https://doi.org/10.1016/j.jpain.2014.08.011

Schulreich, S., Gerhardt, H., & Heekeren, H. R. (2016). Incidental fear cues increase monetary loss aversion. *Emotion*, *16*(3), 402. doi: 10.1037/emo0000124

Schulte-Mecklenbeck, M., Kuehberger, A., Johnson, J. G. (Eds.). (2019). *A Handbook of Process Tracing Methods*. New York, NY: Routledge. https://doi.org/10.4324/9781315160559

Schwarz, N. (1999). Self-reports: How the questions shape the answers. *American Psychologist*, *54*(2), 93. http://dx.doi.org/10.1037/0003-066X.54.2.93

Schwarz, N. (2000). Emotion, cognition, and decision making. *Cognition & Emotion*, *14*(4), 433-440. https://doi.org/10.1080/026999300402745

Schwarz, N., & Oyserman, D. (2001). Asking questions about behavior: Cognition, communication, and questionnaire construction. *American Journal of Evaluation*, *22*(2), 127-160. https://doi.org/10.1177/109821400102200202

Sears, R. R., & Hovland, C. I. (1941). Experiments on motor conflict. II. Determination of mode of resolution by comparative strengths of conflicting responses. *Journal of Experimental Psychology, 28*(3), 280-286.

Seibt, B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self-and object-related approach–avoidance motions. *Journal of Experimental Social Psychology*, *44*(3), 713-720. https://doi.org/10.1016/j.jesp.2007.04.013

Selen, Luc. P. J., Shadlen, M. N., & Wolpert, D. M. (2012). Deliberation in the motor system: Reflex gains track evolving evidence leading to a decision. *The Journal of Neuroscience, February 15*, *32*(7), 2276–2286.

Seligman, M. E., & Johnston, J. C. (1973). A cognitive theory of avoidance learning. In F. J. McGuigan & D. B. Lumsden, *Contemporary approaches to conditioning and learning.* Oxford, England: V. H. Winston & Sons.

Servatius, R. J. (2016). Avoidance: From basic science to psychopathology. *Frontiers in Behavioral Neuroscience*, *10*, 15. https://doi.org/10.3389/fnbeh.2016.00015

Shechner, T., Klein, Z., & Shechner, T. (2018, April). *The effects of a novel perceptual discrimination training task on fear overgeneralization*. Paper presented at the meeting of the European Meeting of Human Fear Conditioning (EMHFC), Wales, UK.

Sheehan, J. G. (1953). Theory and treatment of stuttering as an approach-avoidance conflict. *The Journal of Psychology*, *36*(1), 27-49. https://doi.org/10.1080/00223980.1953.9712875

Shiv, B., Loewenstein, G., Bechara, A., Damasio, H., & Damasio, A. R. (2005). Investment behavior and the negative side of emotion. *Psychological science*,*16*(6), 435-439. http://pss.sagepub.com/content/16/6/435.short

Sidman, M. (1953). Two temporal parameters of the maintenance of avoidance behavior by the white rat. *Journal of Comparative and Physiological Psychology*, *46*(4), 253-261. http://dx.doi.org/10.1037/h0060730

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston, MA, US: Authors Cooperative.

Sierra-Mercado, D., Deckersbach, T., Arulpragasam, A. R., Chou, T., Rodman, A. M., Duffy, A., ... & Eskandar, E. N. (2015). Decision making in avoidance–reward conflict: a paradigm for non-human primates and humans. *Brain Structure and Function*, *220*(5), 2509-2517. https://doi.org/10.1007/s00429-014-0796-7

Skinner, B. F. (1938). *The behavior of organisms: an experimental analysis*. Oxford, England: Appleton-Century.

Skinner, B. F. (1945). The operational analysis of psychological terms. *Psychological Review*, *52*(5), 270. http://dx.doi.org/10.1037/h0062535

Skinner, B. F. (1953). *Science and human behavior*. Oxford, England: Macmillan.

Skinner, B. F. (1974). *About behaviorism*. New York, NY: Vintage Books.

Skinner, B. F. (1980). *Notebooks*. New Jersey, USA: Prentice-Hall, Inc.

Skinner, B. F. (1987). *Upon further reflection*. New Jersey, USA: Prentice-Hall, Inc.

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2007). The affect heuristic. *European Journal of Operational Research*, *177*(3), 1333-1352. https://doi.org/10.1016/j.ejor.2005.04.006

Slovic, P., Finucane, M., Peters, E., & MacGregor, D. G. (2002). Rational actors or rational fools: Implications of the affect heuristic for behavioral economics. *The Journal of Socio-Economics*, *31*(4), 329-342. https://doi.org/10.1016/S1053-5357(02)00174-9

Snagowski, J., & Brand, M. (2015). Symptoms of cybersex addiction can be linked to both approaching and avoiding pornographic stimuli: Results from an analog sample of regular cybersex users. *Frontiers in Psychology*, *6*, 653. https://doi.org/10.3389/fpsyg.2015.00653

Solomon, R. C. (2008). The philosophy of emotions. In M. Lewis & J. M. Haviland-Jones (Eds.), *The handbook of emotions (3rd ed.)* (pp. 3-16). New York, NY: Guilford Press.

Solomon, R. L., & Wynne, L. C. (1953). Traumatic avoidance learning: Acquisition in normal dogs. *Psychological*

Monographs: General and Applied, *67*(4), 1-19. http://dx.doi.org/10.1037/h0093649.

Solomon, R. L., Kamin, L. J., & Wynne, L. C. (1953). Traumatic avoidance learning: the outcomes of several extinction procedures with dogs. *The Journal of Abnormal and Social Psychology*, *48*(2), 291-302. http://dx.doi.org/10.1037/h0058943

Song, J. H., & Nakayama, K. (2008). Numeric comparison in a visually-guided manual reaching task. *Cognition*, *106*(2), 994-1003. https://doi.org/10.1016/j.cognition.2007.03.014

Spielberg, J. M., Stewart, J. L., Levin, R. L., Miller, G. A., & Heller, W. (2008). Prefrontal cortex, emotion, and approach/withdrawal motivation. *Social and Personality Psychology Compass*, *2*(1), 135-153. https://doi.org/10.1111/j.1751-9004.2007.00064.x

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press Inc.

Spivey, M. (2008). *The continuity of mind*. New York, NY: Oxford University Press.

Spivey, M. J., & Dale, R. (2004). On the continuity of mind: Toward a dynamical account of cognition. In B. H. Ross (Ed.). *The psychology of learning and motivation: Advances in research and theory*, *45* (pp. 87-142). San Diego, California: Elsevier Academic Press.

Spivey, M. J., & Dale, R. (2006). Continuous dynamics in real-time cognition. *Current Directions in Psychological Science*, *15*(5), 207-211. https://doi.org/10.1111/j.1467-8721.2006.00437.x

Spivey, M. J., Grosjean, M., & Knoblich, G. (2005). Continuous attraction toward phonological competitors. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(29), 10393-10398.

Staddon, J. E. R. (2003). *Adaptive behavior and learning*. London, UK: Cambridge University Press.

Stampfl, T. G., & Levis, D. J. (1967). Essentials of implosive therapy: A learning-theory-based psychodynamic behavioral therapy. *Journal of Abnormal Psychology*, *72*(6), 496-503. http://dx.doi.org/10.1037/h0025238

Steimer, T. (2002). The biology of fear-and anxiety-related behaviors. *Dialogues in clinical neuroscience*, *4*(3), 231. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181681/

Stein, M. B., & Paulus, M. P. (2009). Imbalance of approach and avoidance: the yin and yang of anxiety disorders. *Biological Psychiatry*, *66*(12), 1072-1074. https://doi.org/10.1016/j.biopsych.2009.09.023

Stins, J. F., & Beek, P. J. (2011). Organization of voluntary stepping in response to emotion-inducing pictures. *Gait & Posture*, *34*(2), 164-168. https://doi.org/10.1016/j.gaitpost.2011.04.002

Stins, J. F., Roelofs, K., Villan, J., Kooijman, K., Hagenaars, M. A., & Beek, P. J. (2011). Walk to me when I smile, step back when I’m angry: emotional faces modulate whole-body approach–avoidance behaviors. *Experimental Brain Research*, *212*(4), 603-611. https://doi.org/10.1007/s00221-011-2767-z

Stocco, A., & Fum, D. (2008). Implicit emotional biases in decision making: The case of the Iowa Gambling Task. *Brain and Cognition*, *66*(3), 253-259. https://doi.org/10.1016/j.bandc.2007.09.002

Sullivan, N., Hutcherson, C., Harris, A., & Rangel, A. (2015). Dietary self-control is related to the speed with which attributes of healthfulness and tastiness are processed. *Psychological Science*, *26*(2), 122-134. https://doi.org/10.1177/0956797614559543

Suter, R. S., Pachur, T., & Hertwig, R. (2016). How affect shapes risky choice: Distorted probability weighting versus probability neglect. *Journal of Behavioral Decision Making*, *29*(4), 437-449. https://doi.org/10.1002/bdm.1888

Szymanski, J., & O'Donohue, W. (1995). Fear of spiders questionnaire. *Journal of Behavior Therapy and Experimental Psychiatry*, *26*(1), 31-34. https://doi.org/10.1016/0005-7916(94)00072-T

Talmi, D., & Pine, A. (2012). How costs influence decision values for mixed outcomes. *Frontiers in Neuroscience*, 6, 146. https://doi.org/10.3389/fnins.2012.00146

*Teachman, B. A. (2007). Evaluating implicit spider fear associations using the Go/No-go Association Task. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(2), 156-167. https://doi.org/10.1016/j.jbtep.2006.10.006

*Teachman, B. A., & Woody, S. R. (2003). Automatic processing in spider phobia: Implicit fear associations over the course of treatment. *Journal of Abnormal Psychology*, *112*(1), 100. http://dx.doi.org/10.1037/0021-843X.112.1.100

Tolin, D. F., Lohr, J. M., Lee, T. C., & Sawchuk, C. N. (1999). Visual avoidance in specific phobia. *Behaviour Research and Therapy*, *37*(1), 63-70. https://doi.org/10.1016/S0005-7967(98)00111-9

Tooby, J., Cosmides, L., Sell, A., Lieberman, D., & Sznycer, D. (2008). Internal regulatory variables and the design of human motivation: A computational and evolutionary approach. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 251-271). New York, NY: Psychology Press.

Townsend, J. T., & Busemeyer, J. R. (1989). Approach-Avoidance: Return to dynamic decision behavior. In C. Izawa (Ed.). *Cognitive Processes the Tulane Flowerree Symposia on Cognition* (pp. 107-133). New York, NY: Psychology Press.

Treutwein, B. (1995). Adaptive psychophysical procedures. *Vision Research*, *35*(17), 2503-2522. https://doi.org/10.1016/0042-6989(95)00016-X

Tversky, A. (1969). Intransitivity of preferences. *Psychological Review*, *76*(1), 31-48. doi: 10.1037/h0026750

Tversky, A., & Kahneman, D. (2000). *Choices, values, and frames*. Cambridge; UK: University Press.

Tversky, A., Slovic, P., & Kahneman, D. (1990). The causes of preference reversal. *The American Economic Review*, *80*(1), 204-217. https://www.jstor.org/stable/2006743

Tyndall, I., Waldeck, D., Pancani, L., Whelan, R., Roche, B., & Dawson, D. L. (2019). The Acceptance and Action Questionnaire-II (AAQ-II) as a measure of experiential avoidance: Concerns over discriminant validity. *Journal of Contextual Behavioral Science*, *12*, 278-284. https://doi.org/10.1016/j.jcbs.2018.09.005

Valentine, J. C., Pigott, T. D., & Rothstein, H. R. (2010). How many studies do you need? A primer on statistical power for meta-analysis. *Journal of Educational and Behavioral Statistics*, *35*(2), 215-247. https://doi.org/10.3102/1076998609346961

*Valentiner, D. P., Telch, M. J., Ilai, D., & Hehmsoth, M. M. (1993). Claustrophobic fear behavior: A test of the expectancy model of fear. *Behaviour Research and Therapy*, *31*(4), 395-402. https://doi.org/10.1016/0005-7967(93)90096-D

*Van Bockstaele, B., Verschuere, B., Koster, E. H., Tibboel, H., De Houwer, J., & Crombez, G. (2011). Effects of attention training on self-reported, implicit, physiological and behavioral measures of spider fear. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(2), 211-218. https://doi.org/10.1016/j.jbtep.2010.12.004

van Rooij, M. M., Favela, L. H., Malone, M., & Richardson, M. J. (2013). Modeling the dynamics of risky choice. *Ecological Psychology*, *25*(3), 293-303. doi: 10.1080/10407413.2013.810502

Vandeweghe, L., Matton, A., Beyers, W., Vervaet, M., Braet, C., & Goossens, L. (2016). Psychometric Properties of the BIS/BAS Scales and the SPSRQ in Flemish Adolescents. *Psychologica Belgica*, *56*(4), 406-420. http://doi.org/10.5334/pb.298

Vermilyea, J. A., Boice, R., & Barlow, D. H. (1984). Rachman and Hodgson (1974) a decade later: How do desynchronous response systems relate to the treatment of agoraphobia?. *Behaviour Research and Therapy*, *22*(6), 615-621. https://doi.org/10.1016/0005-7967(84)90124-4

*Vervliet, B., & Indekeu, E. (2015). Low-cost avoidance behaviors are resistant to fear extinction in humans. *Frontiers in*

Behavioral Neuroscience, *9*, *351*. https://doi.org/10.3389/fnbeh.2015.00351

Vervliet, B., Craske, M. G., & Hermans, D. (2013). Fear extinction and relapse: state of the art. *Annual Review of Clinical Psychology*, *9*, 215-248. https://doi.org/10.1146/annurev-clinpsy-050212-185542

Vervliet, B., Lange, I., & Milad, M. R. (2017). Temporal dynamics of relief in avoidance conditioning and fear extinction: Experimental validation and clinical relevance. *Behaviour research and therapy*, *96*, 66-78. https://doi.org/10.1016/j.brat.2017.04.011

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software*, *36*(3), 1-48.

Vikesdal, G. H. & Langaas, T. (2016). Saccade Latency and Fixation Stability: Repeatability and Reliability. Journal of Eye Movement Research, 9(2):3, 1-13.

Vogel, J. R., Beer, B., & Clody, D. E. (1971). A simple and reliable conflict procedure for testing anti-anxiety agents. *Psychopharmacologia*, *21*(1), 1-7. https://doi.org/10.1007/BF00403989

Volpp, K. G., Troxel, A. B., Pauly, M. V., Glick, H. A., Puig, A., Asch, D. A., ... & Corbett, E. (2009). A randomized, controlled trial of financial incentives for smoking cessation. *New England Journal of Medicine*, *360*(7), 699-709. doi: 10.1056/NEJMsa0806819

von Hippel, P. T. (2015). The heterogeneity statistic I 2 can be biased in small meta-analyses. *BMC Medical Research Methodology*, *15*(1), 35. https://doi.org/10.1186/s12874-015-0024-z

Waechter, S., & Stolz, J. A. (2015). Trait anxiety, state anxiety, and attentional bias to threat: Assessing the psychometric properties of response time measures. *Cognitive Therapy and Research*, *39*(4), 441-458. https://doi.org/10.1007/s10608-015-9670-z

Wagner, M. K., & Cauthen, N. R. (1968). A comparison of reciprocal inhibition and operant conditioning in the systematic desensitization of a fear of snakes. *Behaviour Research and Therapy*, *6*(2), 225-227. https://doi.org/10.1016/0005-7967(68)90011-9

Wang, M. C., & Bushman, B. J. (1998). Using the normal quantile plot to explore meta-analytic data sets. *Psychological Methods*, *3*(1), 46.

Watson, J. B. & Morgan, J. J. B. (1917). Emotional reactions and psychological experimentation. *American Journal of Psychology*, *28*(2), pp. 163-174. doi: 10.2307/1413718. Retrived from: https://www.jstor.org/stable/1413718

Watson, J. B. & Rayner, R. (1920) Conditioned emotional reactions. *Journal of Experimental Psychology*, *3*(1), pp. 1-14. doi: 10.1037/h0069608

Watts, F. N., & Sharrock, R. (1984). Questionnaire dimensions of spider phobia. *Behaviour Research and Therapy*, *22*(5), 575-580. https://doi.org/10.1016/0005-7967(84)90061-5

Wegner, D. M., & Zanakos, S. (1994). Chronic thought suppression. *Journal of Personality*, *62*(4), 615-640. https://doi.org/10.1111/j.1467-6494.1994.tb00311.x

White, C. N., Skokin, K., Carlos, B., & Weaver, A. (2016). Using decision models to decompose anxiety-related bias in threat classification. *Emotion*, *16*(2), 196 -207. http://dx.doi.org/10.1037/emo0000109.

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. New York, NY: Springer-Verlag.

Wiers, R. W., Eberl, C., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients' approach bias for alcohol and improves treatment outcome. *Psychological Science*, *22*(4), 490-497. https://doi.org/10.1177/0956797611400615

Wiers, R. W., Rinck, M., Kordts, R., Houben, K., & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction*, *105*(2), 279-287. https://doi.org/10.1111/j.1360-0443.2009.02775.x

Wilson, T. D., Lindsey, S., & Schooler, T. Y. (2000). A model of dual attitudes. *Psychological Review*, *107*(1), 101.

Wittekind, C. E., Feist, A., Schneider, B. C., Moritz, S., & Fritzsche, A. (2015). The approach-avoidance task as an online intervention in cigarette smoking: A pilot study. *Journal of Behavior Therapy and Experimental Psychiatry*, *46*, 115-120. https://doi.org/10.1016/j.jbtep.2014.08.006

Woods, D. W., & Kanter, J. W. (Eds.). (2007). *Understanding behavior disorders: A contemporary behavioral perspective*. Reno, NV: Context Press.

Xia, W., Eyolfson, E., Lloyd, K., Vervliet, B., & Dymond, S. (2019). Living in fear: Low-cost avoidance maintains low-level threat. *Journal of Behavior Therapy and Experimental Psychiatry*, *62*, 57-64. https://doi.org/10.1016/j.jbtep.2018.09.001

Yang, J., Zaitlen, N. A., Goddard, M. E., Visscher, P. M., & Price, A. L. (2014). Advantages and pitfalls in the application of mixed-model association methods. *Nature Genetics*, *46*(2), 100. https://doi.org/10.1038/ng.2876

Yonkers, K. A., Bruce, S. E., Dyck, I. R., & Keller, M. B. (2003). Chronicity, relapse, and illness—course of panic disorder, social phobia, and generalized anxiety disorder: findings in men and women from 8 years of follow-up. *Depression and Anxiety*, *17*(3), 173-179. https://doi.org/10.1002/da.10106

Youngstrom, E. & Izard, C. E. (2008). Functions of emotions and emotion-related dysfunction. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 367-384). New York, NY: Psychology Press.

Zeiler, M. D. (1992). On immediate function. *Journal of the Experimental Analysis of Behavior*, *57*(3), 417-427. https://doi.org/10.1901/jeab.1992.57-417

Zgonnikov, A., Aleni, A., Piiroinen, P. T., O'Hora, D., & di Bernardo, M. (2017). Decision landscapes: visualizing mouse-tracking data. *Royal Society Open Science*, *4*(11), 170482. https://doi.org/10.1098/rsos.170482

Zgonnikov, A., Atiya, N., O'Hora, D., Rano, I., & Wong-Lin, K. (2019). *Beyond reach: Do motor costs affect intertemporal choice? A registered report*. Manuscript submitted for publication. https://doi.org/10.31234/osf.io/4bjeg

Zhang, C., Willemsen, M., & Lakens, D. (2018). Can Mouse-tracking Reveal Attribute Processing Speeds in Dietary Self-control? Commentary on Sullivan et al. (2015) and Lim et al. (2018) with New Data. https://doi.org/10.31234/osf.io/725vp

Zhang, Z., Xu, X., & Ni, H. (2013). Small studies may overestimate the effect sizes in critical care meta-analyses: a meta-epidemiological study. *Critical Care*, *17*(1), R2. https://doi.org/10.1186/cc11919

Zilberg, N. J., Weiss, D. S., & Horowitz, M. J. (1982). Impact of Event Scale: a cross-validation study and some empirical evidence supporting a conceptual model of stress response syndromes. *Journal of Consulting and Clinical Psychology*, *50*(3), 407. http://dx.doi.org/10.1037/0022-006X.50.3.407

Appendices

Appendix A. Miller's effect of strength of drive upon height of AAC.

As per Miller (1944) Figure A1 below illustrates how the approach strength (elicited by the appetitive aspect of the goal) will move the subject towards a conflicted goal. As the individual gains proximity to the conflicted goal though, stronger avoidance tendencies will be elicited (by the aversive aspects of the goal). Note that when the approach gradient is raised, the point of intersection not only is shifted nearer to the goal, but also occurs at a higher point on the avoidance gradient. Conversely, if approach tendencies are very weak or absent, the individual will be expected to remain far away from the conflicted goal, giving rise to little if any avoidance.

Therefore, behaviour not only depends on the interaction between approach and avoidance motivations, but it also depends on the relative strength (i.e., height level) and slope (flat/steep) of these. As a consequence, as long as the gradients intersect and the subject has had time and space for free movement, the strength of avoidance aroused (usually accompanied by fear) should be a function of the strength of approach present.

Similarly, keeping the aversiveness of the goal constant and varying the appetitiveness allowing the two gradients to cross would cause the individual to respond as a function of the strongest motivation. Namely, as the strength of approach is weakened (i.e., its appetitiveness is reduced) the individual is expected to move away, and the inverse function is expected if the strength of approach is strengthened (i.e., if the appetitiveness of the goal is kept constant).

For example, if the strength of approach is significantly increased (its slope gradient is raised), it will no intersect with the avoidance motivation gradient, and hence no avoidance (strong enough to affect behaviour) will be elicited; there will be no conflict in approaching.

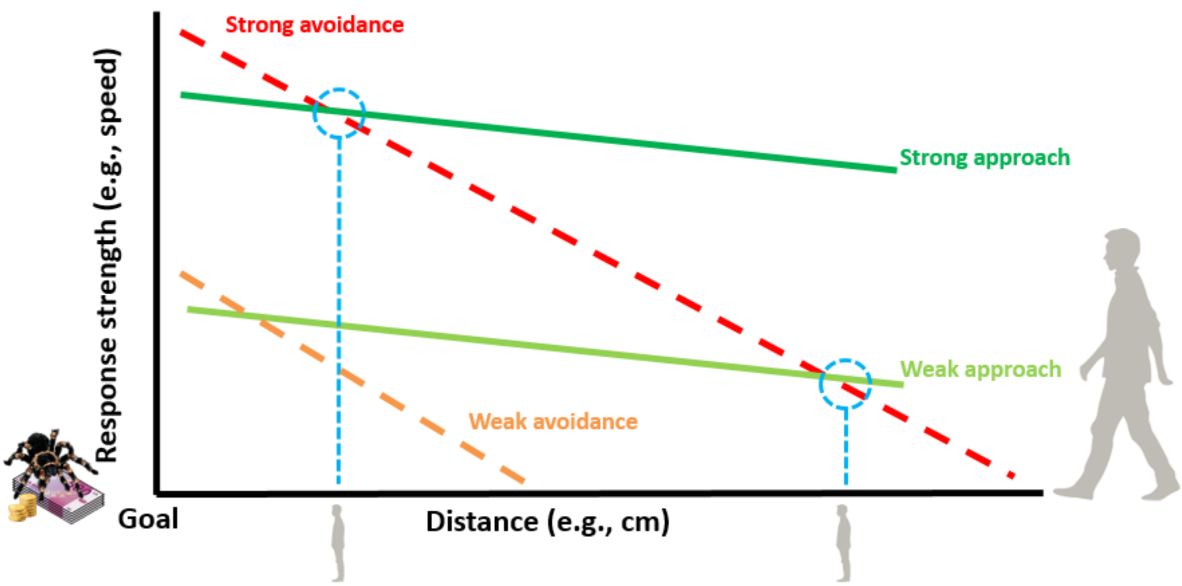


Figure A1. Schematic representation (adapted from Miller, 1944) of the gradients of approach/avoidance drives, their interaction with each other, and their effect on manifested approach behaviour towards a conflicted goal (e.g., money + spider).

Appendix B. Customized form to assess the quality of the selected studies, based on both quality and relevance criteria (*Study 1*).

Study Quality Assessment form

	Quality	**Yes**	**No**	**Partially**
1	*Were the variables and hypotheses of the study clearly defined?*	1	0	.5
2	*Are the self-reported measures used validated/standardized?*	1	0	NA
3	*Do they provide minimal descriptive statistics for the measures used?*	1	0	.5
4	*Was power effect calculated or reported?*	1	0	NA
	Relevance	**Yes**	**No**	**Partially**
5	*Was there a standardized instrument to measure specific threat fear (e.g., spider, snakes, pain –as opposed to general anxiety)*	1	0	NA
6	*Did the BAT employ a real threat? (i.e., non-digital, virtual or hypothetical)*	1	0	.5
7	*Is the BAT procedure (e.g., measure units) clearly described?*	1	0	.5
8	*Were the stimuli used –in the implicit measures– validated (e.g., IAPS, GAPE)?*	1	0	NA
	Global judgement			
9	*Overall, how would you judge the quality of the paper?*	**Poor**	**Acceptable**	**Good**
10	*Overall, how pertinent would you judge the paper to be for the systematic review?*	**Low**	**Medium**	**High**

Scoring: each of the items (1-8) receives either a 1 (Yes) or 0 (No) if such criterion is present or absent in the study respectively. When the criterion is not easily classified as present or absent, due to fragmented information, a "partial" scoring can be provided adding some flexibility/sensitivity to the scoring system (e.g., when only descriptive statistics are reported of relevance to the study's original research question, but left out others of relevance to our endeavour).

The global judgement questions are introduced as a "control" measure to check (dis)agreement with the numerical evaluation.

Appendix C. Studies selected in the systematic review and some of their reported characteristics (Study 1).

ID	Reference / [Rated relevance: L = Low, M = Medium, H = High]	Study's investigative objective	Sample groupings (n)	Explicit/implicit measures; and reported mean scores (SD) for threat assessment	BAT (scale) details [starting distance]: mean score (SD)	Stimuli (Concept-target / Attributes)	Selected summary results
1	Valentiner et al. (1993) / [M]	Predictive validity of the expectancy model (Reiss & McNally, 1985) in claustrophobic fear.	*NA*	Anxiety Sensitivity Index (ASI): 23.60 (9.43) / Self-reported fear (0-100): 44.76 (27.0)	Enclosed experimental chamber. Duration of self-directed exposure [max 120 s]: 106.30 (30.25)	*NA*	* The expectancy model did not relate to fear or hear-rate reactivity. * The expectancy formulation predicted the behavioral component of claustrophobic behavior on the BAT.
2	Teachman et al. (2003) / [H]	Cognitive model of anxiety through changes in automatic associations.	Phobics (31), control (30)	FSQ: 84.9 (13.7) / SPQ: 19.7 (4.8)	Spider (0-12, increasing in approach; 12 = touched spider) [*NA*]: 7.29 (2.97) phobics; 11.30 (1.12) controls	Spiders-Snakes / Disgusting-Appealing; Bad-Good; Danger-Safety; afraid-unafraid	* IAT effects were significantly different for the diagnostic group. * There were Group x Treatment interactions for disgusting-appealing and afraid-unfraid only. * The IAT tasks significantly distinguished between phobic and non-phobics, except for the danger-safety version. * Regression models suggested that implicit fear associations uniquely predicted avoidance beyond standard questionnaire measures.
3	Huijding & de Jong (2005) / [H]	Assess the sensitivity of a pictorial EAST.	Low fear (34), High fear (32)	FSQ: low 5.8 (9.9); high 59.2 (22.7) / EAST-index: low -0.9 (95.5); high -23.9 (67.5) / Startle Probe Response: low 352.7 (244.1); high 392.2 (219.3)	Spider (0-8, increasing in approach; 0 = walk towards the spider as near as you can, 8 = let the spider walk over your hands for 30 s) [4 m]: 7.8 (0.5) low; 5.0 (1.9) high	Positive; Neutral; Negative; Spiders / Positive-Negative	* The pictorial EAST differentiated between normatively positive and negative pictures, except for the RT data for the low fearful participants. * Regression models indicated that FSQ scores above the median, and fast and accurate responses with the negative key in response to spider pictures, independently predicted poor performance on the BAT. The valence index did not explain a significant part of the variance in participants' BAT. * FSQ and EAST indices were not significant predictors of startle responses.
4	Ellwart et al. (2006), Study 1 / [H]	Automatic fear associations in fearfuls using the IAT.	High fear (24); controls (24)	FSQ: 62.42 (15.47) / Spider Anxiety Screening (SAS): 19.21 (2.87)	Spider (proximity distance) [5 m]: 104.8 cm (148) fearfuls; 11.3 (4.5) controls	Spiders-Butterflies / Unpleasant-Pleasant	* Differences in large IAT effects for fearful participants and controls did not reach significance. * Regression models indicated that IAT predicts aspects of avoidance beyond fear questionnaires. * Fearfuls were slower in speed, time, and distance.
5	Huijding et al. (2006) / [H]	predictive power of automatic affective associations for fear responses via the EAST.	Low, Medium and High spider fearfuls.	FSQ: 38.7 (33.5) / EAST-index: 5.0 (45.8)	BAT (0-8, increasing in approach; 0 = walk towards the spiders as near as possible; 8 = let the spider walk over	Plants-Animals / Positive-Negative	* The EAST best predicted automatic fear responses, whereas the FSQ predicted avoidance in BAT. * Higher self-reported fear was associated with strong startle responses for spider stimuli.

					your hands) 1 min [*NA*?]: 5.7 (2.3)		
6	Rinck et al. (2007), Study 1 / [H]	Examined attitudes towards spiders using the AAT, testing its sensitivity and discussing its potential applications.	Spiders Fearfuls (25); non-anxious controls (22)	FSQ: fearfuls 58.8; controls 2.4 / STAI-T: fearfuls 41.6; controls 39.0 / AAT: fearfuls -79(113); controls 15 (92)	Spider (proximity distance) [5 m].	Spider-Spider-Free / push-pull	* ANOVA analyses revealed that fearfuls responded to spider stimuli more quickly by pushing; controls did not show a significant difference between pulling and pushing. * Pushing responses were faster than pulling when responding to spider-free pictures.
7	Teachman B. A. (2007) / [H]	Test the discriminant validity of the GNAT (go/not-go association test) for fearful participants, as a proxy measure for fear schemata.	High fear (17); Low fear (17)	FSQ: high 73.47 (22.07); how 24.72 (13.88) / BDI: high 12 (8.91); low 11.06 (6.59) / GNAT: high 0.26 (0.23); low -0.03 (0.33)	Spider (0-8, increasing in approach; 0 = Not entering the room, 8 = touching the spider) [*NA*]: 3.94 (1.71) High; 7.47 (1.18) Low	Spider / Afraid-Calm; Fire / Afraid-Calm	* Significant Spearman's correlation between the GNAT and BAT. * High fearfuls showed greater implicit GNAT spider fear scores. * Regression models indicated that peak anxiety during the BAT was predicted by both the FSQ and GNAT scores.
8	Cochrane et al. (2008) / [H]	Measured perceived threat behavioral approach in spider-fearfuls using a probabilistic approach-avoidance task (PT-BAT).	Low fear (50); Medium fear (35); High fear (35)	FSQ: low 6.02 (0.67); mid 18.55 (0.84); high 53.35 (2.73) / STAI(Y): low 35.21 (1.45); mid 35.0 (1.60); high 41.72 (1.85)	Probability of Spider (0-8, increasing in approach; 1 = put hand in empty container, 2 = container that previously contained a spider, 3 = 20% chance of spider, 4 = 40%, 5 = 60%, 6 = 80%, 7 = 100%, 8 = nonpoisonous tarantula in container): 6.80 (0.26) Low; 5.55 (0.36) Mid; 2.89 (0.42) High		* The high-fear group completed significantly fewer steps than the mid, and low-fear groups; the mid-fear group completed significantly fewer steps than the low-fear group. * ANOVAs indicated no significant differences among the groups for the subjective ratings reported (i.e., unpleasantness, emotional intensity, unwillingness, unwilling to return) after the last step completed. * Low-fear group was significantly more willing to return than the high- and mid-fear group; no difference between the latter two. * There were moderate-to-strong significant correlations between the FSQ and the BAT and willingness to return, supporting the convergent validity of the PT-BAT.
9	Reese et al. (2010) / [H]	Attention training as means to reducing anxiety in spider fearfuls.	Spider-fearful (41; training subgroup 20, controls 21)	SPQ: 21.5 (4.53) DPT : *NA*	Spider (0-5, increasing in avoidance; 0= touching the spider; 5 = not entering the room). 3 min steps [*NA*]: 3.57 (1.43)	Spider / Siper-Cow; Spider-Bird	* Pre- to post-training change in attentional bias was nonsignificant for the control group, and significant for the training group; similarly for pre- to one-day post-training. * The mean Spider Bias of the control group significantly increased from pre-training to one-week post-training, whereas it did not significantly reduced for the training group. * Measures reduced in self-reported spider fear, avoidance, and fear during the BAT over the course of the experiment for both groups. * Reduction in spider bias between pre- to post-training was not significantly correlated with reduction in avoidance for the training group; but it was significant from pre- to one-week post-training for the controls.

10	Van Bockstaele et al. (2011) / [H]	Assessed self-reported spider fear, implicit spider associations, physiological, and behavioural measures of spider fear as a function of changes in attention training.	random (no-preselection based on fear scores)	STAI-T: 38.28 (9.66) / FSQ : 38.84 (26.43)	Spider (hand proximity distance) [130 cm]: *NA*	Spiders-Flowers / Positive-Negative	* Attention training reduced an attentional bias towards spiders in one group and away from spiders in the other group. * Attentional training reduced self-reported, implicit spider fear and physiological responses; except for implicit bias measures there were no group differences.
11	Nicholson et al. (2012) / [H]	Tested the usefulness of the IRAP in measuring implicit aversive bias towards spiders.	High-fear (15) ; Low-fear (15)	FSQ: high 61.27 (16.86); low 7.27 (4.93)	Spider (0-6, increasing in approach; 0 = room's door open; 6 = keep hand in the terrarium). 2 min steps [*NA*]: High (7 out of 15 completed 6 steps); Low (14/15 completed all 6 steps)	Spiders-Pleasant Pictures / True-False / Fear statements-Approach statements	* The IRAP can distinguish between two groups with varying levels of spider fear. * High-fearfuls showed aversive bias IRAP effects for spiders, whereas the low-fearfuls a small approach bias. * Significant difference in aversive bias toward spiders between the high- and low-fearfuls. * Mann-Whitney U tests revealed a significant difference on BAT performance between the high- and low-fearfearfuls. * There was a significant correlation between the spider D-IRAP and FSQ, and the BAT. * Regression models suggested that the IRAP provides a nonrelative measure of spider fear.
12	Asnaani et al. (2014) / [M]	The efficacy of approach-avoidance modification (via AAT) for positive stimuli associated with social anxiety.	Social anxious (43; training subgroup 21; controls 22)	SPIN: 41.44 (11.35) / LSAS: 70.40 (14.85) / AAT-approach: 20.35 (60.36)	Speech (videotaped in front of confederates) [max 10 min]: 248.13 (182.66)	Smiling faces-Checkboards / Push-Pull	* Control group scored higher than the training group on the SPIN and LSAS at pre-test; no differences for the other of the measures. * Levels of initial approach bias on the AAT were similar in both groups. * Short-term effectiveness of the AAT training in modifying biases in individuals with SAD. This effect was not maintained between sessions, both groups had similar levels of approach and avoidance during sessions 2 and 3.
13	Vervliet et al. (2015) / [M]	Validation of a response prevention and extinction (RPE) protocol in human avoidance conditioning.	Experiment 1 (20); Experiment 2 (20)	STAIT-T: 37.65 (8.22) / CBAS: 53.78 (15.13) / IU: 66.35 (18.29)	Shock (frequency of contacted or avoided shocks on cue; safe/avoidable threat)	Shock / Room pictures with blue or yellow cues	* After fear conditioning, participants learned to produce the avoidance response primarily to the danger cue than to the safety cue. * Shock-expectancy and SCR decreased over avoidance trials; removal of the avoidance response is followed by return of shock-expectancy and SCR, decreasing in turn during extinction.

14	Dour et al. (2016) / [M]	Positive valence training of feared stimuli as means to improved treatments' lasting effects.	Spider-fearfuls (61; training group 36, controls 25)	SPQ: 20.45 (3.98)	Spider (0-11, increasing in approach; 0 = moving closer; 11 = probing the spider with a tip). 30 s-15 cm, steps [150 cm]	7-min video positively depicting spiders	* The Positive Valence group reported less subjective fear than the controls group at spontaneous recovery. * Greater percentage of individuals in the Positive Valence group approached more the spider after reinstatement. * Adjunct positive valence training may increase the longevity of exposure therapies by increasing valence after exposure to an aversive experience.
15	Leech et al. (2016), Study 1 / [H]	The IRAP as a measure of implicit fear, approach and avoidance of spiders.	*NA*	*NA*	Spider (0-5, increasing in approach; 0 = opening room's door; 5 = put hand into the box and touch the tarantula moult for ten seconds). [*NA*]	Spiders / response concordance pro/anti-spider / Spider-Fear and Spider-Avoid statements	* Correlational analyses do not support the premise that fear or approach/avoidance biases on the IRAPs predicted BAT performance.
16	Leech et al. (2016), Study 2 / [H]	Increase the validity of the IRAP as a measure of implicit fear, approach and avoidance of spiders.	*NA*	*NA*	Spider (0-5, increasing in approach; 0 = opening room's door; 5 = put hand into the box and touch the tarantula). 10 s [*NA*]	(*Idem.*)	* Significant correlation between the Spider-Approach trial-type and the BAT (IRAP approach bias towards spiders predicted BAT performance); Spider-Approach trial-type and the FSQ approached significance (low approach bias relate to higher self-reported fear). * BAT performance across the two IRAPs related only to the Spider-Approach trial-types (rather than avoidance or fear).
17	Meulders et al. (2016) / [L]	Development and test of an operant conditioning procedure for pain-related overt avoidance.	Experimental (25); yoke control (25)	FPQ: exp 59.56 (12.75); yoke 63.76 (13.98) / STAI-T: exp 44.88 (4.48) ; yoke 46.44 (3.90)	Shock (frequency of contacted or avoided shocks as a function of 3 levels of physical response effort; T1 = no tractive force, T2 = moderate, T3 = high tractive force, with 100%, 50% and 0% of CS+)	Shock / T1-T2-T3	* Slower responses to CS+ than to CS-. * Experimental Group reported more pain-related fear and pain-expectancy to T1 vs T2 vs T3 and deviated more from the shortest trajectory than the Yoked Group. * There was resistance to extinction in pain-expectancy, self-reported fear and avoidance. * Significant correlations between both trait, fear of movement-related pain and avoidance behaviour.

Appendix D. Methodological characteristics of spider BATs (*Study 1*).

Table D1
Methodological aspects of spider BATs present in the sampled studies

	Measure Lapse	BAT instructions	Role of experimenter	Inanimate spider	Qualitative step	BAT-Anxiety	BAT-steps	BAT-distance	BAT-duration	BAT-speed
Teachman et al. (2003)						X	X	X		
Huijding & de Jong (2005)		X	X		X		X			
Ellwart et al. (2006)					X			X	X	X
Huijding et al. (2006)		X	X		X		X			
Rinck & Becker (2007)					X					X
Teachman B. A. (2007)					X	X	X			
Cochrane et al. (2008)		X				X	X			
Reese et al. (2010)					X	X	X			
Bockstaele et al. (2011)				X		X		X		X
Dour et al. (2016)					X	X	X			
Leech et al. (2016)				X	X		X			
Experiment 2 (this thesis)	X	X	X	X	X	X	X	X	X	

Note. The columns correspond to methodological aspects present in each of the spider BAT procedures sampled as part of the systematic review (*Study 1*). *Measure lapse*: if there was a significant time lapse between verbal and non-verbal measures of fear (e.g., administering a questionnaire and a BAT task); *BAT instructions*: if the BAT instructions given to the participants were reported; *Role of experimenter*: information about the role and positioning of the experimenter whilst participants performed in the BAT; *Inanimate spider*: if the threat consisted of dead spider or moult; *Qualitative step*: if there was a step in the BAT procedure that constituted a qualitatively different level of exposure to the threat stimulus (e.g., opening a door to make the spider visible or touching it); *BAT-steps, BAT-distance, BAT-duration, BAT-speed*: if any of these units of measurement were reported.

Appendix E. Exploratory moderator analyses for the first meta-analysis (k = 16) exploring the relation between explicit measures of fears and BATs (left hand-side), and the second meta-analysis (k = 11) between explicit measures and BATs (right hand-side). (*Study 1*).

Moderator variable Explicit – BAT	I^2 %	*Q* (df)	*p*	Implicit – BAT	I^2 %	*Q* (df)	*p*
Age	84.37	0.14 (1)	.700	Age	6.17	1.59 (1)	.207
Sample size	84.65	0.59 (1)	.441	Sample size	25.86	0.02 (1)	.867
Gender	82.64	1.37 (1)	.241	Gender	22.27	0.48 (1)	.484
Gender ratio	84.24	0.57 (1)	.449	Gender ratio	26.03	0.02 (1)	.884
Quality score	82.61	2.59 (1)	.106	Quality score	25.14	0.04 (1)	.838
Clinical samples	85.34	0.46 (1)	.496	Clinical samples	0.00	3.02 (1)	.082
Quality overall judgement	81.49	3.70 (1)	.054	Quality overall judgement	26.08	0.00 (1)	.962
Questionnaire type	72.20	16.57 (5)	.005**	Type of implicit (RT) task	39.10	2.51 (5)	.774
Type of BAT	82.36	4.60 (4)	.330	Type of BAT †	-	-	-
BAT unit	82.69	5.61 (4)	.229	BAT unit	20.55	0.70 (1)	.402
Data source (published/emailed)	85.13	0.61 (1)	.431	Data source	25.46	0.01 (1)	.893

Note: Significant code *p.* levels at .05 "*", <.05 "**", and .001 "***"
† No available contrasts to run this analysis as all of the studies in this sample used a "spider BAT."

Appendix F. Recruitment information sheet and consent form (*Experiment 1*).

Experiment Participation Information Sheet

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. This Participant Information Sheet will tell you about the purpose, risks and benefits of this research study. If you agree to take part, we will ask to ask you to sign a Consent Form. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read it. You should only consent to participate in this research study when you feel that you understand what is being asked of you, and you have had enough time to think about your decision.

Title: The Price of Fear: Measuring fear and avoidance on our decisions and actions.

Location: Eye-Tracking lab (AMB-2069, top floor Psychology Building).

Rationale and Aim of the study:

You're being invited to participate in an exciting study in decision making. We make decisions every minute of our lives and we think most of them are rational. However, psychological research has demonstrated that a great part of our decisions are in fact influenced by our feelings. The current project aims to explore the role of fear-driven avoidance within this context. When the choices have a cost, avoidance patterns in the way people choose allows us to estimate a score. We hope this scoring system can be a contribution to the way we assess certain fears; as an alternative to self-reported questionnaires. In addition, eye-tracking technology can provide us with information about the aspects of a situation that we attend, thereby giving us insights into the attentional processes at play.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw or not to take part, will not affect your rights in any way.

What will happen to me if I take part? (The experimental task)

The experimental task consists of a card game where you will have to choose between two decks of cards, each yielding different payoffs and followed by the presentation of visual stimuli. As the purpose of the study is to explore the process of fear, *at times, the visual stimuli will contain real spiders, displayed on the computer screen. Even though these are harmless, if you are afraid of spiders you could experience some discomfort*. During the task, your eye-movements will be recorded using an eye-tracker devise. This is a non-invasive procedure and it only involves resting your chin on a fix frame to keep you head movements steady.

At the end of the experimental task, we will ask you to complete some questionnaires to assess motivational predispositions, your fear of spiders, and sociodemographic data. In addition, you can decide to be taken to a room where we want to see how willing you would be to approach a spider contained in a terrarium; for this task you will have absolute control and we will only ask you to approach the terrarium to the point where you would start feeling uncomfortable (you could also skip this task you wish).

How long will my part in the study last?

The experimental task will only take about 35 min. However, taking into account the reading material, FAQ, and the time required to complete some questionnaires, your participation time is estimated to last about 50 min.

What are the possible benefits in taking part?

If you're an undergrad student, this study will provide you with 2 credits for experimental participation. Moreover, you'll be making a contribution to science and research that may later lead to clinical applications for people who suffer from anxiety conditions. Additionally, at the end of the experiment, you can get to know your calculated score; this is, you'll find out whether your fear has a "cost" within the rationale of the project. Finally, at the end of the experiment you can opt to participate in a prize draw to win a cinema ticket (which will be carried out after the researchers finish collecting data).

What are the possible disadvantages and risks of taking part?

After viewing some of the visual stimuli in the task, you may experience discomfort and would like to get some support to minimise any distress experienced. We will be happy to recommend support services to you.

Will my data be anonymized?

Yes. At no point identifying or individual information will be gathered. All information that is collected about you during the course of the research will be kept strictly confidential and only the researchers in charge of the study will have access to it. The information collected in this study will be stored in a way that protects your identity. Once aggregated with all of the participants' data, the results will be included in future publications but will be reported as group data and will not identify you in any way.

Eye Movement measurement

Heavy eye make-up (i.e., mascara) can interfere sometimes with the eye-tracker. We would appreciate if you waited until the experiment is over to wear it.

Unfortunately, if you suffer from an eye disease such as aphakic or macular problems or you have been diagnosed with dyslexia, schizophrenia or attention deficit hyperactivity disorder, we will not be able to record your eye movements during the experiments. You may still choose to participate, but please let the experimenter know about your condition.

You can contact any of the following:
Mr. Santiago Garcia (principal researcher),
Email: s.garciaguerrero1@nuigalway.ie
Phone: 0857298497,
Office: Room G055, Arts Millennium Building Extension –AMBE),
Dr. Denis O'Hora (supervisor)
Email: denis.ohora@nuigalway.ie
Phone: 091 495126

Alternatively, if you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee, c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie

Thank you for your interest in the study and we hope to see you soon!

Informed Consent Form

Participant Identification Number:____________

Title of Project: Price of Fear: Measuring fear and avoidance on our decisions and actions.

Name of Researcher: Santiago Garcia **email**: s.garciaguerrero1@nuigalway.ie
Supervisor: Dr. Denis O'Hora **email**: denis.ohora@nuigalway.ie

Description of the experiment:
In this study you will complete a decision-making computer task. At times, images of spiders will be displayed which, although harmless, could cause discomfort. We will also ask you to complete a couple of psychological questionnaires (some non-identifying demographic information is collected too). We estimate it will take approximately 50 minutes to complete.

In order to participate in this research study, it is necessary that you give your informed consent. By signing this informed consent form you are indicating that you understand the nature of the research study, your role in it, and that you agree to participate in the research.

Please consider the following points before signing:
1. I confirm that I have been given a copy of and read the information sheet dated .... (version ....) for the above study and have had the opportunity to ask questions.

2. I am satisfied that I understand the information provided and have had enough time to consider the information.

3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

4. I further understand that the data I provide may be used for analysis and subsequent publication.

5. I agree to take part in the above study.

Name of Participant: Date: DD/MM/YYYY Signature: ______________
Participant's email (for prize draw purposes):

Name of Person taking consent: Date: DD/MM/YYYY Signature: ______________
(if different from researcher)

Researcher: Santiago Garcia Date: DD/MM/YYYY Signature: ______________

Appendix G. Instructions presented to the participant as part of the experimental task (*Experiment 1*).

The instructions at the start of the task were as follows:

> The following task consists of a card game where on each trial you can choose one of two decks displayed at the upper corners of the screen (by clicking on it with the mouse).
>
> Each deck will provide you with different amounts of points and it will be followed by an image. You'll have to look at the image for a specified period before you can continue; you won't be able to control this.
>
> Each trial starts when you press the button "start," located at the lower centre of the screen. It is important that you initiate your response as soon as you press this button.
>
> If you hear a beep, it means that you were too slow, so try to initiate your response in the next trial sooner (i.e., start moving the mouse as soon as you hit "start").
>
> Each trial-block will terminate upon completing a specified number of points.
>
> Your goal is to gain as many points as possible in the least amount of trials, but you might want to consider also the stimuli associated with each deck. You can choose any deck at any time, and there will always be a spider-free choice.
>
> When you're ready to continue just click (anywhere) the left-button of the mouse.

And then, preceding the practice block:

> The following trials are not part of the data collection phase.
>
> This part of the experiment is so you get a sense of the task and get used to it. Feel free to ask any questions at any time.
>
> Each deck has its own characteristics and you can choose either deck every time.
>
> Click with the mouse to continue

Participants were notified of the end of practice:

> That's the end of the practice.
>
> The next block of trials is the start of the real experiment.
>
> The task is the same as the one you did before, but as you progress from block to block some characteristics of the decks will change.
>
> *Remember*: Your choice is between both the points and the stimuli associated with each deck.
>
> Click with the mouse to begin the experiment

Before starting each block, participants were informed about the minimum points criteria to complete the current block:

> For the next block you will have to make the following amount of points:
>
> [*Respective No. of Points*]

After completion of each block, participants were prompted of the change in the decks' payoffs:

Well done! You've completed this block.

Take a couple of minutes if you need.

Note that the characteristics of the decks will change from block to block.

When you're ready to continue, just click with the mouse.

And, at the end of the last block, participants were shown the following message:

Congratulations! You’ve finished this part of the experiment.

Your score was: [*displayed individual’s score*]

Please let the experimenter know and wait for further instructions.

Appendix H. Form asked to be completed after the task (*Experiment 1*).

Participant No: Age: Gender: First Language: Right or Left handed:
"I am more fearful of spiders than most other people." correct/incorrect

Please answer the following questions referring to the experimental task you've completed. There are not correct or incorrect answers, we simply want to get an idea of your particular experience, indicating your degree of agreement with the statements: 1 = Entirely agree 2 = Mostly agree 3 = Neither agree nor disagree 4 = Mostly disagree 5 = Entirely disagree	**Entirely Agree** **1**	**Mostly Agree** **2**	**Neutral** **3**	**Mostly Disagree** **4**	**Entirely Disagree** **5**
Overall, this task was upsetting (made me feel uneasy).					
At times, I found it difficult to decide which deck to choose.					
I realised that greater reward points got me quicker through the task.					
I realised that the greater reward was associated with the threat.					
I found going quicker through the task, by preferring the higher reward, to be a motivating factor.					
I was motivated to avoid the spider-related stimuli in this task.					
I based my choices based on avoiding the threat-related deck.					
I found the spider-related stimuli in this task unpleasant.					
I found the spider-free stimuli pleasant (different from neutral).					
I found the spider-free stimuli neutral.					
The spider-related stimuli in this task made me feel anxious or uncomfortable.					
I found myself choosing the spider-related deck because of the higher points reward, despite of my fear towards the spider stimuli.					
If it wasn't for the higher reward on the spider-related deck I would have avoided it.					
I will generally do things I don't want to if there is enough incentive.					

How would you describe or label each of the decks (select as many as applicable)

Simply with respect to their colours (i.e., the "red deck" and "blue deck")	
The red deck = "negative"; the blue deck = "positive"	
The blue deck = "pleasant/neutral"; the red deck = "unpleasant"	
The red deck = "faster"; the blue deck = "slower"	
Based on the values (i.e., higher points) only	
Based on the values (i.e., lower points) only	
None of the above	
I chose the cards randomly	

In one way or another I applied some of the previous criteria whilst performing the task: Y/N

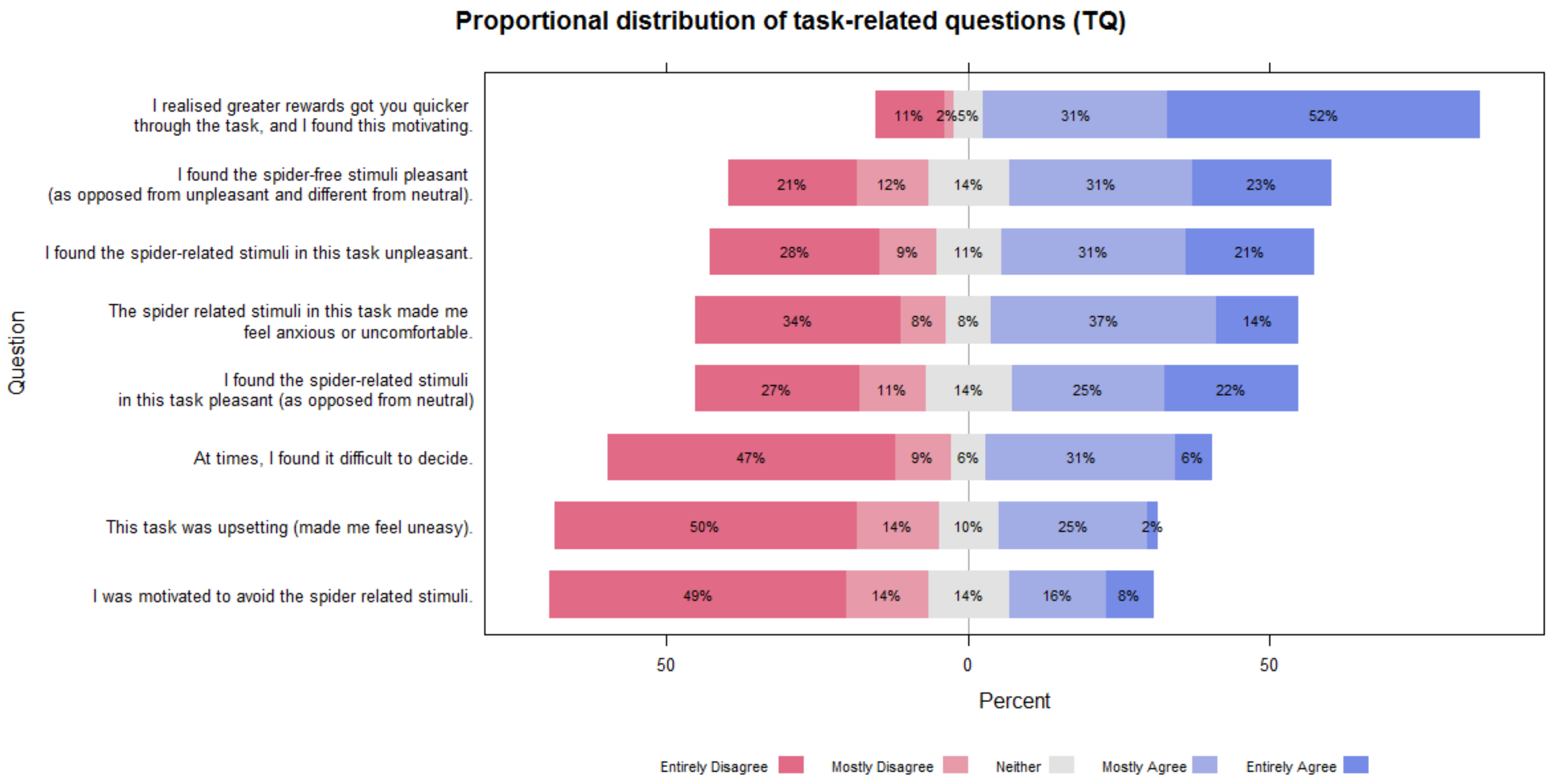


Figure H1. Proportion of answers to task related questions (*Experiment 1*). The order of the questions has been rearranged in accordance to the diverging stacked barcharts. The left column shows the statements to which participants indicated their responses in accordance to the 5-poin Likert scales (response labels at the bottom of each set). The bars to the right of each statement shows the distribution of the participants' answers to them. This graph was done using the "HH" R package (Heiberger, 2018; Heiberger & Robbins, 2014 – with a slight modification in the code to include the percentages within each response level).

Appendix I. Research participation letter and consent form (*Experiment 2*).

Experiment Participation Information Sheet

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. This Participant Information Sheet will tell you about the purpose, risks and benefits of this research study. If you agree to take part, we will ask you to sign a Consent Form. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read it. You should only consent to participate in this research study when you feel that you understand what is being asked of you, and you have had enough time to think about your decision.
Thank you for reading this.

Title: The role of spider fear in approach-avoidance motivation during decision-making tasks.
Location: Eye-Tracking lab (AMB-2069, top floor Psychology Building). [***see map attached at the end***]

Rationale and Aim of the study:
You're being invited to participate in an exciting study in decision making. We make decisions every minute of our lives and we think most of them are rational. However, psychological research has demonstrated that a great part of our decisions are in fact influenced by our feelings. The current project aims to explore the role of fear-driven avoidance in a computer task. We hope this task can shed some light on fear-based avoidance processes and can contribute to the way we assess specific fears. Moreover, eye-tracking technology can provide us with information about the aspects of a situation that we attend, thereby giving us insights into the attentional processes at play. In addition, behavioural exercises such as approaching a real spider, can help us explore the extent to which someone's spider fear is manifested in more realistic scenarios, and the relation this may have with our decisions in other scenarios.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time (e.g., opting out of the exercise with the real spider), or a decision not to take part at all, will not affect your rights in any way.

What will happen to me if I take part? (The experimental task)
The experimental task consists has different stages: (a) computer task, (b) questionnaires and (c) a behavioural exercise: (a) The computer task consists of a card game where you will have to choose between two decks of cards, each yielding different payoffs and followed by the presentation of visual stimuli. As the purpose of the study is to explore the process of fear, *at times, the visual stimuli will contain real spiders, displayed on the computer screen*. Even though these are harmless, if you are afraid of spiders you could experience some discomfort. During the task, your eye-movements will be recorded using an eye-tracker devise. This is a non-invasive procedure and it only involves resting your chin on a fix frame to keep you head movements steady. (b) We will also ask you to complete some questionnaires to assess motivational predispositions, your fear of spiders, and—non-identifying—sociodemographic details. (c) After this, *you can decide to be taken to a room where we want to see to what extent and how willing you would be to approach a spider (contained in a terrarium 6 m away).* For this task you will have absolute control and we will only ask you to approach the terrarium to the point where you would start feeling uncomfortable (you could skip this task you wish).

What do I have to do to take part?
(1) Signing up to an available slot;
(2) Complete the preliminary screening which consists of filling in a questionnaire in this link https://tinyurl.com/FSQscale whilst using your school sona-email as "Participant ID" (Note: *filling this questionnaire does not count as participation and therefore does not grant you participation credits*);
(3) Let the experimenter know (s.garciaguerrero1@nuigalway.ie) that you've completed the screening questionnaire (specifying the email you used as Participant ID); Depending on the cases, exclusion to the

experiment can take place at this stage, if so, the experimenter will let you know as soon as possible via cancelling your sign up.
(4) If, after alerting the experimenter of step (2), you don't hear back from him, it means you're in so turn up to the slot you've signed up for.
Failure to follow steps (2) and (3) here described may result in exclusion of the experiment on the day you turn up for participation.

How long will my part in the study last?
Approximately 50 min. The experimental task will only take about 35 min. However, taking into account the reading material, FAQ, and the time required to complete some questionnaires, your participation time is estimated to last no longer than an hour.

What are the possible benefits in taking part?
If you're an undergrad student, this study will provide you with 2 credits for experimental participation. Moreover, you'll be making a contribution to science and research that may later lead to clinical applications for people who suffer from anxiety conditions.
Additionally, you can get to know your approach-avoidance threshold; this is, you'll find out how much your fear "costs" within the rationale of the project.
At the end of the experiment you can opt to participate in a prize draw to win a €15 one-for-all voucher (which will be carried out after the researchers finish collecting data).
Finally, if you experience extreme fear of spiders you could sign up to be part of a sample of volunteers that would be testing a phone app aimed at helping people bring their spider fear to manageable levels. Feel free to discuss this with the researcher if interested (if you know of somebody who could benefit from this, please feel free to pass along the researcher's details).

What are the possible disadvantages and risks of taking part?
The study includes psychometric measures related to anxiety conditions. You might find, while answering the questions, that you would like to talk to someone about some of the issues this raises. In addition, you may experience discomfort after viewing some of the images in the task or the specimen from the behavioural exercise. If you would like to get some support to minimise any distress experienced, we will be happy to recommend support services to you.

Will my data be anonymized?
Yes. At no point identifying or individual information will be gathered. All information that is collected about you during the course of the research will be kept strictly confidential and only the researchers in charge of the study will have access to it. The information collected in this study will be stored in a way that protects your identity. Once aggregated with all of the participants' data, the results will be included in future publications but will be reported as group data and will not identify you in any way.

Eye Movement measurement
Heavy eye make-up (i.e., mascara) can interfere sometimes with the eye-tracker. We would appreciate if you waited until the experiment is over to wear it.
Unfortunately, if you suffer from an eye disease such as aphakic or macular problems or you have been diagnosed with dyslexia, schizophrenia or attention deficit hyperactivity disorder, we will not be able to record your eye movements during the experiments. You may still choose to participate, but please let the experimenter know about your condition.

What if I have a complaint, have any concerns or would like to find out more?
You can contact any of the following:
Mr. Santiago Garcia (principal researcher),
Email: s.garciaguerrero1@nuigalway.ie
Phone: 0857298497,
Office: Room G055, Arts Millennium Building Extension –AMBE),

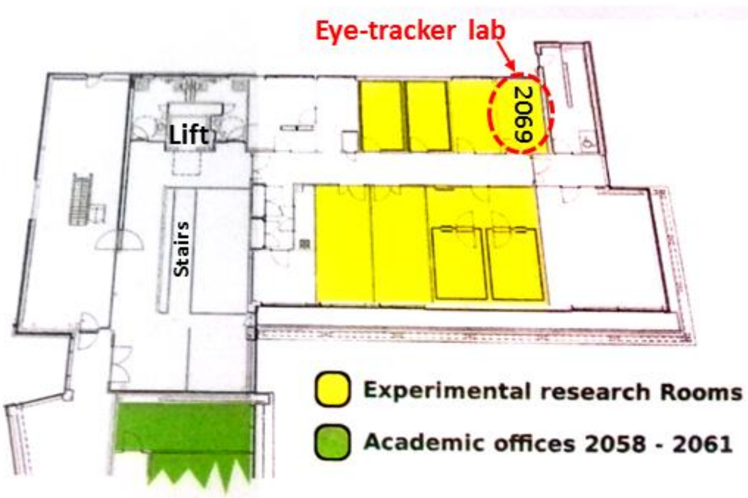
Dr. Denis O'Hora (supervisor)
Email: denis.ohora@nuigalway.ie

Phone: 091 495126

Alternatively, if you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee, c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie

Thank you for your interest in the study and we hope to see you soon!

Directions:
Once inside the psychology building, take the lift up to the top (2nd) floor, exit to your left and it would be the last room on the left. Also, follow the "eye-tracker lab" signs.



Psychology (AMB) 2nd Floor

Appendix J. Instructions presented to the participant as part of the computerised experimental task (*Experiment 2*).

At the beginning of the computer task:

The following task consists of a card game where on each trial you can choose one of two cards displayed at the upper corners of the screen (by clicking on it with the mouse).

Each card will provide you with different amounts of points and it will be followed by an image. You'll have to look at the image for a specified period before you can continue.

Each trial starts when you press the "start" button, located at the lower centre of the screen. You have to move your mouse upwards to make the cards appear, and please choose one of them as soon as you can.

Each trial-block will terminate upon completing a specified number of points.

Your goal is to gain as many points as possible in the least amount of trials, but you might want to consider also the stimuli associated with each deck:

At one point during the task, one card will be associated with neutral images whereas the other one will be associated with images of spiders. You can choose any card at any time, and there will always be a spider-free choice (i.e., if you don't want to see the spiders you can always select the alternative card instead).

Click with the mouse to continue

Introducing the practice trials:

The following trials are not part of the data collection phase.

This will give you a chance to have an idea of the mechanics and layout of the task

Feel free to ask any questions at any time.

Click to continue

Upon completing the practice:

That's the end of the practice.

The next block of trials is the start of the real experiment.

The task is the same, but as you progress from block to block some characteristics of the decks will change.

REMEMBER: Your choice is between both the points and the stimuli associated with each card (one of the choices will always be spider-free).

And don't forget to move your mouse upwards to make the decks appear!

Click to begin the experiment

Prior to each block:

For the next block you will have to make the following amount of points: ##

After each block:

(First screen)

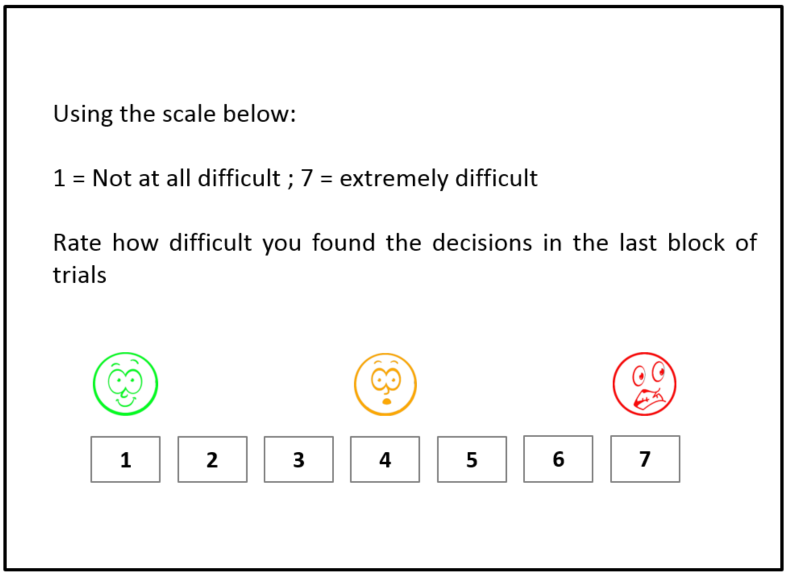


Figure I1. Illustration of the rating scale used by participants to indicate the level of difficulty experienced whilst completing the trials after each block.

(Second screen)

Well done! You've completed this block.

Take a couple of minutes if you need.

Note that the characteristics of the decks will change from block to block.

Click to continue

At the end of the experimenter:

Congratulations! You've finished this part of the experiment.

Please let the experimenter know and wait for further instructions.

Verbal instructions presented to the participant as part of the computerised experimental task.

Appendix K. Form asked to be completed after the task (*Experiment 2*).

Thank you for completing the experimental task. Next, we ask you to answer the following questions about the experimental task you've completed, and some basic details. This information will not identify you in any way. There are not correct or incorrect answers, we simply want to get an idea of your particular experience.

Participant ID: Age: Gender:

Indicate your degree of agreement with the statements: 1 = Entirely Disagree 2 = Mostly Disagree 3 = Neither agree nor disagree 4 = Mostly Agree 5 = Entirely Agree	**Entirely Disagree** **1**	**Mostly Disagree** **2**	**Neutral** **3**	**Mostly Agree** **4**	**Entirely Agree** **5**
I am very afraid of spiders.					
At times, I found it difficult to decide which card to choose.					
I realised that greater reward points got me quicker through the task.					
I based my choices based on avoiding the spider-related card.					
The spider stimuli in this task made me feel anxious.					
I found the spider-free stimuli to be neutral.					
I choose the spider-related option because of the higher points reward, despite of my fear towards the spider stimuli.					
If it wasn't for the higher reward on the spider-related card I would have avoided it.					
I based my choices based on the points, regardless of the images.					
I experience anxiety in anticipation whenever I chose the spider-related card.					

If asked to approach a big spider located in a terrarium 15 steps away, how close you think you'd go? (choose only one)

I would not attempt it	
15 steps away	
More than 10 steps away	
More than 5 steps away	
3 steps away	
2 steps away	
All the way, stand next to it	

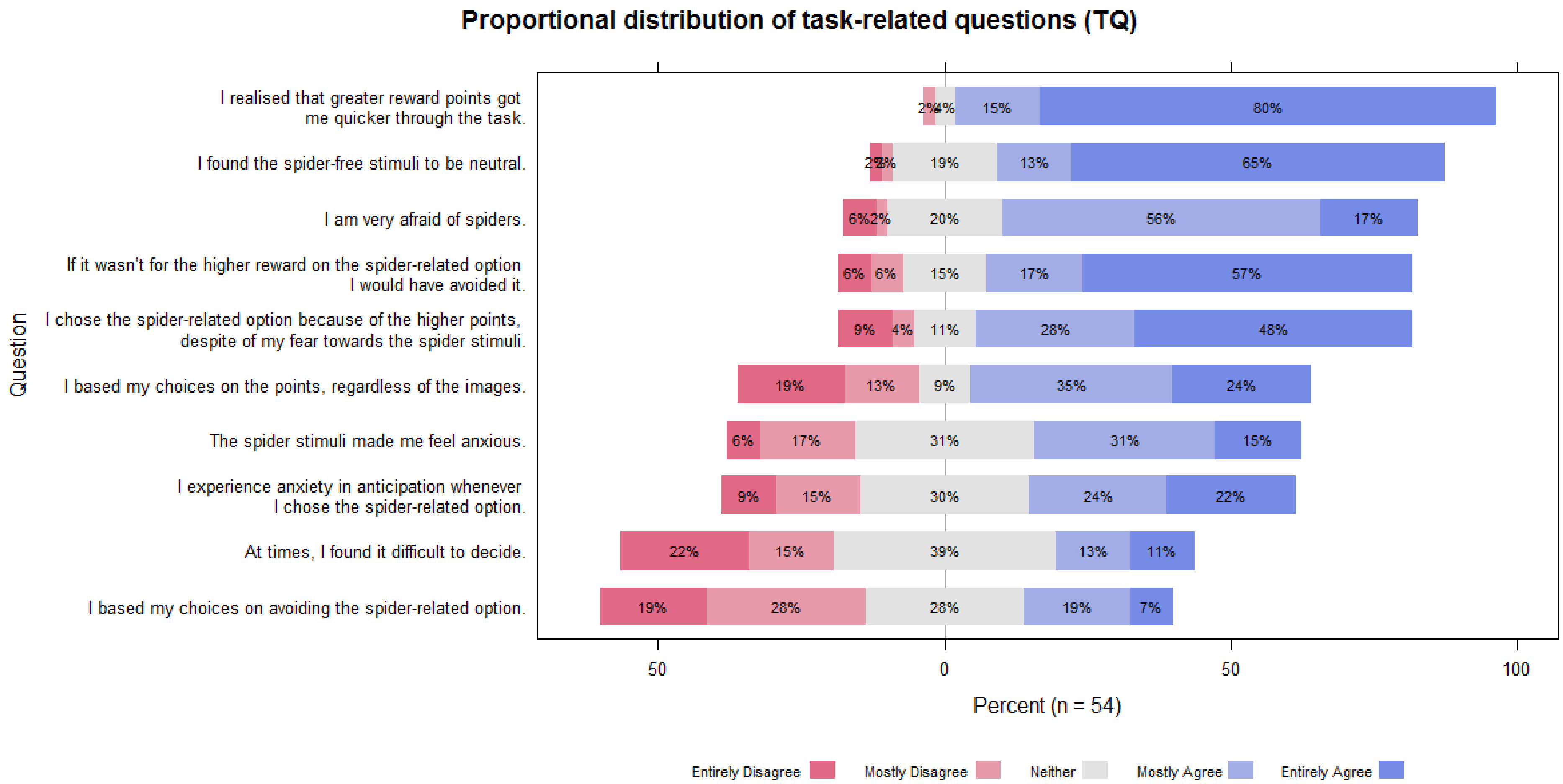


Figure K1. Proportion of answers to task related questions in accordance to the 5-poin Likert scales and arranged in diverging stacked barcharts (*Experiment 2*).

Appendix L. Introducing the behavioural exercise—BAT. (*Experiment 2*).

> "The next phase of this experiment consists of a behavioural exercise in which I ask you to approach a real spider. I will explain everything before we go ahead with this, but first, we'll go over to the next room."

The experimenter led the participant to the door of the room where the spider was kept and (after unlocking it) he explained:

> "*Inside this room I've arrange a corridor, on the other side of the room there is a big spider in a box. If willing, we want you to start walking towards the spider, as soon as you open the door, to the point where you wouldn't want to get any closer.*
>
> *At that point, looking at the spider, I need you to say aloud how much anxiety you're experiencing in a scale from 0 to 10, 0 being none to 10 being extreme anxiety.*
>
> *Is this clear? Do you have any questions?*
>
> *Whenever you're ready… [beckoning towards the door]*"

As soon as the participant opened the door, the experimenter started a timer until the participant stopped (keeping his distance behind). If participants did not mention the level of anxiety, the experimenter asked how much anxiety they were experiencing.

If a participant did not approach all the way, the experimenter placed a temporary mark on the floor (to measure the distance), and asked the following questions:

> Q1. "Hypothetically speaking, would you approach all the way to the table for €5?"
>
> – follow-up if negative answer: "What's the least amount of money you would do it for?"
>
> Q2. "Would you stay in this room on your own for 15 minutes for €5?"
>
> – follow-up if negative answer: "What's the least amount of money you would do it for?"
>
> Q3. "Can you try to get a bit closer?"

If a participant approached all the experimenter asked:

> Q4. "Would you lean over to look at it closely for 4 seconds?"
>
> – if given the case, "how much anxiety you're experiencing now?" [in a scale from 0 to 10]

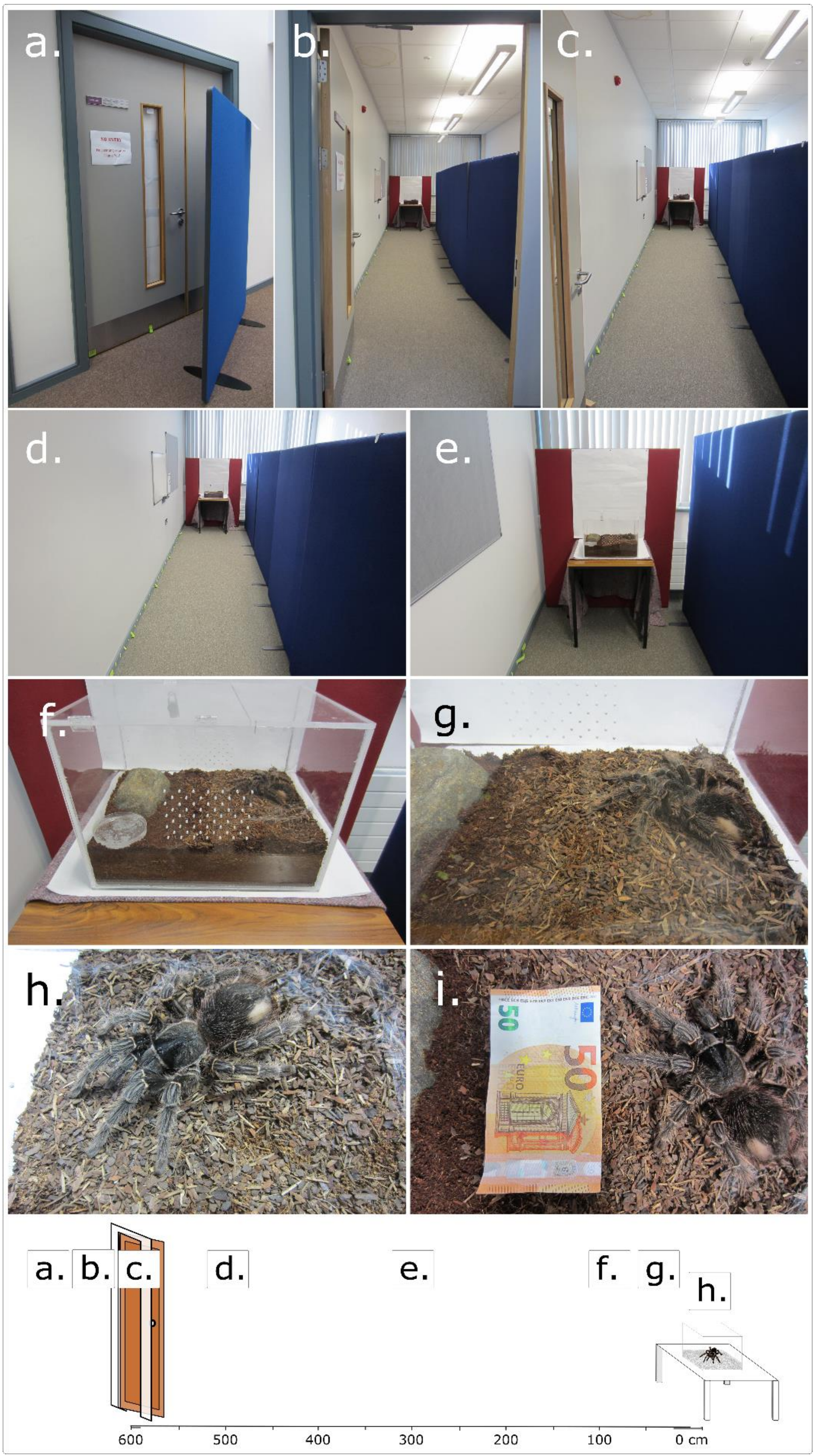


Figure L1. Photographic record showing the behavioural exercise (*Experiment 2*) of approaching the tarantula used as threat stimulus (images *a.* to *h.*). The illustration at the bottom shows the respective perspective point from which each photograph was taken. Image *i.* provides a reference (i.e., € note) for the size of the specimen used.

Appendix M. Form asked to be completed after the task (*Experiment 3*).

Participant No: Age: Gender: First Language: Stimulation level: Perception threshold (e.g., "6" for strong)

"I consider myself more fearful of electric stimulation than most other people." correct/incorrect

Please rate the level of PAIN from the electric stimulation experienced in this experiment in accordance to the following:				
1 Not at all	2 A little	3 A fair amount	4 Very much	5 Extreme
Please rate the level of ANTICIPATION ANXIETY you might have experienced just before choosing "T" for red numbers:				
1 Not at all	2 A little	3 A fair amount	4 Very much	5 Extreme

Threshold (stimulation level):
Perception threshold (e.g., "6" for strong):

Please answer the following questions referring to the experimental task you've completed. There are not correct or incorrect answers, we simply want to get an idea of your particular experience, indicating your degree of agreement with the statements: 1 = Entirely Disagree 2 = Mostly Disagree 3 = Neither agree nor disagree 4 = Mostly Agree 5 = Entirely Agree	**Entirely Disagree** **1**	**Mostly Disagree** **2**	**Neutral** **3**	**Mostly Agree** **4**	**Entirely Agree** **5**
Overall, this task was upsetting (made me feel uneasy).					
Overall, this task was unpleasant					
At times, I found it difficult to decide which deck to choose.					
I believed greater rewards to be associated greater with probability of threat.					
I felt motivated to choose to "take" the points.					
I found going quicker through the task to be a motivating factor.					
I was motivated to avoid the aversive stimulation in this task.					
I based my choices based on avoiding the threat-related option.					
I found the electric stimulation in this task unpleasant.					
I was motivated to choose the threat probability (by selecting "T") only when the reward was relatively high.					
I found losing points when selecting the "L" option demotivating.					
I experience some uneasiness whenever the probability of threat was on (coloured numbers).					
I chose the threat-related option because of the higher points reward, despite of my fear/unwillingness towards experiencing the electric stimulation.					
I will generally do things I don't want to if there is enough incentive.					
I felt habituation/desensitization to the aversive stimulation as the experiment progressed.					
I based my choices on the available rewards.					
My choice strategy was "be always on the safe", therefore not even try my luck on the trials with threat probability.					
I chose randomly.					

Some people only risk shock (red numbers) when the points available are over a certain value. If, at any point, you had such a value, input it here.

Following on the previous question, please indicate when you applied such a strategy:
1 = at the beginning only; 2 = somewhere in the middle only; 3 = at the end; 4 = during most of the task

How many shocks do you think you received during the task (excluding set up)?

Appendix N. Recruitment information sheet and consent form (*Experiment 3* & *4*).

Experiment Participation Information Sheet

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. This Participant Information Sheet will tell you about the purpose, risks and benefits of this research study. If you agree to take part, we will ask to ask you to sign a Consent Form. If there is anything that you are not clear about, we will be happy to explain it to you. Please take as much time as you need to read it. You should only consent to participate in this research study when you feel that you understand what is being asked of you, and you have had enough time to think about your decision.
Thank you for reading this.

Title: Fear-related decision-making and dynamic avoidance.

Location: Eye-Tracking lab (AMB-2069, top floor NUIG Psychology Building).

Rationale and Aim of the study:
You're being invited to participate in an exciting study in decision-making. We make decisions every minute of our lives and we think most of them are rational. However, psychological research has demonstrated that a great part of our decisions is in fact influenced by our feelings. The current project aims to explore the role of fear-driven avoidance within this context. When the choices have a cost, patterns in the way people choose allows us to estimate the underlying fear driving avoidance. We hope this paradigm can be a contribution to the way we assess certain fears. In addition, eye-tracking technology can provide us with information about the aspects of a situation that we attend to, thereby giving us insights into the attention processes at play.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to participate you will be given a copy of this information sheet to keep and be asked to sign a consent form. If you volunteer to the experiment you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your rights in any way.

What will happen to me if I take part? (The experimental task)
The experimental task consists of a simple game-like decision-making task where you will have to choose between two options, one that increases your points, and one that decreases your points. As the purpose of the study is to explore the process of fear, *on occasions known to you choosing the option that provides points may be followed by mild electric stimulation. Even though such stimulation is harmless, and you will have the opportunity to choose its level, it can cause some degree of discomfort.* During the task, your eye-movements will be recorded using an eye-tracker devise. This is a non-invasive procedure and it only involves resting your chin on a fix frame to keep you head steady.
At the end of the experimental task, we will ask you to complete some questionnaires to assess motivational predispositions, your fear of pain, and sociodemographic data.

How long will my part in the study last?
The experimental task will only take about 40 min. However, taking into account the reading material, FAQ, and the time required to complete some questionnaires, your participation time is estimated to last about 55 min.

What are the possible benefits in taking part?
If you're an undergrad student, this study will provide you with 2 credits for experimental participation. Moreover, you'll be making a contribution to science and research that may later lead to clinical applications for people who suffer from anxiety conditions. Finally, you can opt to participate in a prize draw to win a €45 one-for-all voucher (carried out after the researchers finish collecting data).

What are the possible disadvantages and risks of taking part?
The study includes questionnaires related to psychological conditions. You might find, while answering the questions, that you would like to talk to someone about some of the issues this raises. In addition, after experiencing instances of the aversive stimulation in the task, you may experience discomfort and would like to get some support to minimise any distress experienced. We will be happy to recommend support services to you.

Will my data be anonymized?
Yes. At no point identifying or individual information will be gathered. All information that is collected about you during the course of the research will be kept strictly confidential and only the researchers in charge of the study will have access to it. The information collected in this study will be stored in a way that protects your identity. Once aggregated with all of the participants' data, the results will be included in future publications but will be reported as group data and will not identify you in any way.

Am I eligible? (exclusion criteria)
Heavy eye make-up (i.e., mascara) can interfere sometimes with the eye-tracker. We would appreciate if you waited until the experiment is over to wear it. Unfortunately, if you suffer from an eye disease such as aphakic or macular problems or you have been diagnosed with dyslexia, schizophrenia or attention deficit hyperactivity disorder, we will not be able to record your eye movements during the experiments. You may still choose to participate, but please let the experimenter know about your condition.
Also, due to the stress this experiment may cause, individuals in pregnancy or undergoing treatment for (or use of medication for) psychiatric conditions such as anxiety and depression are likely to be excluded.
If you present any of the following, however, you will not qualify for this experiment: heart conditions, especially if you are currently using an electricity-driven aid (e.g., pacemaker).

What if I have a complaint, have any concerns or would like to find out more?
You can contact any of the following:
Mr. Santiago Garcia (principal researcher),
Email: s.garciaguerrero1@nuigalway.ie
Phone: 0857298497,
Office: Room G055, Arts Millennium Building Extension –AMBE),

Dr. Denis O'Hora (supervisor)
Email: denis.ohora@nuigalway.ie
Phone: 091 495126

Alternatively, if you have any concerns about this study and wish to contact someone independent and in confidence, you may contact the Chairperson of the NUI Galway Research Ethics Committee, c/o Office of the Vice President for Research, NUI Galway, ethics@nuigalway.ie

Informed Consent Form

Participant ID: ____________

Title of Project: Fear-related decision-making and dynamic avoidance.

Name of Researcher: Santiago Garcia **email**: s.garciaguerrero1@nuigalway.ie
Supervisor: Dr. Denis O'Hora **email**: denis.ohora@nuigalway.ie

Description of the experiment:
In this study you will complete a decision-making computer task. At times when you are alerted, there is a probability of experiencing a short electric stimulation depending on your choices; although mild and harmless, it could cause discomfort. We will also ask you to complete a couple of psychological questionnaires and answer some questions about non-identifying demographic information. We estimate your participation will take 55 minutes to complete.

In order to participate in this research study, it is necessary that you give your informed consent.
By signing this informed consent form you are indicating that you understand the nature of the research study, your role in it, and that you agree to participate in the research.

Please consider the following points before signing:

1. I confirm that I have been given a copy of and read the information sheet dated .... (version __2.0__) for the above study and have had the opportunity to ask questions.

2. I am satisfied that I understand the information provided and have had enough time to consider the information.

3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

4. I further understand that the (anonymised) data I provide may be used for analysis and subsequent publication.

5. I agree to take part in the above study.

Name of Participant: Date: DD/MM/YYYY Signature: ______________
Participant's email (for prize draw purposes):

Name of Person taking consent: Date: DD/MM/YYYY Signature: ______________
(if different from researcher)

Researcher: Santiago Garcia Date: DD/MM/YYYY Signature: ______________

Appendix O. Experimental instructions for both *Experiment 3* and *4*.

Preliminary task instructions. Displayed at the start of the task:

> The following task consists of trials in which you can choose to earn or lose points.
>
> After pressing the "start" button, two selection buttons will appear at the upper corners of the screen: "T" stands for "take it", whereas "L" stands for "Lose it".
>
> As you start moving your cursor upwards a number will appear on the screen, this represents the points that you can either decide to "take" or "lose", by clicking on the corresponding buttons "T" or "L".
>
> On occasions, the number will appear in red colour. When this happens, there is a 20 % probability of receiving a mild shock if you choose to take the points displayed (selecting "T"). This probability is constant and does not depend on the point values (i.e., higher points will not have higher shock probability).
>
> Selections of "L" will never be accompanied by a shock.
>
> Each trial-block will terminate upon completing the specified number of points, displayed at the beginning of each block.
>
> --------------------
>
> Remember: the more points you "take" the quicker you get through a block; the more you lose by avoiding the red numbers the longer it will take you to complete a block of trials. So the decision is yours. You can choose "safely" and take more time, or take "your chances" and spend less time in the task.
>
> Please try to make your selections as quickly as possible, when you see the number.
>
> When you're ready to continue just click.

And, each trial-block was followed by:

> Well done! You've completed this block.
>
> Take a couple of minutes if you need.
>
> When you're ready to continue, please position yourself back in the frame, and click with the mouse.

Setting up and calibration of the electric stimulator

Verbal explanation and instructions given to the participant after placing the electrodes:

> "Here we have a scale that goes from 0 to 7, and a representation of the dial that controls the intensity of the electric discharge. When I press this button down [the *initiator*] I'll be delivering a discharge, and I want you to let me know how much you felt that stimulation by rating it in accordance to this scale; for example, if you didn't feel anything, you draw a zero underneath the level 1 and so on and so forth".

This rating procedure was repeated for each increasing unit of electric discharge until participants request to stop, provided a rating of "6 – strong", or the maximum level of amplitude was reached.

When the desired level of stimulation was reached, the following was explained:

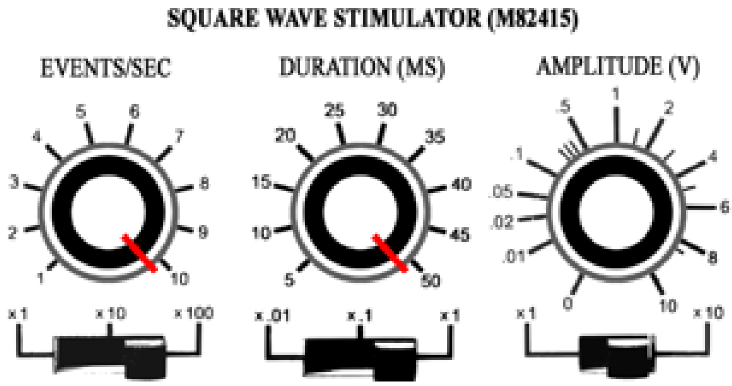
> "So it seems that we've reached your tolerance level. I take it that you wouldn't like the stimulation to increase any further, correct?.. So if that is ok with you, this will be the intensity we'll keep for the duration of the task".

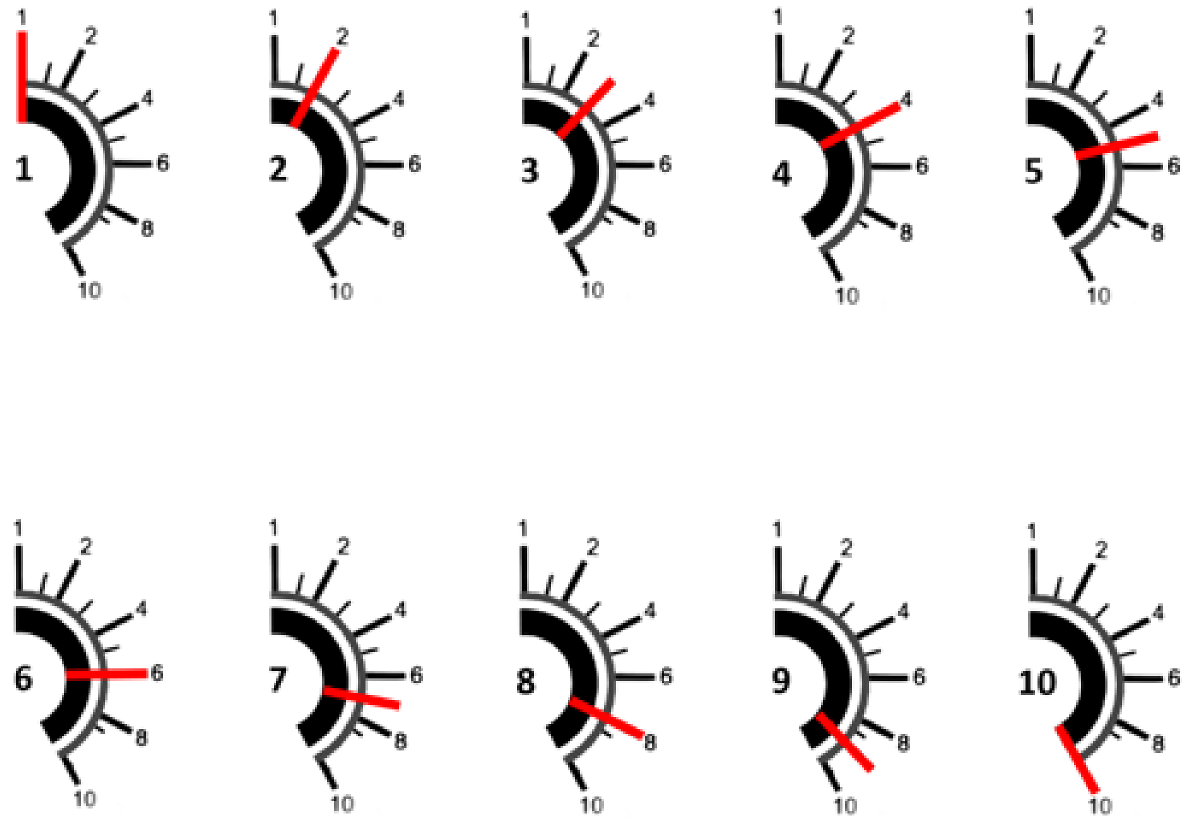
Perception scale used during the setup of the ISWS stimulator (Template in next page).

The perception scale used contains the dials and values (indicated in red) controlling the intensity of the electric pulse. The top shows the dials corresponding to *event/sec* and *duration* whose values are set for all participants. The rightmost dial corresponds to the *amplitude* of the pulse, which will vary across participants depending on their particular perception thresholds. The two rows of dials underneath, thus, represent each of the ten *amplitude* increases participants are asked to sample.

For each amplitude unit delivered, the participant provides a subjective rating of discomfort in accordance to the perception scale values at the bottom: a 7-point Likert scale (0 = "not sensation at all", 4 = "moderately uncomfortable", 7 = "painful"). These ratings are written beneath each of the amplitude dials being sampled (such record is then kept for each participant).

PERCEPTION LEVEL CALIBRATION FOR THE ELECTRIC STIMULATOR





0	1	2	3	4	5	6	7
Nothing	Tickle	Weak	Mild	Moderate	Tolerable	Strong	Painful

Appendix P. Debrief experiment sheet and retroactive consent form (*Experiment 3* & *4*).

Participant Debrief Sheet

Aims and rationale of the study:
This study explores how avoidance of fearful threats interferes with our decision-making processes. The options in the experimental task involve aspects that people might want to actively seek (i.e., points), and aspects that they might want to avoid (i.e., aversive stimulation). This creates a psychological competition when deciding and recording the mouse movements allows us to see how such a conflict occurs for individuals with different levels of fear/anxiety. Tracking your eye and mouse movements while you made your decisions also provides richer psychological information than simply registering the chosen option. For example, we can see if there is vacillation and determine whether choosing one option over another was easy or difficult (depending on the available potential reward values and threat probability).
In addition, choices that avoid the fearful threat entail a loss of points and based on this “the cost of such avoidance” can be calculated. Such value can then be used as a subjective indicator of fear (as a driver of avoidance); something we call “the price of fear”. We want to see how indirect measures of fear, such as self-reported questionnaires, and computer tasks like the one we’re designing correlate and informs us about psychological processes of avoidance.

Justification:
We need to better understand decision-making so we can help people make better choices. Often, choices are not as simple, we could have reasons both in favour and against a choice (known as approach-avoidance paradigms in science), and our emotions can play a crucial part in deciding (e.g., I would like to present my work in front of an audience but that makes me anxious). A new way to investigate decision making is to track a person’s behaviour while they choose. Neuroscientific studies suggest that cognitive activity “leaks” into the motor system. Consequently, in the laboratory, we can investigate the process of a decision by examining how people move a computer-mouse while deciding. To date, decisions are examined as simple outcomes (e.g., I either gave a presentation in front of an audience or I did not). However, most theories of decision making suggest that considerable activity occurs prior to that final action. We weigh up the available alternatives before reaching a decision and competing factors might determine the outcome (e.g., I might be willing to address an audience and experience a bit of anxiety if it is worthwhile, because of the potential feedback I could get). Research on decision making is used to help improve practices and policies that affect us all in our daily lives (e.g. education and health).

Retroactive Informed Consent

As explained above, we also recorded your computer-mouse movements during your performance. Research demonstrates that prior knowledge of this affects the reliability of such measurement and bias responses. As this information was not shared when you decided to participate, it is required that we obtain consent from you upon this disclosure. *If you do not sign this consent, your individual data will immediately be removed from our database*. By signing this consent, you still do not forfeit your right to request your data to be removed at a later stage (prior to data analysis and report).

- I was made aware that my mouse movements were also recorded during the experiment.
- I understand the reasons why I was not informed about this prior to my involvement.
- I still want my participation data to be part of the study.

Participant’s signature: ____________________ ID: ___________ Today’s Date: ____________

Thank you for your participation. ***We would appreciate it if you did not share details of this study with your friends, as this can affect the validity of their data should they also take part in the experiment.***
If you have any questions or would like additional information about the research, please do not hesitate to ask the researcher in person or by email.

Researcher Contact Details
Mr. Santiago Garcia (principal researcher),
Email: s.garciaguerrero1@nuigalway.ie
Phone: 0857298497,
Office: Room G055, Arts Millennium Building Extension –AMBE),

Dr. Denis O’Hora (supervisor)
Email: denis.ohora@nuigalway.ie

In the unlikely event of participants suffering negative consequences from participating, please contact the support services in NUI, Galway:
Student Counselling Service
National University of Ireland, Galway, University Road, Galway, Ireland.
Phone: **+353 (0)91 524411 ext. 2484**
E-mail: **counseling@nuigalway.ie**

Appendix Q. Mixed-effects models for both *Experiment 3* and *4*. The Tables Q1 to Q10 present comparative fits for each of the mixed-effects regression models and their respective predictor variables, for both experiments. The absolute values of the variable Target Valence were used for these models, and Trial underwent logarithmic transformation. Except for the models in Table Q1 and Table Q6, the slope and intercept of Target Valence were allowed to vary per participant.

Experiment 3

Table Q1

Generalized linear binomial mixed-effects models predicting approach responses

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	2	5733.3	5746.7	-2864.6	5729.3			
Target (slope) by Participant	2	2	6990.2	7003.7	-3493.1	6986.2	0	0	1
Target (slope and intercept) by Participant	3	4	3531.9	3558.9	-1762.0	3523.9	3462.3	2	< .001
Fixed effects									
Model 3 + Target	4	5	3472.1	3505.8	-1731.1	3462.1	61.814	1	< .001

Table Q2

Linear mixed-effects models used to predict log transformed response time

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	3	2922.4	2942.6	-1458.2	2916.4			
Target Valence (slope and intercept) by Participant	2	5	2720.1	2753.8	-1355.1	2710.1	206.29	2	< .001
Fixed effects									
Model 2 + Trial	3	6	2624.4	2664.9	-1306.2	2612.4	97.712	1	< .001
Model 3 + Target Val.	4	7	2585.1	2632.3	-1285.6	2571.1	41.288	1	< .001
Model 4 + Approach * Target Valence	5	9	2565.7	2626.3	-1273.8	2547.7	23.467	2	< .001

Table Q3

Linear mixed-effects models used to predict Maximum Absolute Deviation of response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects model									
Participant	1	3	85730	85750	-42862	85724			
Target Valence (slope and intercept) by Participant	2	5	85606	85640	-42798	85596	127.88	2	< .001
Fixed effects									
Model 2 + Trial	3	6	85586	85626	-42787	85574	22.820	1	< .001
Model 3 + Target Val.	4	7	85572	85619	-42779	85558	15.296	1	< .001
Model 4 + Approach * Target Valence	5	9	84712	84773	-42347	84694	864.047	2	< .001

Table Q4

Poisson generalized linear mixed-effects models used to predict x-flips during response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	2	19262	19275	-9628.8	19258			
Target Valence (slope and intercept) by Participant	2	4	19244	19271	-9617.8	19236	22.08	2	< .001
Fixed effects									
Model 2 + Target Val.	3	5	19223	19257	-9606.6	19213	22.291	1	< .001
Model 3 + Trial	4	6	19179	19219	-9583.5	19167	46.328	1	< .001
Model 4 + Target Valence * Approach	5	8	19165	19219	-9574.3	19149	18.311	2	< .001

Table Q5

Linear mixed-effects models used to predict sample entropy of response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	3	-10535	-10515	5270.3	-10541			
Target Valence (slope and intercept) by Participant	2	5	-10593	-10560	5301.6	-10603	62.498	2	< .001
Fixed effects									
Model 2 + Target Val.	3	6	-10609	-10569	5310.7	-10621	18.292	1	< .001
Model 3 + Trial	4	7	-10631	-10584	5322.3	-10645	23.130	1	< .001
Model 4 + Approach * Target Valence	5	9	-10703	-10643	5360.4	-10721	76.287	2	< .001

Experiment 4

Table Q6

Generalized linear binomial mixed-effects models predicting approach responses

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	2	4231.3	4244.6	-2113.7	4227.3			
Target (slope) by Participant	2	2	5484.1	5497.4	-2740.1	5480.1	0	0	1
Target (slope and intercept) by Participant	3	4	2546.0	2572.5	-1269.0	2538.0	2942.1	2	< .001
Fixed effects									
Model 3 + Target	4	5	2495.2	2528.4	-1242.6	2485.2	52.77	1	< .001

Table Q7

Mixed-effects models used to predict log transformed response time

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects model									
Participant	1	3	2857.8	2877.7	-1425.9	2851.8			
Target Valence (slope and intercept) by Participant	2	5	2809.7	2842.8	-1399.8	2799.7	52.167	2	< .001
Fixed effects									
Model 2 + Trial	3	6	2799.0	2838.8	-1393.5	2787.0	12.625	1	< .001
Model 3 + Target Val.	4	7	2785.8	2832.2	-1385.9	2771.8	15.272	1	< .001
Model 4 + Approach * Target Valence	5	9	2750.2	2809.9	-1366.1	2732.2	39.588	2	< .001

Table Q8

Mixed-effects models used to predict Maximum Absolute Deviation of response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	3	76990	77010	-38492	76984			
Target Valence (slope and intercept) by Participant	2	5	76973	77006	-38482	76963	21.126	2	< .001
Fixed effects									
Model 2 + Trial	3	6	76973	77013	-38480	76961	2.2372	1	.134
Model 3 + Target Val.	4	7	76968	77014	-38477	76954	7.1443	1	.007
Model 4 + Approach * Target Valence	5	8	76770	76830	-38376	76752	201.5403	1	< .001

Table Q9

Poisson generalized linear mixed-effects models used to predict x-flips during response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	2	17262	17275	-8628.8	17258			
Target Valence (slope and intercept) by Participant	2	4	17263	17289	-8627.4	17255	2.8163	2	.244
Fixed effects									
Model 2 + Trial	3	5	17259	17292	-8624.5	17249	5.7741	1	.016
Model 3 + Target Val.	4	6	17256	17296	-8621.9	17244	5.2106	1	.022
Model 4 + Approach * Target Valence	5	8	17242	17295	-8613.1	17226	17.5659	2	< .001

Table Q10

Mixed-effects models used to predict sample entropy in response trajectories

Model	No.	df	AIC	BIC	logLik	Deviance	Chi sq.	Chi df	*Pr*(>Chisq)
Random effects									
Participant	1	3	-11552	-11532	5779.1	-11558			
Target Valence (slope and intercept) by Participant	2	5	-11557	-11524	5783.7	-11567	9.2201	2	.009
Fixed effects									
Model 2 + Trial	3	6	-11565	-11525	5788.3	-11577	9.2563	1	.002
Model 3 + Target Val.	4	7	-11568	-11522	5791.0	-11582	5.5106	1	.018
Model 4 + Approach * Target Valence	5	9	-11607	-11547	5812.3	-11625	42.5606	2	< .001

Appendix R. Descriptive eye data for Experiment 3

In addition to response allocation, response trajectories and within-trial influences on response angle, we collected data on participants' eye movements. The Figure R1 below shows the probability of looking at three specified areas of interest (AOIs) corresponding to the area where the target numbers were displayed, and the response areas corresponding to "Taking" or "Losing" the value of the target. The panel on the left headed "False" shows the eye data when there was no probability of receiving an electric shock for choosing "Take"; the panel on the right headed "True" indicates that choosing "Take" involved a risk of shock.

It can be observed that participants began each trial looking at the Target AOI. Such behaviour is expected given that the target number is the first stimulus being displayed, but it also has relevant information about whether the trial has a risk of shock for choosing "Take".

When the threat was absent (left hand-side panel) participants were more likely to look at the "Take" response option. As expected, after looking at the target area and identifying that it was a "safe" trial, the probability of looking at the "Lose AOI" in non-threat trials is practically null. Next, however low, is the probability of looking at the "Target AOI", presumably indicating that participants sometimes checked the points they were earning with their response choice. During threat trials (right hand-side panel) participants were more likely to look at the "Take" option, whereupon they were more likely to look at the "Lose" option. This pattern contrasts that of non-threat trials and indicates that the presence of threat led participants to consider avoiding by looking at the alternative response option.

It could be argued that these data corroborates the stimulus control exerted by the presence of threat as captured by the within-trial TCMR analyses and the shifts from approach to avoidance (viz. looking at the "Take" then "Lose" AOI) as indexed by the response curvature of the mouse-tracked response trajectories (hand-movement redirection as a function of conflict).

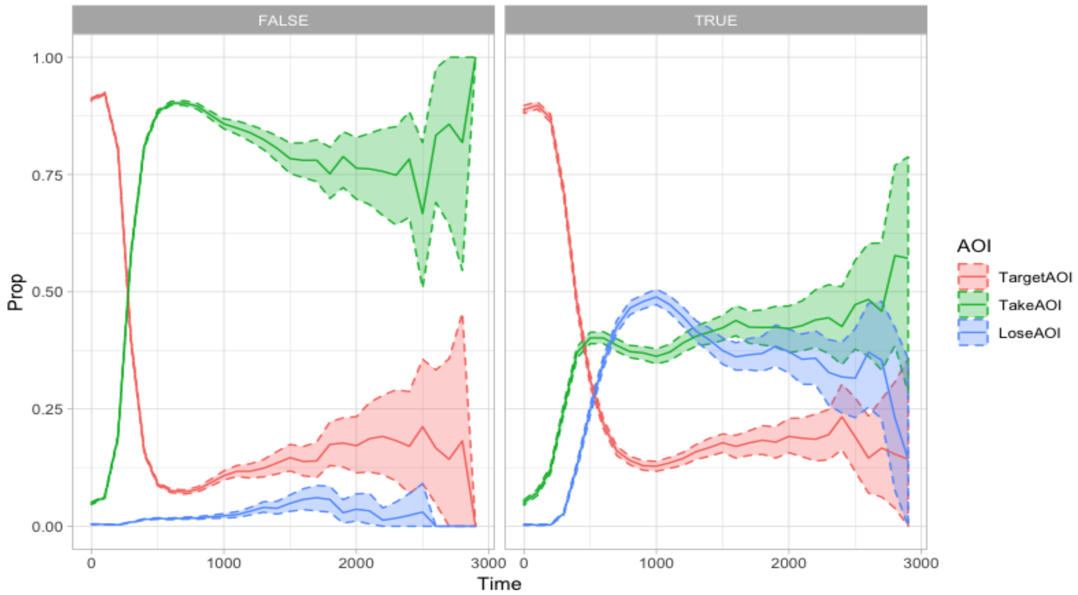


Figure R1. Probability of looking at the Areas of Interest (AOIs) corresponding to the target numbers, and response options, as a function of time; the shaded areas are the respective standard errors. The panel on the left shows the data during non-threat trials; the one on the right during threat trials involving a risk of shock.

Appendix S. Form asked to be completed after the task (*Experiment 4*).

Thanks for completing the experimental task. Next, we ask you to answer the following questions about the experimental task you've completed, and some basic details. This information will not identify you in any way. There are not correct or incorrect answers, we simply want to get an idea of your particular experience.

Participant No: Stimulation level: Perception threshold: Age: Gender: First Language:

Please rate the level of PAIN from the electric stimulation experienced in this experiment in accordance to the following:				
1 Not at all	2 A little	3 A fair amount	4 Very much	5 Extreme
Please rate the level of ANTICIPATION ANXIETY you might have experienced just before choosing "T" for red numbers:				
1 Not at all	2 A little	3 A fair amount	4 Very much	5 Extreme

----

Indicate your degree of agreement with the statements: 1 = Entirely Disagree 2 = Mostly Disagree 3 = Neither agree nor disagree 4 = Mostly Agree 5 = Entirely Agree	Entirely Disagree 1	Mostly Disagree 2	Neutral 3	Mostly Agree 4	Entirely Agree 5
Overall, this task was upsetting (made me feel uneasy).					
At times, I found it difficult to decide which deck to choose.					
I believed greater rewards to be associated greater with probability of threat.					
I felt motivated to choose to "take" the points.					
I found going quicker through the task to be a motivating factor.					
I was motivated to avoid the shock during the task.					
I based my choices on avoiding the shock-related option.					
I was motivated to choose the threat probability (by selecting "T") only when the reward was relatively high.					
I experience some uneasiness whenever the probability of threat was on (coloured numbers).					
I found losing points when selecting the "L" option demotivating.					
I chose the threat-related option because of the higher points reward, despite of my fear/unwillingness towards experiencing the shock.					
My choice strategy was "be always on the safe", therefore not even try my luck on the trials with threat probability.					
I didn't care about the shock probability, I always went for 'T'.					
I only assessed the number when these were red.					
I chose randomly.					

- Some people decide to choose "L" and avoid the probability of shock only for digits below a particular number. If this is something that you did, please type in such a number
- Following on the previous question, please indicate when you applied such an strategy: 1 = at the beginning only; 2 = somewhere in the middle only; 3 = at the end; 4 = during most of the task

Task-related questions common to both *Experiment 3* and *4*. Participants in both experiments completed a set of questions relating their experiences of the protocol. Figure R1 depicts the percent of respondents that provided responses at each level of the Likert scale. The percentage provided is based on the combination of responses from *Experiment 3* and *Experiment 4*. On the whole, the responses indicate that participants engaged with the protocol as expected (e.g., they were motivated to earn points and complete the paradigm quickly).

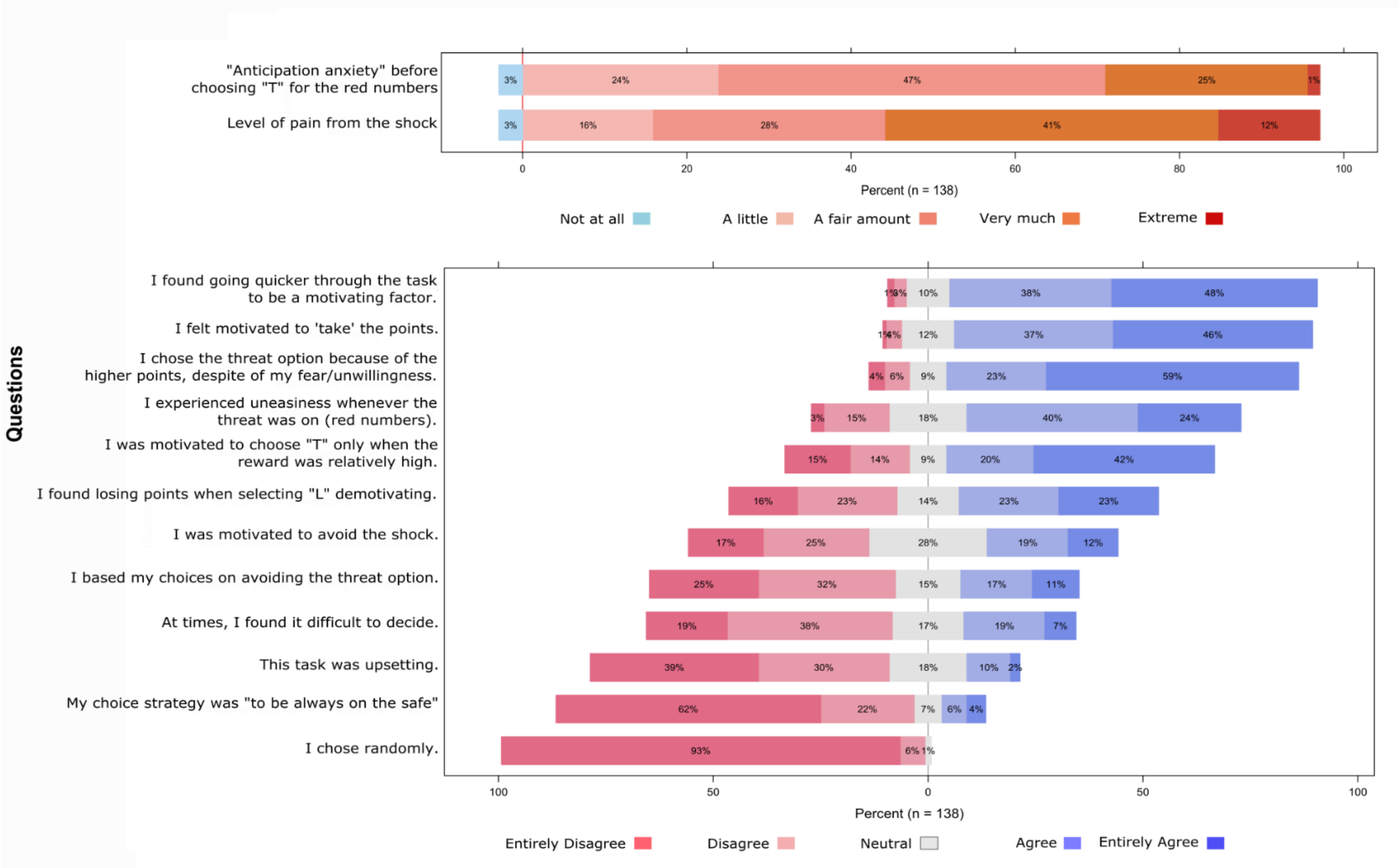


Figure S1. Proportion of answers to task related questions. The order of the questions has been rearranged in accordance to the diverging stacked barcharts. The left column shows the statements to which participants indicated their responses in accordance to the 5-poin Likert scales (response labels at the bottom of each set). The bars to the right of each statement shows the distribution of the participants' answers to them. This graph was done using the "HH" R package (Heiberger, 2018; Heiberger & Robbins, 2014 –with a slight modification in the code to include the percentages within each response level).

Appendix T. Average trajectory profiles per level of avoidance (*Experiment 3* & *4*).

Figure T1 below shows the average responses trajectories for both non-threat (safe) and the trials with shock probability (threat), for the different avoidance subgroups in both experiments.

When it was safe to choose (non-threat trials), responses exhibited relatively straight and uniform trajectories. By comparison, in the face of threat, trajectories were more complex, and this complexity was influenced by the response chosen and level of avoidance. For example, responses by Low Avoiders when choosing “Take”—rare—exhibited less attraction towards the safe “Lose” option in comparison to Moderate Avoiders and High Avoiders. Moreover, when deciding to avoid the threat option, Low Avoiders did so later (i.e., higher on the y-axis) than Moderate Avoiders and High Avoiders.

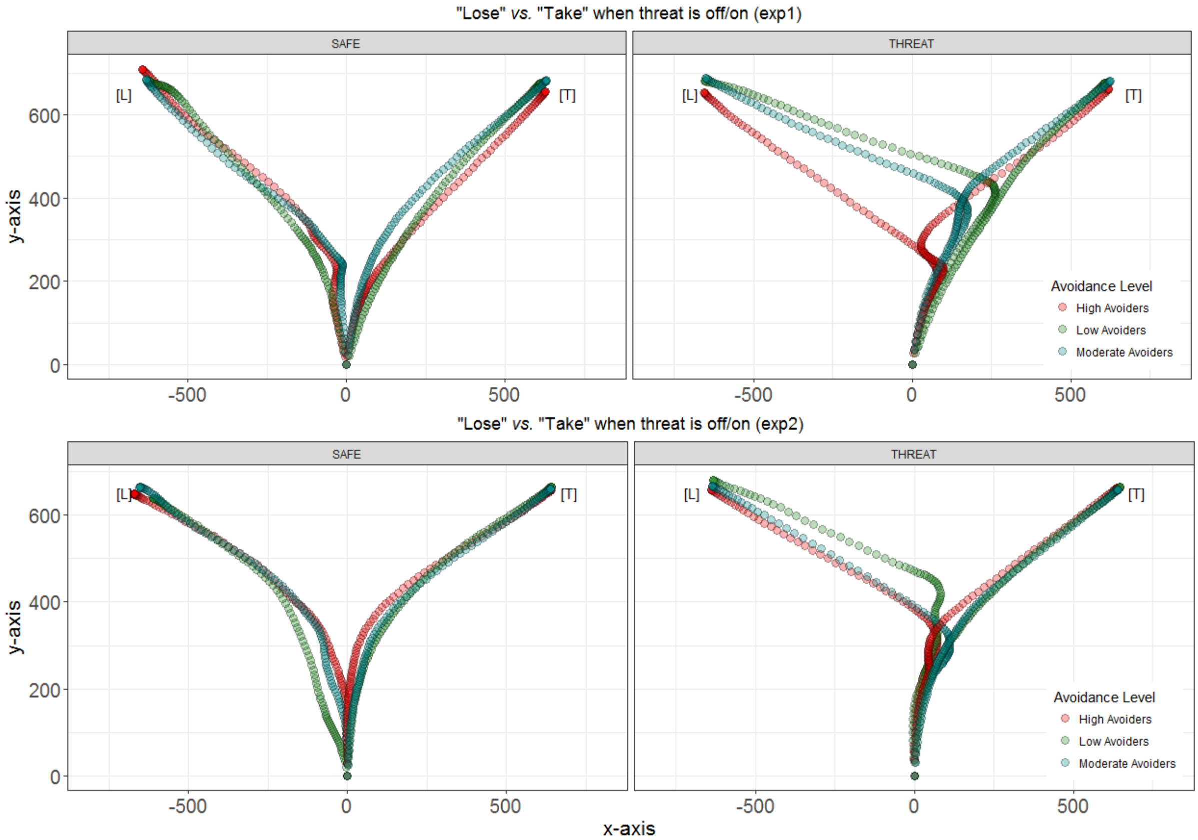


Figure T1. Averaged response trajectories per choice option (*L*, *T*), trial type (*safe*, *threat*) and avoidance level grouping (*High Avoiders* in red, *Moderate Avoiders* in blue, and *Low Avoiders* in green). The ordinate represents the height of the computer screen in pixels, the abscissa the width. Since response options changed positions, for comparative purposes, response trajectories have been remapped so responses to the left represent avoiding (i.e., choosing “L”) and responses to the right represent approaching (i.e., choosing “T”). Equally, the y-axis of the screen is inverted and the x-coordinates are rescaled so the starting middle position corresponds to 0, 0 coordinates, with leftward responses taking negative values on the x-axis and rightward responses being positive. Participants were grouped based on their indifference points (see Data processing): indifference point above 7 = High Avoiders; indifference point below 3 = Low Avoiders.