Quantity of Movement as a Measure of Engagement for Dementia: The Influence of Motivational Disorders

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Abstract

Engagement in activities is crucial to improve quality of life in dementia. Yet, its measurement relies exclusively on behavior observation and the influence that behavioral and psychological symptoms of dementia (BPSD) have on it is overlooked. This study investigated whether quantity of movement, gauged with a wrist-worn accelerometer, could be a sound measure of engagement and whether apathy and depression negatively affected engagement. Fourteen participants with dementia took part in 6 sessions of activities: 3 of cognitive games (eg, jigsaw puzzles) and 3 of robot play (Pleo). Results highlighted significant correlations between quantity of movement and observational scales of engagement and a strong negative influence of apathy and depression on engagement. Overall, these findings suggest that quantity of movement could be used as an ancillary measure of engagement and underline the need to profile people with dementia according to their concurrent BPSD to better understand their engagement in activities.

Keywords

engagement, dementia, motivation, activities, quantity of movement, triaxial accelerometer

Introduction

Dementia is a neurodegenerative disorder that impairs cognition, functioning, and behavior. People with dementia experience a decline in thinking, planning, and mnemonic abilities. What is more, they pass through a progressive decrease in independence due to their inability to carry out activities of daily living, such as self-feeding and getting dressed. These limitations are often accompanied by a series of concurrent symptoms (eg, apathy, depression, anxiety), which are called behavioral and psychological symptoms of dementia (BPSD). The BPSD are just partially a consequence of the disease and greatly affect quality of life and psychosocial well-being.[1,2]

Zuidema et al[3] discovered that the prevalence of neuropsychiatric symptoms in nursing homes is influenced by the psychosocial environment to which people with dementia are exposed. Roos and Malan[4] found that people with dementia living in nursing homes experience loneliness also as a consequence of an environment deprived of meaningful stimulation and psychosocial contact.

In general, people with dementia living in nursing homes spend most of their time unoccupied.[5] Activities reduce agitation, restraint, and medication consumption.[6-8] They give a sense of purpose to residents' lives, expose them to social interactions, and increase positive affect.[9,10] The study of engagement is crucial in order to identify which activities are meaningful for the person with dementia. However, an agreement on the definition of engagement and on its measurement in dementia has not been reached yet, and the literature abounds of attempts.[11-14] We define engagement as the psychological state of well-being, enjoyment, and active involvement that is triggered by meaningful activities and causes people with dementia to be enraptured by the activity (thus more resistant to distraction), more energetic (thus prone to work more to achieve their objectives and less inclined to feel the effort), and in a more positive mood.

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This article presents the results of a longitudinal study on the engagement of people with dementia involved in 2 activities: cognitive games (ie, jigsaw puzzles, shape puzzles, and dominoes) and robot play (with the dinosaur robot Pleo). It shows how the measurement of quantity of movement through a wrist-worn triaxial accelerometer enhances the assessment of engagement and discusses the influence of motivational disorders (MDs, ie, apathy and depression) and dementia severity (mild and moderate) on engagement in activities.

Related Work

Measures of Engagement

Literature on engagement includes 2 different definitions of the construct. The first regards engagement as social interaction[11,15,16] and the second considers engagement as participation in activities.[17-19] Both viewpoints have produced different measurement tools. Hereinafter, we focus on studies on engagement defined as participation in activities and report the related work on scales of engagement developed for people with dementia.

Engagement is difficult to measure and especially so in dementia. Self-assessment techniques are used with normative participants,[20-22] but such techniques are not reliable when it comes to people with dementia. Indeed, when asked to self-report their psychological states during activities, people with dementia may struggle in recalling the activities to which they participated, in retrieving how they felt during them, and in ranking the different experiences. Currently, engagement in people with dementia is exclusively measured through behavior observation.

Sheratt et al[19] drew inspiration from Kitwood's Dementia Care Mapping[23] to measure the engagement of older people with dementia during music interventions. They rated behavior across 6 dimensions: levels of well-being or ill-being, level and type of activity, physical location, response to music, interaction with staff or researcher, and individually defined challenging behaviors (eg, wandering).

van der Ploeg et al[9] and Materne et al[24] assessed the effect of personalized Montessori-based activities and group-based sensory stimulation activities using the Philadelphia Geriatric Center Affect Rating Scale[25] and the Menorah Park Engagement Scale (MPES).[26] The former is a prior version of the Observed Emotion Rating Scale (OERS),[27] an observational rating scale that rates the extent or duration of affective states, such as *pleasure*, *anger*, *anxiety/fear*, *sadness*, and *general alertness* in older people. The latter is an observational rating scale which rates 4 types of engagement: *nonengagement* (eg, blank stare), *self-engagement* (eg, fiddling with clothes), *passive engagement* (eg, listening), and *constructive engagement* (eg, actively handling objects).

Cohen-Mansfield et al[28] defined engagement as "the act of being occupied or involved with an external stimulus" and developed an observational assessment technique, the Observational Measurement of Engagement (OME), made of 4 items: *duration* (time in seconds that the participant is involved with a stimulus), *attention* (manipulation of the stimulus, gaze, and verbal behavior directed to the stimulus), *attitude* (positive or negative stance toward the stimulus), and *refusal* (acceptance or rejection of the stimulus).

As noted by Jones et al,[16] observational rating scales are far from being conclusive measures of engagement for 3 reasons: (1) people with dementia may have disorders such as apathy which blunt the expression of emotions on a behavioral level, (2) most of the observational scales available do not provide an overall score of engagement, and (3) current scales of engagement fail to assess social engagement. We suggest that a comprehensive measurement of engagement in dementia needs to take into account not only the systematic observation of behavior but also its minute physiological correlates. In this sense, the quantification of movement of the wrist during activities could be thought of as an objective measures of engagement-related behavior (*handling*, *holding*, *manipulating* objects, but also *reaching out others*).

Motivational Disorders in Dementia

Motivational disorders may greatly affect engagement in activities. Indeed, engagement is sometimes described as the action and the behavioral, emotional, and cognitive manifestation of motivation.[29]

Motivational disorders such as apathy and depression are the most common BPSD in people with dementia, with an occurrence of 55.5% and 44.9%, respectively.[30] Marin[31] defined apathy as lack of motivation, with motivation being the set of behaviors and cognitive activities that transform the intention of doing something into a concluded action. Robert et al[32] enriched Marin's definition proposing that apathy is not only characterized by diminished motivation but also by emotional blunting (ie, restricted emotional display). As for depression, the *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition)[33] defines it as a period of at least 2 weeks characterized by sad mood and loss of interest and pleasure in almost all aspects of life with concomitants such as dysphoric symptoms (eg, helplessness, hopelessness, and feelings of guilt), appetite disorders, insomnia, and low energy. Apathy and depression share key symptoms such as reduced volition, loss of interest, and loss of motivation.[34,35] For this reason, we grouped them under the label *motivational disorders*.

The majority of studies on engagement focus on the improvement in BPSD and engagement that recreational activities could bring about and treat participants with dementia as a single entity that is equally susceptible to improve.[36,37] We argue that the presence of BPSD, especially of motivational disorders (MD), might affect the capability of people with dementia to engage in activities already at baseline and that overlooking the heterogeneity of people with dementia as a group with different clinical and psychological comorbidities might cause researchers to miss relevant results.

Quantity of Movement and MD

In the attempt to reinforce the diagnosis of apathy and depression, several studies have used the measurement of quantity of

movement through the use of an actigraph (a triaxial accelerometer usually worn on the wrist) and have shown a lower mean motor activity (MMA) in participants with apathy and depression compared to people with dementia not affected with these disorders.[38-41] Across studies, MMA significantly correlated with the items of apathy scales related to "lack of interest" and "lack of initiative."

David et al[38] used an actigraph to measure the MMA of people with dementia during neurological and behavioral examination and found out that participants with apathy showed lower MMA, total motor activity, and minutes with movements and had a longer time without activity. Kuhlmei et al[39] estimated daytime MMA over 5 consecutive days in elderly people affected with dementia and mild cognitive impairment (MCI), finding that daytime MMA was lower in participants with dementia in comparison with participants with MCI, and that, in both dementia and MCI, daytime MMA was lower in participants affected with apathy compared to participants without apathy. David et al[40] measured quantity of movement with a wrist actigraph for 7 days for 24 consecutive hours and showed that daytime MMA and mean duration of napping were lower in patients with apathy. Volkers et al[41] asked participants to wear a wrist actigraph for 3 consecutive 24-hour periods and found that depressed patients were less active during daytime, but more active during nighttime.

Wrist actigraphy substantially measures the amount of movement of the nondominant hand during long periods of time (hours, days, and weeks). In activities, arm and hand movements are mostly directed toward objects (eg, games) with the intent of handling and manipulating them. *Handling objects* and *manipulating/holding objects* are considered signs of engagement in both the MPES (ie, *constructive engagement*) and the OME (ie, item *attention*). Drawing inspiration from this more diagnostic approach, we measured the quantity of movement of participants during activities using a wrist-worn triaxial accelerometer. We assumed that the quantity of movement measured using the accelerometer on the nondominant wrist would have correlated with the observational scales of engagement and that people with MD would have moved considerably less than other participants across activities.

Methods

Aim

The present study was carried out with a 2-fold objective: (1) investigate whether the quantity of movement measured on the wrist with a triaxial accelerometer could be used as an ancillary quantitative measure of engagement in activities and (2) study whether MD (apathy and depression) and dementia severity (mild or moderate) have an effect on engagement in activities.

Participants

Fourteen participants (12 women and 2 men) aged between 69 and 92 years (M_{age}: 83.93, SD_{age}: 7.28) took part in the study.

Participants were included in the study if they had a confirmed dementia diagnosis and a deterioration level ranging from mild to moderate (scores 4 and 5 of the Reisberg Global Deterioration Scale [GDS]).[42] We measured severity and frequency of MD through the Neuropsychiatric Inventory (NPI)–Nursing Home version,[43] and used depression and apathy subscores (clinical significance ≥ 4) to divide participants into participants with and without MD. Exclusion criteria of the study were a diagnosis of bipolar or schizophrenic disorder, Parkinson disease, strong hallucinatory and delusional states, and bedridden condition.

In order to replicate as much as possible a real-life activity undertaken in a group, participants were randomly coupled and took part in activities in pairs. Participants in the couples did not know each other before the start of the study.

Design

The study adopted a repeated measurement design with the 2 activities as experimental conditions: cognitive games and robot play. Activities were conducted in the nursing homes. Each activity was repeated 3 times, for a total of 6 sessions per participant, 3 of cognitive games and 3 of robot play (42 sessions overall). Activities were presented in an alternated order: sessions of cognitive games and robot play were carried out every other week starting with cognitive games. The duration of the study was 6 weeks.

Every session was carried out by a facilitator (the psychologist or social educator of the nursing home) in the presence of an experimenter. Given the impossibility of randomizing the variable facilitator without disrupting the workflow of the nursing home, we controlled it and provided facilitators with scripts and guidelines to follow during sessions. The experimenter (always the same researcher from the university) was present during every session to monitor the instrumentation (camera, sensors) and check for the correct execution of all phases of the activity. In order to avoid his or her presence to disrupt the natural behavior of participants, the experimenter took part in the activities of the nursing homes for 1 month before the start of the study so as to become familiar to the participants and reduce the likelihood of his or her presence affecting their spontaneity.

Activities

Cognitive games consisted of jigsaw puzzles, shape puzzles, and dominoes. In the jigsaw puzzles, participants were asked to combine a set of pieces bearing a part of a picture on them into a complete image. In the shape puzzles, participants were asked to wedge a set of wooden shapes in a board with slots. In dominoes, participants were asked to down a numbered tile matching the tile on the table. The completion of the cognitive games took around 20 to 25 minutes. The order of presentation of cognitive games was randomized across the sessions using a Latin squares technique.

The play with the robot consisted of a free interaction session of 20 minutes with Pleo (Figure 1). During sessions, the

Figure 1. Pleo, the dinosaur robot.

participants could pet, feed, play, interpret the inner states, and express their feelings about the robot. Facilitators were given details about the interactions that Pleo was able to support (eg, *call Pleo*, *feed Pleo*, *cradle Pleo*) and intervened with prompts in case of necessity.

Pleo is an animatronic pet robot commercialized by UGOBE (www.pleoworld.com), which has the appearance of a baby dinosaur. It is equipped with an array of sensors: touch sensors, microphones, ground foot sensors, force feedback sensors, orientation tilt sensors, and infrared mouth sensors. It also has a camera-based vision system to detect light and navigate, a beat detection system allowing it to dance and listen to music, and is able to express its internal drives (eg, hunger or sleep) and moods (eg, happy, scared, curious). We chose Pleo among the available robots, because, while being very interactive and responsive, it features a series of traits that are demonstrated to be appealing to old people[44]: it is small (in relation to human size), it has animal-like features, its behavior mimics that of a domestic animal (eg, cat and dog), and it has a creative design.

Instruments and Measures

Together with activities (cognitive games and robot play), we considered dementia severity (mild or moderate dementia) and MD (presence or absence of MD) as independent variables. The former was measured through the Reisberg GDS (N = 14; 5 participants with mild dementia and 9 participants with moderate dementia). The latter was measured through the NPI (N = 14; 6 participants with MD and 8 participants without MD).

The dependent variables of the study were engagement as measured through the OME[28] and OERS[27] and quantity of movement (gauged with a wrist-worn triaxial accelerometer). We used the items attention (4-point Likert scale, from not attentive to very attentive) and attitude (7-point Likert scale,

from very negative to very positive) of the OME (see Related Work), using the latter twice, to qualify the *attitude toward the game* and the *attitude toward the partner*. Also, we included the item "cognitive difficulty" (5-point Likert scale, from not at all difficult to very difficult). The OERS was used in its original form, which included 5 items: pleasure, anger, anxiety/fear, sadness, and general alertness.

Accelerometer data were collected using the E4 wristband.[45] From the accelerometer signal, we extracted the following features: signal magnitude area of the module of the 3 axes (SMA_M) following Equation (1) and summation of the signal magnitude areas of the 3 axes (SMA_S) as defined in Equation (2). Signal magnitude area can be defined as the amount of variation in the accelerometer signal within a certain window. Although SMA_M is more related to the general quantity of movement, SMA_S is more related to the variability of movements.

$$SMA_M = \int_{i=0}^{T} \left| \sqrt{x_i^2 + y_i^2 + z_i^2} \right| dt \qquad (1)$$

$$SMA_S = \int_{i=0}^{T} |x_i| dt + \int_{i=0}^{T} |y_i| dt + \int_{i=0}^{T} |z_i| dt \qquad (2)$$

where x_i, y_i, and z_i are the acceleration on X, Y, and Z axes in the i sample. T is the length of the window measured in the number of samples. In our case, the windows of interest were the 2 activities: cognitive games and robot play (see *data collection phase* in the section "Procedure").

Procedure

Each session of the study had 6 phases:

1. *Preparation phase* (10 minutes): The experimenter sets up the activity room, while the facilitator picked up the participants in their units.
2. *Habituation phase* (5 minutes): Participants sat for few minutes to recover from the effort of walking from the unit to the activity room. A small conversation was prompted by the experimenter and facilitator to put participants at their ease and make them familiarize with the situation.
3. *Synchronization phase* (2 minutes): The experimenter helped the participants to wear the wristbands and explained their function. When the wristbands were in position, the experimenter synchronized them with the video footage pressing the tag button on top of them.
4. *Baseline collection* (5 minutes): The baseline was collected to calibrate the sensors and have a reference for the state of the person on the day of data collection (eg, sleepy, angry). Facilitators read 5 minutes of a fairy tale to participants with the aim of making them relax.

Table 1. Items of OME and OERS (Mean, SD) and SMA_M and SMA_S (Mean, SD) in participants without and with motivational disorders (MD) in cognitive games and robot play.

	Cognitive games				Robot play			
	No Motivational Disorders		Motivational Disorders		No Motivational Disorders		Motivational Disorders	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Attention	3.75	(0.46)	3.50	(0.55)	4.00	(0.00)	2.50	(0.84)
Attitude (game)	6.13	(0.99)	5.17	(0.98)	6.63	(0.52)	4.67	(1.03)
Attitude (partner)	5.88	(1.25)	4.83	(0.98)	5.88	(1.36)	4.50	(0.55)
Cognitive Difficulty	2.00	(0.76)	2.17	(0.75)	1.00	(0.00)	1.00	(0.00)
Pleasure	2.25	(1.28)	1.50	(0.84)	4.63	(0.52)	3.00	(1.10)
Anger	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)	1.67	(1.03)
Anxiety/Fear	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)
Sadness	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)	1.33	(0.82)
General alertness	5.00	(0.00)	5.00	(0.00)	4.75	(0.46)	4.50	(0.55)
SMA_M	0.023	(0.006)	0.015	(0.006)	0.019	(0.002)	0.013	(0.005)
SMA_S	0.065	(0.018)	0.040	(0.017)	0.053	(0.009)	0.034	(0.012)

Abbreviations: M, mean; MDs, motivational disorders; OERS, Observed Emotion Rating Scale; OME, Observational Measurement of Engagement; SD, standard deviation; SMA_M, signal magnitude area of the module of the 3 axes; SMA_S, signal magnitude areas of the 3 axes.

5. *Data collection* (20-25 minutes): Participants played the cognitive games or interacted with Pleo.
6. *End of activity* (5 minutes): The experimenter removed the wristband, switched off the cameras, and facilitators filled out the OME and OERS after having accompanied participants back to their units.

Ethical Approval

The study was conducted according to the Declaration of Helsinki and to Spanish law number 159 of July 4, 2007. An informed written consent was signed by all the legal guardians of participants (closest relatives). All participants were informed about the study and gave their consent to participate. Both the consent of the legal guardian and that of the participant were required in order to take part in the study.

Results

Observational Measurement of Engagement and OERS

As a preliminary step, we calculated the median of the OME and OERS items along the 3 sessions of cognitive games and the 3 sessions of robot play. We computed statistical analyses with the median scores.

We performed a mixed factorial analysis of variance (ANOVA) to disclose whether there were significant differences between conditions on the items of OME and OERS and to examine whether distinguishing participants based on MD and dementia severity could bring about additional results. We performed 2 analyses. In the former, the 2 activities (cognitive games and robot play) were used as a within-subject factor and the presence of MD (presence or absence) was considered a between-subject factor (Table 1).

In the latter, the 2 activities (cognitive games and robot play) were used as a within-subject factor and dementia severity (mild or moderate) as a between-subject factor (Table 2).

Results revealed a main effect of activity on cognitive difficulty ($F_{1,12} = 28.265$, $P < .001$, $\eta^2 = .702$), pleasure ($F_{1,12} = 28.902$, $P < .001$, $\eta^2 = .707$), and general alertness ($F_{1,12} = 7.714$, $P < .05$, $\eta^2 = .391$). Overall, participants found cognitive games significantly more difficult at a cognitive level and felt less pleasure during them. However, they were less alert during robot play.

The ANOVA also disclosed an interaction effect of condition and MD on attention ($F_{1,12} = 11.688$, $P = .005$, $\eta^2 = .493$) and a main effect of MD on attention ($F_{1,12} = 16.800$, $P = .001$, $\eta^2 = .583$), attitude toward the game ($F_{1,12} = 14.384$, $P < .005$, $\eta^2 = .545$), attitude toward the partner ($F_{1,12} = 4.921$, $P < .05$, $\eta^2 = .291$), and pleasure ($F_{1,12} = 9.521$, $P < .05$, $\eta^2 = .442$; see Figure 2), with participants affected by apathy and depression scoring less than participants without MD in all the aforementioned items.

In relation to dementia severity, the mixed factorial ANOVA revealed an interaction effect of activity and dementia severity on attitude toward the partner ($F_{1,12} = 4.824$, $P < .05$, $\eta^2 = .287$; see Figure 3). Participants with moderate dementia had a more positive attitude toward the partner as compared to participants with mild dementia, especially during robot play.
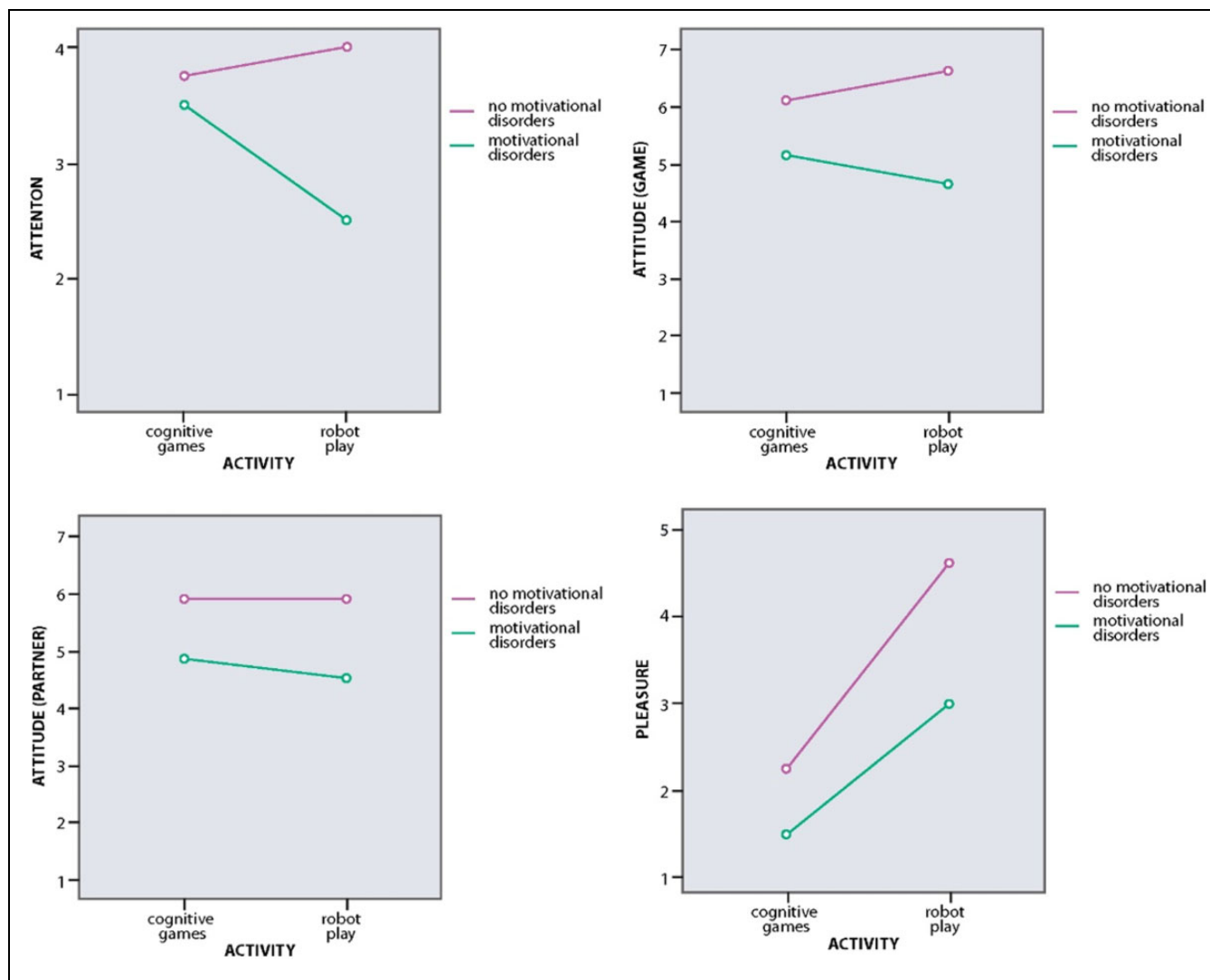
Quantity of Movement

Accelerometer data were synchronized and labeled through the Kinovea and Matlab software using the video footage of the sessions and an established protocol tested with healthy participants in the laboratory. The accelerometer features, SMA_M and SMA_S, were extracted in the window between the

Table 2. Items of OME and OERS (Mean, SD) SMA$_M$ and SMA$_S$ (Mean, SD) in participants with mild and moderate dementia in cognitive games and robot play

	Cognitive games				Robot play			
	Mild dementia		Moderate dementia		Mild dementia		Moderate dementia	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Attention	3.60	(0.55)	3.67	(0.50)	3.00	(1.00)	3.56	(0.88)
Attitude (game)	5.80	(1.10)	5.67	(1.12)	5.40	(1.14)	6.00	(1.32)
Attitude (partner)	5.20	(1.10)	5.56	(1.33)	4.40	(0.55)	5.78	(1.30)
Cognitive Difficulty	2.00	(1.00)	2.11	(0.60)	1.00	(0.00)	1.00	(0.00)
Pleasure	2.20	(1.30)	1.78	(1.09)	4.00	(1.00)	3.89	(1.27)
Anger	1.00	(0.00)	1.00	(0.00)	1.40	(0.89)	1.22	(0.67)
Anxiety/Fear	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)	1.00	(0.00)
Sadness	1.00	(0.00)	1.00	(0.00)	1.40	(0.89)	1.00	(0.00)
General alertness	5.00	(0.00)	5.00	(0.00)	4.40	(0.55)	4.78	(0.44)
SMA$_M$	0.019	(0.010)	0.018	(0.005)	0.016	(0.005)	0.017	(0.005)
SMA$_S$	0.053	(0.029)	0.049	(0.014)	0.042	(0.017)	0.043	(0.014)

Abbreviations: M, mean; OERS, Observed Emotion Rating Scale; OME, Observational Measurement of Engagement; SD, standard deviation; SMA$_M$, signal magnitude area of the module of the 3 axes; SMA$_S$, signal magnitude areas of the 3 axes.

Figure 2. Significant effects of motivational disorders on the items of OME and OERS in cognitive games and robot play. OERS denotes Observed Emotion Rating Scale; OME, Observational Measurement of Engagement.
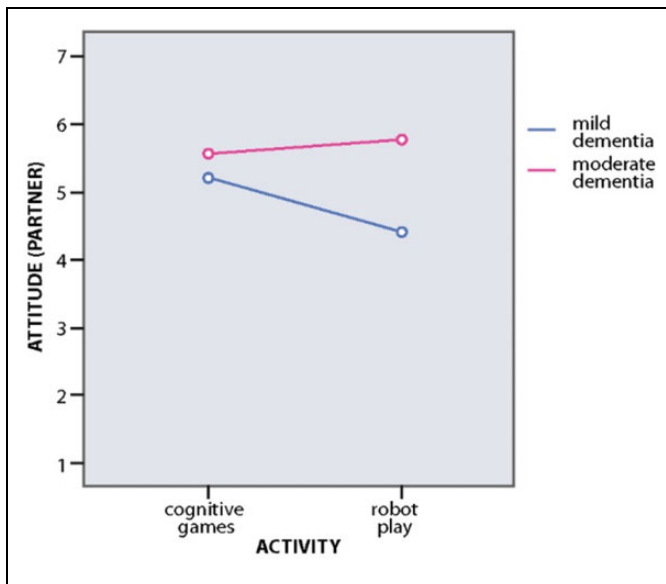
Figure 3. Significant effects of dementia severity on the items of OME and OERS in cognitive games and robot play. OERS denotes Observed Emotion Rating Scale; OME, Observational Measurement of Engagement.

beginning and end of activities (see *data collection phase* in the section "Procedure").

Most participants (n = 11) wore the E4 wristband on the nondominant wrist. However, some of them wore it on the dominant hand, since we encountered problems in collecting data on the nondominant wrist (eg, bruises due to dialysis). In the calculation of the quantity of movement, we took into account just the participants wearing the wristband on the nondominant wrist. In our final sample of 11 participants, MD were present in 6 participants and absent in 5 participants. Five had mild and 6 moderate dementia.

The features SMA_M and SMA_S were extracted in the 3 sessions of cognitive games and in the 3 sessions of free robot play. We calculated the mean SMA_M and the mean SMA_S of the 3 sessions with cognitive games and of the 3 sessions with Pleo. We computed statistical analyses with the mean values.

A mixed factorial ANOVA with the 2 activities (cognitive games and robot play) as a within-subject variable, and alternatively the presence of MD and dementia severity as between-subject variables, was performed (Tables 1 and 2). Main effects of activity on the quantity of arm and hand movement were not taken into account, since we realized that cognitive games could produce a higher quantity of movement with respect to robot interactions due to the quantity of actions that participants had to perform to complete them.

Analyses revealed a main effect of MD on SMA_M ($F_{1,9} = 7.285$, $P < .05$, $\eta^2 = .447$) and SMA_S ($F_{1,9} = 8.100$, $P < .05$, $\eta^2 = .474$; see Figure 4), with participants with MD moving considerably less than participants without MD. Interestingly, no such effect came upon when participants were sorted according to dementia severity (see Figure 4).

Relationship Between OME and OERS and Quantity of Movement

As last analysis, we performed a Pearson product-moment correlation between SMA_M and SMA_S and the items of OME and OERS. Signal magnitude area of the module of the 3 axes was significantly positively correlated with the item attitude toward the game ($r[9] = .643$; $P = .033$) and significantly negatively correlated with cognitive difficulty ($r[9] = -.641$; $P = .034$) in the cognitive games, and the same held for SMA_S (attitude toward the game: $r(9) = .608$; $P = .047$ and cognitive difficulty: $r(9) = -.611$; $P = .046$). In robot play, SMA_M was significantly correlated with the item pleasure ($r[9] = .771$; $P = .006$) and significantly negatively correlated with the item anger ($r[9] = -.620$; $P = .042$), whereas SMA_S was significantly positively correlated with the items attitude toward the game ($r[9] = .603$; $P = .050$) and pleasure ($r[9] = .800$; $P = .003$). Scatterplots revealed that the correlation between anger and SMA_M violated the assumption of linearity and brought us to discard it as a significant result.

Limitations of the Study

The main limitation of this study is the small sample size which has prevented us from examining the combined effects of MD and dementia severity on engagement. Given the amount of structuring that the study involved (see section "Procedure"), a bigger sample size was very challenging to achieve. Future iterations should focus on enlarging the sample size to the detriment of structuring. Additional research is also needed to test whether the results of the present study hold when participants play in groups of 3 or more.

Another limitation of the research was in the relatively narrow range of activities tested. We focused on only 2 types, but people with dementia might engage in a larger amount of activities. Moreover, further testing with other types of social robots is also recommended.

Discussion

General Discussion

The present study advanced the research on the measurement of engagement in dementia in 2 ways: (1) it showed that unobtrusive sensing technologies, such as wrist-worn triaxial accelerometers, could be used to objectively assess engagement in people with dementia and (2) it documented the effects that MD have on engagement in activities, as opposed to dementia severity.

Regarding the first contribution, we found several strong correlations between the items of OME and OERS and the quantity of movement measured on the wrist (all with an r above $\pm .600$). Such correlations render quantity of movement a promising way of measuring engagement in activities in people with dementia. Further research needs to investigate whether the results described in this article hold with bigger sample sizes, different dementia levels (not just mild and moderate but also severe), and in more unconstrained settings (during real-life activities).
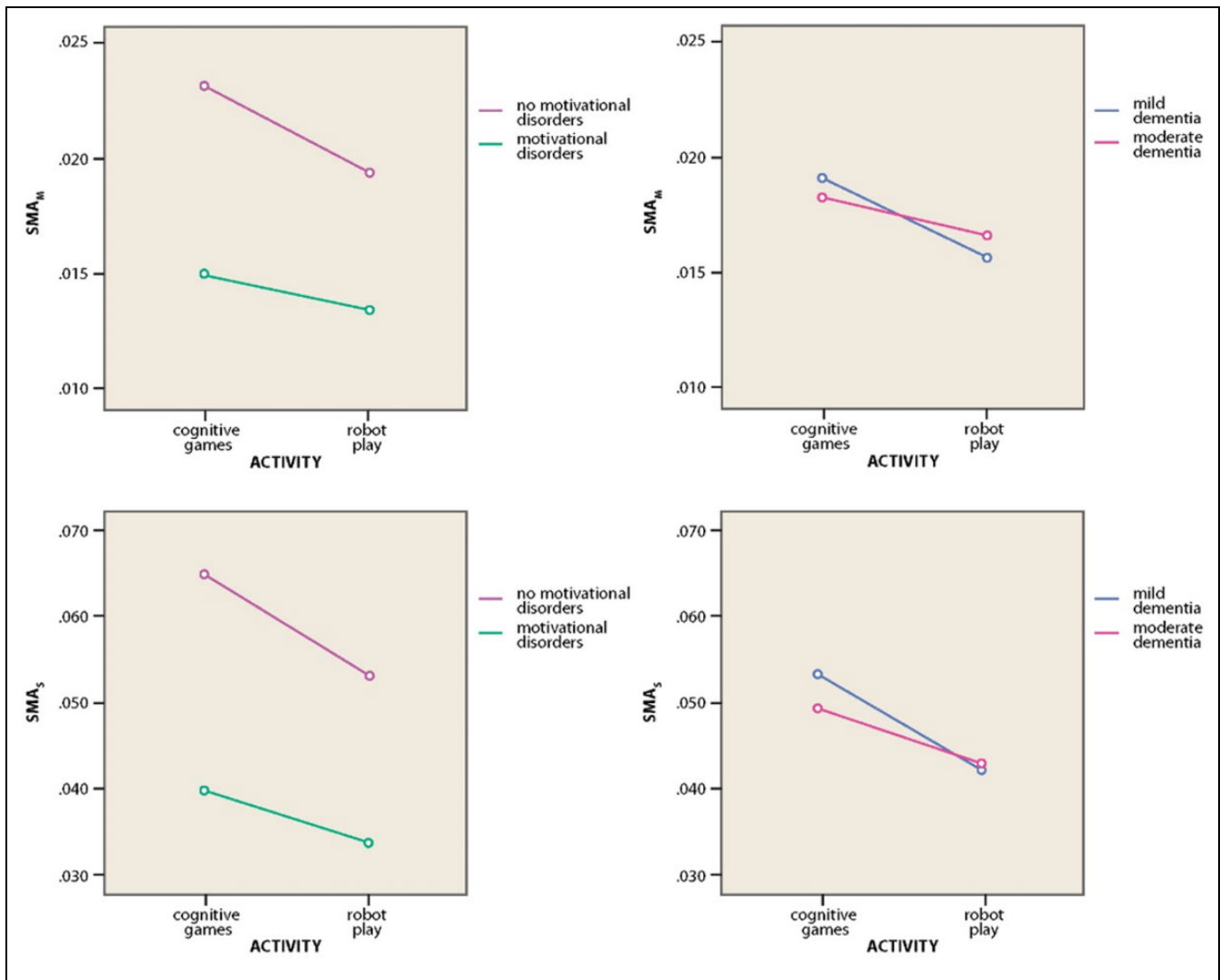
Figure 4. Effects of motivational disorders and dementia severity on SMA$_M$ and SMA$_S$ in cognitive games and robot play. SMA$_M$ denotes signal magnitude area of the module of the 3 axes; SMA$_S$, signal magnitude areas of the 3 axes.

In relation to the second contribution, to the best of our knowledge, the effect of MD on engagement in activities, as well as the preference of people with MD for more structured and less emotionally intense activities (eg, cognitive games), was undocumented in the literature. In this study, participants with apathy and depression had a worse attitude toward the game and the partner and showed less pleasure compared to other participants in both activities. Moreover, they were more prone to distraction during robot play. This last finding might be due to the fact that cognitive games had a very precise structure of goals and actions to be performed, while robot play did not. This self-evident and highly defined structure might have sustained the attention of people with MD during cognitive games, and let it drop during robot play. Participants with MD differed from those without such disorders also in terms of quantity of movement. Indeed, they moved considerably less in both cognitive games and robot play.

The effects of MD on engagement are especially noticeable when compared to those of dementia severity. Indeed,

moderate dementia did not yield any significant negative effect on engagement (measured with the OME and the OERS and with quantity of movement), but just a positive effect on attitude toward the partner during robot play. Participants with moderate dementia, who were more prone to unleash emotions, tried to bring participants with mild dementia, who were more cautious, into the interaction with the robot and this might have resulted in a better attitude toward the partner.

Implications for Clinical Practice

To conclude, we would like to highlight that the findings of this study could be beneficial also for clinical practice for a number of reasons:

1. In nursing homes, the clinical staff allocated to activities is in most cases limited in number and filling out scales is time-consuming. The use of accelerometer

data could provide a quick overview of differences in engagement among residents.

2. Recreational activities usually involve more than 2 residents, and it is difficult for facilitators to keep track of the engagement-related behaviors of all attendees. Accelerometers can measure the quantity of movement in parallel on several participants and give important instances of information about engagement.

3. In clinical research, most observational measures, especially those that require video recording, are subject to privacy issues and are in general hard to handle. Accelerometers do not collect personal health-related information, nor do they record explicit information on what people with dementia exactly do, they just record how much they move.

4. Residents with dementia are usually involved in all the activities of the nursing home in spite of their preferences. Taking into account how MDs affect engagement might be helpful for clinicians to make decisions about which activities are the most likely to be meaningful for such residents.

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