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The effects of MARIO, a social robot, on the resilience of people with dementia: A multiple case study

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Abstract

Background: Resilience is a process of adapting to stress. For people with dementia, resilience is enhanced through having positive social relationships. Social robots, such as MARIO, can facilitate social engagement. However, the effect of social robots on resilience has not yet been determined.

Objective: To investigate how MARIO, a social robot, affects the resilience of people with dementia.

Method: Multiple case study methodology was used to explore the resilience of people with dementia during and after they used MARIO in 12 facilitated sessions. Data collection was conducted using: dementia care mapping; semi-structured interviews with people with dementia (n=10), caregivers (n=6), and relatives (n=7); and questionnaires including the Quality of Life in Alzheimer's disease and The Resilience Scale. During sessions, data was collected using the Observational Measure of Engagement. Data analysis was guided by framework analysis. Qualitative and quantitative data were analysed in NVIVO 12 and SPSS respectively. Then, all data was triangulated in a matrix, analysed for similarities and differences within and across cases, and themes were developed.

Results: The cross-case analysis produced four themes: Resilience changes minute to minute; Initiating and maintaining readiness; Active co-creation of meaningful activity; Impact on resilience. The findings revealed that people with dementia required skilled facilitation to use MARIO. During interactions with MARIO, the resilience of eight out of ten people was supported. Sessions with MARIO increased the wellbeing of people with dementia by providing a meaningful activity that re-enforced their positive self-concept.

Conclusion: Social robots need to have greater capability to interpret and respond to the emotional needs of users if they are to benefit the resilience of people with dementia without the presence of a supportive facilitator. Future research should explore how strength-based strategies can empower people with dementia to create a meaningful activity using social robots.

Keywords: Dementia, Alzheimer's, resilience, case study, social robots

INTRODUCTION

Dementia is a syndrome that causes stress for people with dementia and their families (Prince, 2016). Stress can result from the symptoms of dementia that include cognitive, communication, emotional, and sensory difficulties (WHO, 2020), which makes performing everyday activities challenging (Prince, 2016). Stress can also be caused by poor relationships with other people and environmental factors (Beard 2009), such as moving into residential care (Sury et al., 2013) and stigma (Bryden, 2018). However, people with dementia can demonstrate resilience (Newman et al., 2018) and be regarded as 'doing okay'

(Harris & Keady, 2008) or doing better than expected (Bailey, 2017) whilst living with the limitations of dementia.

Resilience has been defined as a process of negotiating and adapting to stress that occurs in the presence of adversity (Windle, 2011). Resilience is impacted by a person's ability to access the resources that are available to them at the individual, community, and societal levels (Windle & Bennett, 2012). However, people need to be motivated to use resources, and motivation is increased if people consider that resources are meaningful to them (Ungar, 2008).

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For people with dementia, the goal of resilience is to achieve a degree of wellbeing that includes having: a positive self-concept (Harris & Keady, 2008), a positive mood, and being engaged with life (Sabat, 2018). To achieve wellbeing, people with dementia need to accept: support from other people, that they have dementia, and that this necessitates changes to their lives (Pipon-Young et al., 2012). The ability of people with dementia to achieve a good level of wellbeing is enhanced through the availability of protective assets and resources (Harris & Keady, 2008). All people have personal resilience repertoires (Ottmann & Margoudaki, 2015). These include the practical and psychological strategies that people use to cope with difficulties in life. Casey and Murphy (2016a) interviewed people with dementia (n=6) and found that their resilience repertoires included spirituality, being determined, having a fighting spirit, a positive attitude, and a sense of gratitude. Williamson and Paslawski (2016) examined the perspectives on the resilience of people with dementia (n=7) and their care partners (n=5). They identified that resilience is supported by having a sense of purpose in life and being involved in meaningful activity. Resilience is also supported by resources that are available at the community level, by having positive relationships with other people (Harris 2010). Harris (2010) interviewed people with dementia (n=6) to examine how resilience can facilitate people with dementia to have a more meaningful life. They found that resilience can be fostered through having a social environment that promotes dignity, respect, and attainable independence. Societal level resources that can support resilience concern the social, economic, and institutional policies (Windle, 2011) that underpin the practices used to care for people with dementia.

Previous research has revealed that social robots have the potential to support constituents of resilience in people with dementia. Kang et al. (2019) systematically reviewed randomised controlled trials (n= 8). They found that PARO, a zoomorphic robot, which appears as a baby harp seal, can improve social interactions. People with dementia (n=5) and caregivers (n=12) have also reported a sense of social connection and positive emotions when using the telepresence robot, Giraff (Moyle et al., 2019). Higher levels of engagement during robot-assisted psychomotor therapy and increased emotional positivity were also found when people with dementia (n=9) used NAO, a humanoid robot (Rouaix et al., 2017). Feng et al. (2019) also found the communication and engagement of people with dementia (n=9) were enhanced when they evaluated an interactive system, LiveNature, involving a robotic sheep and an ambient wall display unit, which provides pictures of nature. However, a recent review of

randomised controlled trials (n=11) and meta-analysis on the effectiveness of social robots on quality of life and psychological outcomes, found that their impact was not statistically significant (Pu, et al., 2019). Researchers have also speculated that the initial improvements in wellbeing, due to the novelty of robots, may not be sustained in the long-term (Moyle et al., 2017).

While the research described above has revealed that social robots can beneficially impact constituents of resilience, research has not yet been conducted that focuses on the effects of social robots on resilience. Research is also lacking regarding how social robots can be used to support the resilience of people with dementia through stimulating human to human contact (Jøranson et al., 2016) and promoting engagement in meaningful activities (Neal et al., 2019).

The current study aimed to investigate how using MARIO, a social robot, effected the resilience of people with dementia. Its objectives were to: (i) identify the key characteristics of resilience in this context, (ii) explore how resilience changed due to using MARIO and (iii) identify how MARIO was used to impact the resilience of people with dementia. This study was part of a wider EU project (<http://www.mario-project.eu>) that developed MARIO, to increase the social connectedness of people with dementia. MARIO uses a mobile Kompai robotic platform (www.kompairobotics.com). The robot has a camera and sensors to enable indoor navigation and obstacle avoidance (D'Onofrio et al., 2019). MARIO is capable of 2-way voice communication via a microphone and speakers (Barrett et al., 2019). The robot's eyes are animated and move when it speaks and MARIO has a range of applications that can be personalised to the interests of individual users: My Music, My Memories, My Games, My Calendar, and My News. These applications were developed in response to the feedback provided by people with dementia and caregivers (Casey et al., 2016b). Users can operate MARIO's applications using speech and/or touchscreen commands, responding to MARIO's voice and/or written instructions. A description of MARIO's applications is provided in *Table 1*.

METHODOLOGY

The study used Case Study Methodology (CSM). CSM is useful for in-depth investigations of contemporary phenomena in real-world settings, where the phenomenon of interest interacts with the context that surrounds it (Yin 2014). The examination of a 'case' within its context is central to CSM. In this study, the case was defined as, the resilience of a person living with dementia who uses MARIO. The context, surrounding each case, was the residential care setting, and

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Table 1. Description of MARIO's applications.

| | |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| My Music | Allows people with dementia to enjoy, remember, and talk about their favourite music or songs. The user can select the music, move between the music tracks, and alter the volume using touchscreen controls or verbal commands. |
| My Memories | Uses principles of reminiscence therapy to encourage communication and recall of experiences and memories. MARIO displays pictures of the person's life and engages the user in conversation reminding the user about the content of the pictures and using prompt questions. |
| My Games | Provides entertainment and cognitive stimulation. Users can select, play, and move between their favourite activities e.g. painting, games of golf and darts, card games, chess. |
| My News | Provides news from web feeds of online news sites that conforms to the user's interests. MARIO reads the headlines and provides the text on the touchscreen. MARIO invites the user to indicate if they want to hear/see more about any item of news. e.g. MARIO reads the headlines from Manchester United football club then the user asks to hear more news about a specific player. |
| My Calendar | Facilitates participation in society and temporal orientation. Reminds users about the day and time and provides information about daily activities and forthcoming events e.g. appointments, religious ceremonies, birthdays. |

the phenomenon of interest was change in the resilience of each person with dementia. To facilitate a focused, in-depth inquiry, and to obtain relevant data, each case contained three embedded units of analysis: (1) The perceptions of the person with dementia about their resilience and usage of MARIO; (2) The perceptions of relatives and caregivers about the resilience of the person with dementia and their usage of MARIO; (3) The psychosocial factors that impact the resilience of the person with dementia and their usage of MARIO. A multiple case study design (n=10) was chosen in which the cases were the resilience of ten people with dementia who lived in a residential care setting. This design was chosen because the phenomenon of interest in the study was broader than that contained in a single

case (Stake, 1995) and because examining multiple cases provided greater opportunity to address the study's aims, through comparing and contrasting the findings from multiple cases.

The concept of resilience was operationalised through drawing on the resilience framework (Windle and Bennett, 2012) and adapting this to accommodate key components of adversity, resources for resilience and outcomes of resilience in the context of dementia, that were identified from the literature on resilience in dementia that has been described above. Therefore, adversity was investigated by focusing on the challenges experienced by people with dementia. Resources for resilience were examined by identifying resilience repertoires, meaningful activities, and

Table 2. The inclusion and exclusion criteria for participant eligibility.

| Inclusion | Exclusion |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| People with Dementia | |
| Had to be living in the care setting for at least one month prior to the study because moving into residential care requires significant adaptive efforts (Aminzadeh et al., 2009). Therefore, if MARIO was introduced during the first month, it would be difficult to determine whether resilience processes were being impacted by MARIO or adapting to living in residential care. | Not be likely to continue living in the care setting for the study's duration. |
| Have either a formal diagnosis of dementia of any severity and/or it was stated that they have dementia in the medical records because it was recognised that not all people with dementia might have a formal diagnosis (Cahill et al., 2012). | Not have a significant sensory impairment or acute illness which caregivers considered would impair their ability to participate. |
| Caregivers | |
| Have provided care to the person with dementia during the preceding month. | Are not likely to continue to provide care to the participant. |
| Relatives | |
| Will be visiting with the person with dementia during the study period. | |

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focusing on social relationships and cultural care practices. Change in the outcomes of resilience was assessed through examining the wellbeing of the people with dementia, regarding their levels of mood and engagement, quality of life, capacity for resilience, and the degree to which they could be regarded as *'doing okay'*.

Sampling and recruitment

The case selection strategy used purposive sampling, according to inclusion and exclusion criteria (Table 2). Each case required the selection of one person with dementia, two formal caregivers, and a relative. The recruitment strategy was designed to accommodate the cognitive and communication difficulties of people with dementia and to achieve their informed consent to participate in the study. A senior nurse, who knew the residents well, asked people with dementia, who fulfilled the inclusion criteria if they would like to meet the researcher. If the person with dementia agreed, the researchers, who were trained by experienced dementia researchers, spent considerable time talking with them, building rapport, explaining the study and reading with them the participant information leaflet, which was designed for people with dementia. In addition, before deciding to participate, the person was given the opportunity to meet MARIO. Conversations about consent used a person-centred approach (Mayo & Wallhagen, 2009) in which researchers took time to get to know the views of the person, to check their understanding, and to assess their capacity to consent using the Psychological Society (Herbert, 2019) guidelines. Conversations were facilitated by the researcher taking the advice of caregivers (Hubbard et al., 2003) and they occurred when the person was not tired and was most likely to be able to process information (Mayo & Wallhagen, 2009). After initial conversations took place, researchers allowed potential participants the time and opportunity to discuss participation with their relatives and caregivers. Researchers then returned seven days later. On returning, researchers explained the study once more, reading the consent form which had been designed for people with dementia, with the person and answered any questions. Following this, if the person wanted to be included in the research, their consent was recorded by the researcher in writing. In addition, on every occasion that participants were involved in the study, researchers took the time to reintroduce themselves, remind participants about the project, confirm their understanding of this, and their ongoing verbal consent (Dewing, 2007). After the person with dementia had consented to participate, their relatives and caregivers were approached, told about the study, and given opportunities to ask questions. If relatives and caregivers met the inclusion/exclusion criteria they were given a patient

information leaflet and their written consent was sought seven days later.

The intervention

MARIO was offered to participants with dementia (PWD) for up to 12 individual sessions, 3 times a week, during 5 weeks. This was comparable to the other studies that have tested robotic devices in similar contexts (Gustafsson et al., 2015; Moyle et al., 2015; Joshi et al., 2019). Sessions were conducted between 10 am and 4 pm, avoiding mealtimes, in places that were convenient to the PWD, including bedrooms, dayrooms, and corridors. One researcher facilitated the sessions and another researcher recorded observations.

Before each interaction, the researcher opened the individual user's personalised folder on MARIO. At the beginning of sessions, MARIO introduced himself to the user addressing the user by name. Then, MARIO used verbal and visual prompts inviting the user to engage. MARIO reminded the user what activities it could provide and how the user could choose an activity by saying a keyword or using the touchscreen. When the user had selected an application, MARIO then reminded the user how to use the application and prompted them, as necessary. Sessions ended when PWD indicated to researchers that they had used MARIO for long enough.

Data collection

Multiple methods were used to collect the data, which were piloted with people with dementia in the research site who were not involved in the study. Data were collected in three phases before MARIO was introduced (Pre-MARIO), during 12 sessions with MARIO, and after the 12 sessions had been completed (Post-MARIO).

Data collection Pre-MARIO

Pre-MARIO, data collected included the participants' demographic information, screening for depression using the Cornell Scale for Depression in Dementia (Alexopoulos et al., 1988), and cognitive function was assessed using the mini-mental state examination (MMSE) (Folstein et al., 1975). Then, Dementia Care Mapping (DCM) (Bradford, 2016) was used by the lead author (SW, a registered nurse with training in dementia and DCM) to capture data about the activities, social relationships, care practices, and mood and engagement levels (ME) and the wellbeing of PWD. DCM is a semi-structured non-participant observation technique that involves a trained mapper recording the activities and the ME levels of people with dementia every 5-minutes throughout the observation period, using DCM codes and values. The resulting ME levels are used to calculate wellbeing scores. In addition, qualitative notes are recorded throughout the

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Table 3. The eight stages of framework analysis used during the data analysis (Derived from Gale et al., 2013).

| Phase | Key feature | Description |
|-------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Transcription | Interview data was professionally transcribed. |
| 2 | Familiarisation with data. | Transcripts were reviewed for errors, for familiarisation with the data, and uploaded into NVIVO 12. |
| 3 | Coding of data from 4 cases. | The transcripts from four cases were read line by line and segments of the data were copied into codes. After codes had been created they were examined and judged according to their meaning in relation to one another. During this process, some codes that contained data of similar meanings were amalgamated and renamed. |
| 4 | Developing a coding framework. | A formal coding framework was then developed through reviewing the codes that had already been created, in light of the literature concerning resilience and robot acceptability in the context of dementia. |
| 5 | Framework implemented, coding the remaining data. | Data from the remaining six cases were then read line by line and coded according to the framework whilst also remaining open to creating new codes from the data. |
| 6 | Charting data into a matrix. | A matrix was created, and all qualitative and quantitative data was copied into relevant cells. Following this, the data in each case were systematically examined and case summaries were written. Across case analysis was then conducted, by comparing and contrasting the coded data from all the cases, and themes were identified. |
| 7 | Interpreting and abstracting the data. | The data and the themes were reviewed and analytical memos (Bonello & Meehan, 2019) were written. |
| 8 | Themes were finalised in a written report. | The final themes were defined, and the analytical memos were synthesised into a cohesive report. |

observation period. DCM has been successfully used to determine the effect of interventions on people with dementia (Hsu et al., 2015; Kontos et al., 2016). Each person with dementia was 'mapped', on a typical day, between 10.00 am-12.00 pm and 1.00 pm-4.00 pm.

Also Pre-MARIO, semi-structured audio-recorded interviews were undertaken by SW, with PWD, using a flexible supportive approach necessary for people with dementia (Beuscher & Grando, 2009). And, the following questionnaires were administered: The Resilience Scale (RS-14) (Wagnild & Young 1993) which measures capacity for resilience and The Quality of Life in Alzheimer's Disease Scale (QOL-AD) (Logsdon et al., 1999). The RS-14 and QOL-AD are valid and reliable for older adults (Wagnild 2009) and people with dementia (Logsdon et al., 2002). The questionnaires were administered by researchers who received training on how to administer the measures from an experienced dementia researcher with a Ph.D. and Registered Nurse Tutor qualification, and each questionnaire was administered on a different day to avoid participant fatigue.

Data collection during 12 sessions with MARIO

The semi-structured Observational Measure of Engagement (OME) (Cohen-Mansfield et al., 2009) was used to capture data during interactions with the robot. The OME enables the measurement of variables of engagement with

a stimulus: duration, refusal, attention, and attitude. The OME has been used to assess the response of people with dementia to robotic devices (Cohen-Mansfield et al., 2011; Feng et al., 2019). In addition, contextual details surrounding the sessions and what the PWD said during sessions were recorded.

Data collection post MARIO

A second DCM mapping period of two hours was undertaken immediately after participants had engaged with MARIO for approximately the sixth time. And, after the 12 sessions were undertaken with MARIO, the same researchers re-administered the RS-14 and QOL-AD, and the interviews with PWD were repeated. In addition, caregivers, and relatives of the PWD were also interviewed.

Data organisation and analysis

Data was stored throughout the study in accordance with the General Data Protection Regulations (Crowhurst, Bergin, & Wells, 2019). Initial data analysis commenced during data collection, as recommended in CSM (Merriam & Tisdell, 2016). This involved summarising observational notes and listening to interview recordings.

Quantitative DCM data were analysed according to DCM procedures using a DCM excel template (Bradford, 2016). The quantitative OME and questionnaire data were entered into SPSS and analysed using descriptive statistics of percentage,

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Table 4. The participant details.

| Participant type | Gender | Age (years) | Highest educational level | Mini-mental state examination | |
|----------------------|--------------|----------------------|---------------------------|----------------------------------------------|----------------------------|
| People with Dementia | Female (n=7) | Mean Age 83; SD 10.1 | Primary school (n=10) | Mild dementia (MMSE 21 to 30) (n=2) | |
| | Male (n=3) | | Secondary School n=6 | Moderate dementia (MMSE 11 to 20) (n=6) | |
| | | | Third level (n=3) | Severe dementia (MMSE 0 to 10) (n=2) | |
| Nursing caregivers | Female (n=4) | Age Groups | Secondary School (n=2) | Training in Dementia or Care of Older Adults | Grade of Caregiver |
| | Male (n=2) | 20-29 (n=2) | Third Level (n=2), | Yes (n=3) | Registered Nurse (n=4) |
| | | 30-39 (n=1) | Higher Diploma (n=2), | No (n=3) | Healthcare Attendant (n=2) |
| | | 40-49 (n=1) | Masters (n=1), | | |
| Relatives | Female (n=7) | 40-49 (n=7) | Secondary School (n=2) | Yes (n=2) | N/A |
| | | | Third Level (n=3) | No (n=5) | |
| | | | Masters (n=2) | | |

standard deviation, mode and mean. Then, the Wilcoxon signed-rank test ($\alpha = 0.05$) was used to assess mean rank differences between the group questionnaire results, and changes to mood and engagement levels as a result of using MARIO. Qualitative data was uploaded into a database in NVIVO 12 (<http://www.qsrinternational.com>). Then, framework analysis (Ritchie & Lewis, 2003; Gale et al., 2013) was used to code and analyse the data, in eight iterative phases which are described in Table 3. Data analysis included creating a matrix that had the case study cases in rows, codes in their categories in the columns, and the cells containing the data. The matrix was used to examine all the data from all the data sources, within and across the cases to develop themes that provided a holistic explanation of the cases (Merriam & Tisdell, 2016; Gale et al., 2013).

Rigour

Strategies based on Lincoln and Guba (1985) were adopted during the study to ensure rigour and demonstrate the trustworthiness of the findings, through concepts that align with constructivism: credibility, confirmability, and data dependability and transferability. Credibility was enhanced by the collection of both qualitative and quantitative data, the inclusion of multiple stakeholders (PWD, relatives, caregivers), and member checking of the findings (Miriam & Tisdell, 2016). Dependability and confirmability were enhanced through using NVIVO 12 because this software stores the raw data and records all stages of the analysis data analysis so processes can be audited (Bonello and Meehan, 2019). Decisions about transferability were aided through the final study report containing thick descriptions, including direct quotations and examples of observational data (Houghton et al., 2013).

Ethical issues

The study was granted ethical approval from the National University of Ireland Galway research committee, as part of the wider EU MARIO project. Before MARIO's arrival, the residential care home managers completed a risk assessment, and Health Service Executive health and safety procedures were followed throughout the research. In addition, researchers were guided by an ethical distress protocol whereby in the event of a person with dementia becoming distressed, the researcher would talk with the person to ascertain what the issue might be and then if necessary, the advice of the participant's carer would be sought, MARIO would be removed, and the research activity discontinued.

The findings of the cross-case analysis are presented in the next section. To protect their anonymity, PWD have been given pseudonyms (and their caregivers and relatives are not individually identified).

FINDINGS

The participants included people with dementia (n=10), caregivers (n=6) and relatives (n=7) (Table 4). All PWD experienced short term memory loss, physical and/or mental ill-health in addition to dementia. The majority were unable to walk without assistance, some were physically frail, and many had communication difficulties.

A total of ninety-six sessions with MARIO were completed: Seven PWD completed twelve sessions; Brendan completed seven sessions before he moved away to another residential care home; Clare completed one session before deciding that she did not want to use MARIO again; Cheryl completed four sessions and then withdrew from the study, for reasons explained below.

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Table 5. Change in resilience as a result of using MARIO.

| Outcomes | Mean (Standard deviation) | | P-Value |
|--------------------------------|---------------------------|---------------|---------|
| | Pre-MARIO | Post-MARIO | |
| Quality of Life: QOL-AD | 32.13 (4.73) | 32.25 (6.54) | 0.61 |
| Capacity for Resilience: RS-14 | 84.50 (13.92) | 83.12 (11.66) | 0.93 |
| Wellbeing: WIB | 1.03 (0.44) | 1.99 (0.58) | 0.81 |

Sessions with MARIO lasted from five-sixty minutes with a mean duration of twenty-four minutes. Six PWD increased their usage duration over the course of sessions, but for four PWD, the typical duration for did not change. The data analysis resulted in four themes being identified: Resilience changes minute to minute; Initiating and maintaining readiness; Active co-creation of meaningful activity; Impact on resilience.

Theme: Resilience changes minute to minute

This theme describes how PWD experienced and responded to adversity with fluctuating degrees of adaptation and wellbeing, which impacted how they used MARIO.

Adversity for PWD was caused by memory loss, difficulty concentrating on tasks, disorientation, and having experienced loss. The degree of adversity experienced by PWD could change from moment to moment, due to fatigue and degrees of lucidity. For example, Emily stated:

"One minute I'd know it [whatever she is thinking about] and again I'd say no, I don't know." (Interview Emily)

Sometimes PWD might not recall participating in activities that they found meaningful. For example, Lucy was observed during Pre-MARIO DCM playing cards with friends during the afternoon. However, she had no recollection that this had occurred when interviewed later that day when she voiced regret that she could no longer enjoy playing cards with her friends. In addition, PWD had difficulty initiating activities and maintaining their concentration. This meant PWD were dependent on caregivers, who may or may not be available, to help them participate in meaningful activities. For example, Peter was observed to stop engaging with a sensory activity board that was designed to promote stimulation and interaction, when the caregiver supporting him started to talk with another caregiver.

All PWD had experienced losses: through bereavement, and of their independence, and through not being able to participate in activities that were meaningful to them. It was evident that individuals became upset when they remembered these losses. Indeed, recalling good memories for PWD could be followed by feelings of loss when PWD remembered that they were bereft. For example, when Sarah described

a memory she said:

"She [Margaret] was the oldest sister and she'd always say to me, 'Sarah won't you house-keep for me, while I go away for a few days', I'd say, 'I will Margaret, I'll be delighted to'... I loved her. That's why I miss her so much" (Interview Sarah Post-MARIO).

The behaviour and verbalisations of the PWD revealed that their mood fluctuated. For example, a carer described how Jack was 'on and off' and his relative said:

"Sometimes you go in and he's in great form and he talks and there's other days ...he's not in any humour to talk about anything" (Interview Relative).

When PWD exhibited low adaptability to their life with dementia they also exhibited low levels of wellbeing through expressing negative thoughts and emotions. Negativity could be linked to episodes of anxiety, or feeling fatigued with life:

"You get sick in some too much trying..... I am too old." (Interview Jack)

"I'm anxious to get home now." (Interview Sarah)

Intermittent unhappiness was expressed by all PWD, but the Cornell Scale for Depression scores ranged from 1-9 with a group Mean/SD of 4.50/2.77. This suggested PWD had no significant symptoms of depression. However, two participants, more frequently than other PWD, exhibited low adaptability and lower levels of wellbeing; Sarah was frequently preoccupied with events surrounding her husband's death, and Brendan, expressed his unhappiness through resistance and refusing care:

"He could wake one day and refuse his drugs, refuse his insulin, refuse, refuse." (Interview Carer)

However, at times, all PWD demonstrated positive adaptation and relative wellbeing by being accepting and having positive thoughts and feelings. *"Doing okay"* was illustrated when participants said they felt *"alright"* but also when they possessed the motivation to be proactive and do what they wanted to satisfy their desires, for example, reaching out for food, drink, contact with others, entertainment or to perform acts of self-care. Even the most physically and cognitively debilitated participants could be observed to be *"doing okay"* despite living with the limitations of dementia whilst they were completely absorbed by simple activities. For example:

Jack stares at his cup and takes the lid off the cup to drink without the lid...then he endeavours to put the lid back on and this takes studied concentration for almost 2 minutes. (Post-MARIO DCM Jack).

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However, “*doing okay*” also involved PWD doing their best whilst accepting that life was not ideal: “*Well, I play [live] the best I can.*” (Interview Jack)

Sometimes this involved stoicism and putting up with circumstances PWD found difficult. For example, it was observed that good social etiquette at mealtimes was important to Sarah and yet she continued eating stoically, despite being aware of the lack of etiquette during mealtime in the dementia unit dayroom:

A carer stopped another resident from taking food from Sarah’s plateOne resident reaches across the table and takes a spoon from Sarah, the carer intervenesSarah continues eating quietly and slowly, eyes down. (Pre-MARIO DCM Sarah).

In responding to the adversity, PWD described a range of coping strategies, which had been learned from parents or previous experience. Strategies included: accepting the past, having good relationships with other people, doing something to change the problem, trying hard, acknowledging that life has difficulties, appreciating what you have, particularly children and family, valuing small things, and not asking too much. For example,

“If you have a building for yourself, your wife, and your family...you come out of life fairly handy enough.” (Interview Peter)

Spirituality and religious practices were also an important part of the current and previous lives of 8 participants, who used these to help them cope with problems:

“You’d be telling God about it and that would be strengthening yourself.” (Interview Emily)

“I don’t know does it make you stronger but you, well you pray to God, it helps you to accept it.” (Interview Sarah)

Some PWD placed value on being helpful to others, being mobile, and busy. However, coping strategies were discussed during interviews when PWD were ‘*doing okay*’ whilst interacting with the researcher. In contrast, when PWD were experiencing poor levels of wellbeing, there was no data that suggested their coping strategies were effective, without the support of other people.

Theme: Initiating and maintaining readiness

This theme describes what needed to be addressed before and throughout each interaction with MARIO, to enable PWD to use MARIO. It concerns PWD’s attitudes towards MARIO, their willingness and ability to use MARIO, and the support PWD required from facilitators to enable them to access and engage with MARIO.

There were no PWD who demonstrated fear of the robot and only one participant (Clare) did not like MARIO and subsequently, she withdrew from the study. The OME data revealed that no PWD was distressed or disruptive during sessions with MARIO. A 7-point scale was used in the OME to measure the PWD’s attitude when using MARIO: 1 (very negative), 2 (negative), 3 (somewhat negative), 4 (neutral), 5 (somewhat positive), 6 (positive) to 7 (very positive). The results showed that the PWD had a positive mood with mean attitudes, most of the time that ranged from 4.92-6.33 ($M=5.52$, $SD=.55$) and that the highest recorded levels of mood in sessions ranged from 6.75-6.86 ($M=6.29$, $SD=.43$).

MARIO was refused by Brendan twice on days when he refused everything that was offered to him, and Peter refused the robot once, saying he was too busy. Most PWD were very willing to use MARIO. However, some PWD could initially be hesitant, expressing tiredness, or low confidence in their ability to use MARIO or they were preoccupied when MARIO was offered. For example, Emily welcomed MARIO and the facilitator at the start of one session but her primary concern was that someone had been in her house without her permission. The facilitator talked with Emily for a few minutes, then she became calmer and was ready to engage with MARIO.

A few PWD were independently able to use the touchscreen to move through MARIO’s applications but all participants had some degree of difficulty. Difficulties included manipulating the stylus, reaching the screen with their hands, or their arms getting tired. Some participants pressed too hard, used multiple taps, or tapped in the wrong part of the screen. PWD also had difficulty maintaining their concentration and levels of distraction varied between having no distraction in sessions to PWD being distracted for most of the time. In addition, three sessions were temporarily disrupted due to technical problems. However, with facilitation, all the PWD were able to use the touchscreen.

Before sessions, facilitators improved PWD’s readiness to use MARIO by preparing MARIO, so PWD could access their pre-personalised files without delay. They also reduced potential distractions. For example, as Peter was often walking in the corridor he needed to be encouraged to walk to a quieter place to use MARIO.

The facilitator responded to the needs of individual PWD by giving explanations, reminding, prompting, modelling, encouraging, advising, reassuring, trouble-shooting, and occasionally stepping in to manipulate the touchscreen. For example, the following observation was recorded:

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Sarah is telling the facilitator about the people in the picture and Sarah is touching the photo – this causes the photo to move right on the screen and the researcher moves it back. Sarah talks about her granddaughter's wedding, a positive memory. ...Sarah is deep in thought, reminiscing, then loses track and needs reminding to press next photo. (OME Sarah Session 7).

Facilitators particularly supported conversation, stimulated by MARIO, when PWD had difficulty initiating and/or maintaining this and, if necessary, they helped PWD recover a positive mood. For example:

[Emily went from] happy to sad talking about her husband and her sadness after he died. ...talked with the researcher and then moved to the next photo spontaneously. (OME Emily Session 9).

Theme: Active co-creation of meaningful activity

This theme describes how sessions with MARIO provided PWD with increased opportunities for meaningful activity. It also describes how PWD were active in responding to MARIO and worked in partnership with facilitators to actively create how MARIO was used for meaningful activity.

All PWD expressed the desire to once again experience activities that they had previously enjoyed and could no longer undertake. In addition, the Pre-MARIO DCM data revealed that PWD spent large amounts of time being passively watchful or cool and disengaged (19% and 17% of the time respectively), without access to meaningful activities. PWD who were able to walk independently walked to obtain interaction with others, but immobile people were frequently observed to be watching and waiting for people to interact with them.

The DCM observations and interview data revealed that caregivers prioritised addressing the physical medical needs of PWD, rather than their psychosocial needs. Indeed, some caregivers acknowledged that they found it difficult to address the PWD's need for meaningful activity. It was observed that the PWD's psychosocial needs were predominantly addressed through brief interactions that took place, whilst caregivers were bringing food or drink to the person or moving them to attend to toilet needs. For example:

A caregiver enters with a tray before dinner and helps her with her drink. Asking if that is better. Inaudible reply from Margaret. The caregiver then says, 'Say your prayers so' and leaves again (1 min interaction total) (Pre-MARIO DCM Margaret).

Caregivers and relatives noted that MARIO provided more opportunity than was normally available for the PWD to have individualised meaningful activity. These views concurred with find-

ings from the OME that revealed PWD were solitary and unoccupied at the beginning of 28% of sessions. Furthermore, only 21% of sessions with MARIO were interrupted, mostly by caregivers performing brief task-based activities.

MARIO particularly provided opportunities for meaningful interaction, through acting as a stimulus for conversational topics that supported feelings of a positive self-concept. PWD spoke to the facilitator in 95% of sessions and during 56% and 23% of these sessions, PWD spoke for some of the time or most of the time, respectively. PWD mostly talked about themselves, their family, and memories:

Emily is speaking about photos on her wedding day '*It was a lovely day, I was happyHe was lovely wasn't he....*' (OME Emily Session 9).

They also talked about their interests. For example, Louise enjoyed talking about plants and Brendan talked about music from the 1970s and his involvement in that era's music scene:

Brendan '*Do you remember this one?...That base is really great....This is where you'd be jumping up and down*'. Brendan talked about shows and concerts. '*I went to all of them.*' (OME Brendan Session 3).

During the sessions, when PWD were not talking, they non-verbally responded to MARIO's applications through singing, clapping, dancing, tapping feet, and listening. PWD responded to MARIO, as they would typically respond to other stimuli. Their responses were influenced by their mood, personal desires, and preferences. For example, caregivers and relatives confirmed that Jack's responses to MARIO were typically muted and somewhat positive when he said MARIO was '*alright*'. Peter also illustrated typical behaviour when initially he examined the robot in detail and in later sessions he used MARIO to paint with the facilitator's support. Peter had a technical degree and his relative reported that he had always enjoyed working creatively alongside other people. In addition, the PWD who were observed and reported to enjoy being sociable and altruistic, preferred to share MARIO using the robot with other residents. Also, many PWD who had enjoyed music throughout their lives did so using MARIO.

PWD personified MARIO in terms of their personal history, their dementia, and what they found meaningful when using the robot. Only Brendan referred to the robot as '*MARIO*'. For example, Sarah called MARIO: '*the gadget*', '*it*', and on several occasions "*he*" was "*a great singer*". For Louise, MARIO was: "*she*", and "*a tolerant teacher*" but on other occasions "*he*" was referred to as being "*well trained*" and "*a*"

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younger thing". All participants responded verbally to MARIO's personalised greeting. However, MARIO's social presence and communication skills were not strong enough to maintain the attention of the PWD who, OME data revealed, mostly ignored MARIO's verbal prompts and preferred to talk with the facilitator.

For PWD to respond to MARIO and use the robot according to their desires, the facilitators created an atmosphere in which PWD felt empowered. Sometimes PWD needed reminding that MARIO was there for them to use as they wished but mostly PWD used MARIO assertively. For example:

Emily *"I'll draw a box"* choosing painting (OME Emily Session 7).

For PWD, sessions with MARIO were sociable occasions with partnership and rapport between them and the facilitators. Most PWD asked facilitators about their families and they enquired about facilitators who were absent. Facilitators and PWD jointly celebrated the efficacy of PWD using MARIO and moments of shared delight were observed. Facilitators also followed the lead of PWD in choosing the content of sessions. This enabled MARIO's applications to be further personalised for future sessions in response to the preferences that individuals revealed. For example:

The facilitator and Margaret were chatting through the photographs then Margaret chose the music application.

Margaret *"It's very good"*, looking at MARIO's face while the music is playing for 1 minute and then she says, *"I would like to get home"*.

Facilitator *"Yes. Does the music remind you of something?"*

Margaret *"I would like to do that myself....the same as other people"*

Facilitator *"You'd like to be more independent?"*

Margaret *"Yes (pause)... Do you like the music?"*

Facilitator *"Yes, it's lovely.....does it remind you of something?"*

Margaret *"Jeanie of the light brown hair."*

Facilitator *"Is that a song?"*

Margaret *"Yes"*

Facilitator *"Would you like MARIO to play it?"* (OME Margaret Session 10).

Theme: Impact on resilience

This theme describes the positive impact on resilience that occurred during sessions with MARIO. It also includes questions as to whether the impact was sustained after the sessions were over.

The resilience of Clare and Cheryl was not positively impacted by MARIO. After having one session with MARIO, Clare said that she did not like the robot and chose not to use it again. Whereas, Cheryl discontinued involvement with the re-

search because she suffered from paranoia. This condition was stable when the research started, but for reasons unrelated to MARIO, as determined by the medical team, the paranoia deteriorated, during the research period.

For the remaining eight PWD the sessions with MARIO provided enjoyment, engagement, increased levels of positive mood and a sense of satisfaction:

Emily *"He'd [MARIO] make you good."* (Interview Emily)

The OME measured engagement with MARIO on a 7-point scale: 1 (very disruptive), 2 (disruptive), 3 (somewhat disruptive), 4 (not attentive), 5 (somewhat attentive), 6 (attentive) to 7 (very attentive). The results recorded that the mean attention scores for each PWD ranged from 5.00-6.43 ($M=5.70$, $SD=.53$) and the highest level of engagement during sessions showed that PWD were very attentive at points during the sessions with scores that ranged from 6-7 ($M=6.44$, $SD=.35$).

Relatives and caregivers commented that some PWD were more stimulated and alert during sessions. For example, one carer considered that MARIO had maintained Peter's interest more than would otherwise be possible saying:

"He was actually doing it [painting]. Whereas, if it were you or I asking him to sit down and asking him to draw a square, it wouldn't happen." (Interview Carer).

If PWD had a low mood at the beginning of sessions this tended to be lifted. For example:

[Sarah] Was praying before the session started for all people [she had] known and lost. She tells the facilitator about these people....the facilitator listens, then asks if she would like to listen to a song.... Immediately the music starts [Sarah] is tapping her hand on the bed and singing happily. (OME Sarah Session 5).

A few caregivers considered that the value of MARIO was contingent on PWD being able to remember the robot after the sessions. PWD had a memory of MARIO or the researchers at the beginning of 64% of sessions. They had no memory in 23% of sessions and there were missing data on this question for 13% of sessions. Post-MARIO, most participants remembered MARIO when prompted by the researcher showing them a picture of MARIO (*Figure 1*). Then, they remembered details about the sessions with variable accuracy:

"I don't know what or how or not, but I got on with it [MARIO]." (Interview Emily)

Only once did a participant with dementia, unprompted, mention material he had seen on

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Figure 1. Picture of MARIO and a participant.

MARIO to his relative. However, a memory of the sessions could be kept ‘alive’ by caregivers and relatives prompting PWD. For example, caregivers put a painting completed by Peter on MARIO on his bedroom wall, and the following day Peter spontaneously showed this to researchers.

The quantitative DCM data revealed that there were positive changes in the level of mood and engagement (ME) after using MARIO. For 2 hours after using MARIO, 58% and 42% of the time, PWD had ME levels of +1 and +3, respectively. This meant that PWD showed signs of considerable positive mood and engagement for 17% more time after using MARIO than they did Pre-MARIO. PWD also showed fewer signs of negative ME, as scores of -1 and -3 improved by 10% on Pre-MARIO levels. *Figure 2* shows the percentage of time that participants spent at different ME levels in the first DCM period Pre-MARIO, in comparison with after using the robot.

Multiple data sources revealed that there were no long term changes to resilience:

“Once that’s over [using MARIO], she [Sarah] is back into listening to the radio again.” (Interview Caregiver)

“Once he [MARIO] was gone he was gone.” (Interview Emily)

“I think it’s [MARIO’s] helped my mother.... temporarily anyway.” (Interview Relative)

Furthermore, as reported in *Table 5*, there were no statistically significant changes in resilience Post-MARIO in comparison with Pre-MARIO levels, measured through the quality of life and capacity for resilience questionnaires and the well and ill-being (WIB) scores. All PWD had a more positive WIB score after using MARIO in comparison to their Pre MARIO levels, except for Jack, whose score was unchanged.

There was a small amount of potential for on-going impact on resilience, as a few caregivers and relatives said they intended to change their

behaviour as a result of witnessing sessions with MARIO and learning more about the preferences and abilities of individual PWD. For example, Sarah’s carer learned the type of music Sarah liked and said she would help Sarah access appropriate music in the future. Caregivers and relatives also expressed changed opinions about Peter:

“Before seeing Peter using MARIO I would have been saying that Peter has no attention.” (Interview Carer)

DISCUSSION

This study aimed to investigate how using MARIO affected the resilience of people with dementia by identifying the characteristics of resilience in this context, exploring how resilience changed as a result of using MARIO and identifying how MARIO was used to impact resilience.

The findings revealed that the resilience of people with dementia can be envisaged as existing along an adaptivity-wellbeing continuum. People with dementia moved between experiencing moments of positive adaptation which resulted in them doing okay despite living with limitations, and moments when they exhibited low levels of adaptability and poor wellbeing. These findings are consistent with those of previous studies, that the symptoms and impact of dementia can fluctuate (Rockwood et al., 2014; Bradshaw et al., 2004). Indeed, resilience may be impacted by the increased emotional volatility that is experienced by people with dementia (Bryden, 2005; 2018). The findings also revealed no evidence that people with dementia in this context could effectively deploy their resilience repertoires without the support of other people when they were situated at the negative end of the adaptability-wellbeing continuum.

One person with moderate dementia chose not to use the robot and another person with dementia had to withdraw from the study due to her deteriorating health. Other studies have also found that robots are not acceptable to all people with dementia (Demange et al., 2018; Hebesberger et al., 2017), and conducting research is complicated by people with dementia having co-morbidities (Fox, et al., 2014).

Using MARIO appeared to positively impact the resilience of eight people with dementia, because when they engaged with MARIO and the facilitator, they moved towards the positive end of the adaptation-wellbeing continuum and were more positive in attitude, engaged and they could be said to be ‘doing okay’ (*Figure 3*). There was some evidence that increased resilience outcomes could be maintained for up to two hours after sessions. But, differences in mood and en-

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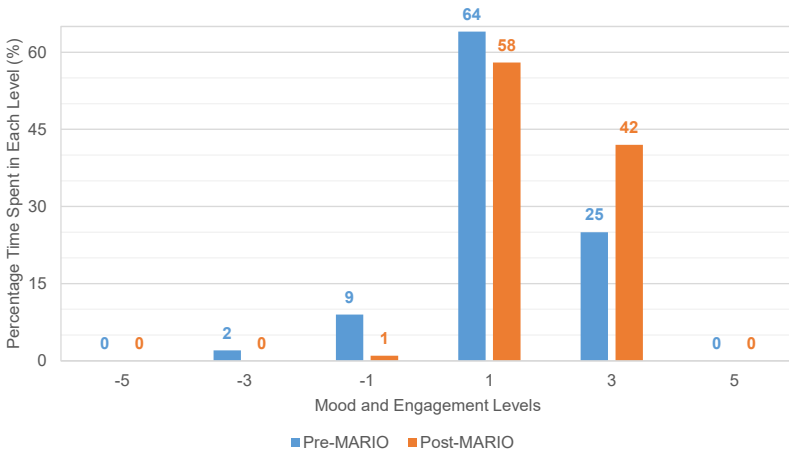


Figure 2. The percentage of time spent at levels of mood and engagement before and after using MARIO. The ME Levels range from -5 Very great signs of negative mood; -3 Considerable negative mood; -1 Small signs of negative mood withdrawn/out of contact; +1 No overt signs of positive or negative mood. Brief, intermittent engagement; +3 Considerable positive mood concentrating but distractible; +5 High Positive mood, deeply engaged. (Bradford, 2016).

agement levels were not statistically significant and there was no difference in resilience outcomes after two hours.

The sessions with MARIO enhanced the resilience of people with dementia because they served as a resource for resilience which addressed people's unmet need for meaningful activity. Opportunities for meaningful activities were lacking in this context, as they can be in other residential care settings (Harmer & Orrell, 2008; Clare et al. 2008). Through meaningful activity, the sessions improved resilience and provided stimulation and opportunities for enjoyment and interaction with other people which increased positivity and engagement. It is also possible that people with dementia achieved a more positive sense of self-concept because the conversation, stimulated by MARIO, focused on their positive memories and topics about which the individuals retained knowledge and held a passionate interest. These personal interests corresponded to the strengths and positive attributes of individuals with dementia (Sabat, 2018). Therefore, MARIO was impactful through being a strength-based platform for meaningful activity. In addition, people with dementia were active in their interpretation and usage of MARIO. Through their active responses and creation of activity, people with dementia illustrated they had, throughout their dementia, maintained intact the personalities and interests that had informed their lives prior to having dementia (Bailey, 2017).

People with dementia in this residential care setting required support and encouragement to access and engage with MARIO. MARIO was unable to independently provide this support be-

cause the robot lacked the technical capacity to assess and respond to the variable and complex physical and psychological needs of the people with dementia. Therefore, the presence of a skilled facilitator was essential to enable the interactions between MARIO and the people with dementia to be sufficiently meaningful to support their resilience. Facilitators have also been important in other interventions that aimed to foster resilience in the context of dementia (Newman et al., 2018; Clarke et al., 2018; Matcher et al.,

2018) and during studies that involved social robots (Feng et al., 2019; Chang, Sabaovic, & Huber, 2013). For robots, including MARIO, to support successful interactions without a facilitator, they will need to be developed to possess more sophisticated human-like communication skills that include the capacity to assess and respond to the complex needs of people with dementia.

In this study, MARIO encouraged engagement through being an embodied presence that provided personalised stimulus material. The facilitators acted in concert with MARIO to support the robot's interactions by enabling people with dementia to prepare for and maintain in-depth meaningful activity. The concept of readiness, that encompassed the attitude and ability of people with dementia to engage with MARIO, was useful in this study, as it has been in other contexts concerning the support of people with chronic health conditions (Dalton and Gottlieb, 2003). Indeed, it is apparent that facilitators needed skills to move people into a state of readiness through 'scaffolding' (Sharma, 2007) their support according to the individual's needs that fluctuated during sessions. The facilitators' responses were based on their knowledge of dementia, active listening, observation, and empathy. The facilitator also enabled access through creating rapport and a human relationship with the person with dementia that was based on reciprocity and partnership. This required the facilitators to have a flexible agenda that focused on the enjoyable joint discovery and responded to what the person with dementia revealed was meaningful to them during the interactions. The equality and rapport created during these ses-

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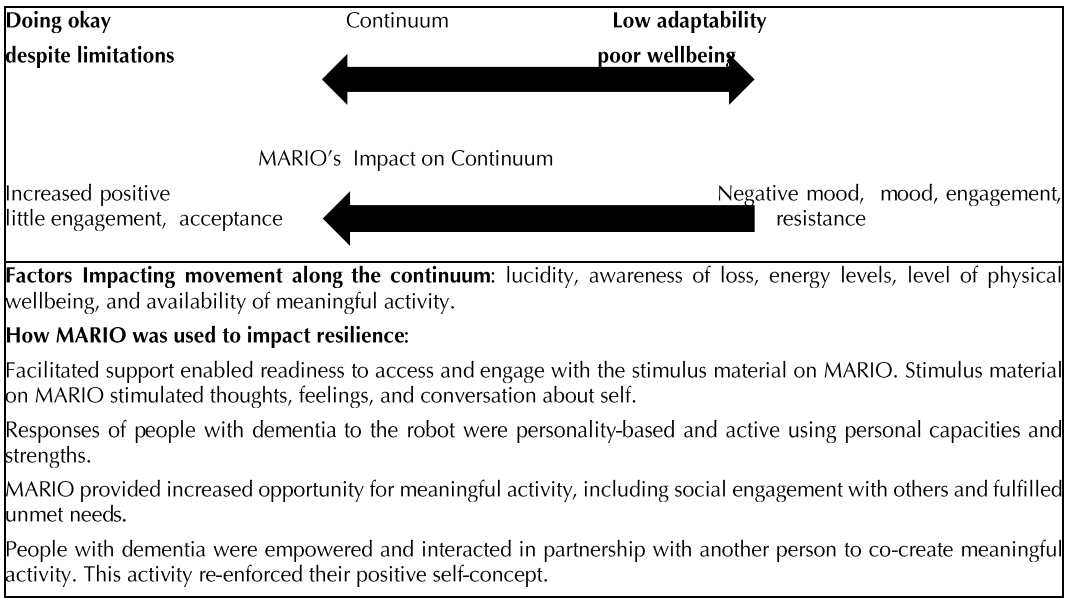


Figure 3. The adaptivity-wellbeing continuum and response to MARIO.

sions may be important for the successful use of social robots for resilience because they emphasise similar qualities to peer relationships, and aspects of positive human relationships that are supportive of resilience (Matcher et al., 2018).

FUTURE RESEARCH

Future investigations need to focus on exploring strategies to facilitate people with dementia being empowered to co-create meaningful activities whilst using social robots alongside other people. Studies need to emphasise that people with dementia are active recipients of interventions (Beard et al., 2009). In addition, investigations need to address the cultural factors that impact the sustainability of resilience after it has been supported through robotic interventions.

STRENGTHS AND WEAKNESSES OF THE RESEARCH

The literature to date indicates that this is the first study to examine how social robots can affect the resilience of people with dementia. The usage and impact of MARIO were examined over a relatively long period and in a real-world clinical context, using multiple sources of data and robust frameworks for data analysis. The use of case study methodology facilitated an in-depth

examination of the personal, relational, and contextual factors which affected MARIO's impact on resilience. This study is limited because it involved a relatively small number of people with dementia and there was no control group or blinding of the researcher to the intervention. Nonetheless, involving this number of participants in the study enabled an in-depth investigation and understanding of resilience and the effect of MARIO. Furthermore, this sample size is typical of investigations that examine the effects of social robots in people with dementia (Moyle et al., 2019; Rouaix et al., 2017; Feng et al., 2019).

CONCLUSION

To conclude, social robots need to have greater capability to interpret and respond to the emotional needs of users if they are to benefit the resilience of people with dementia without the presence of a supportive facilitator. However, with a skilled facilitator, people with dementia were able to access stimulating material on the robot. This was used by the people with dementia to co-create meaningful activity that supported resilience through fostering a positive sense of self-concept.

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