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## TITLE PAGE

### Title of Paper:

**ASSESSING ENGAGEMENT IN PEOPLE WITH DEMENTIA: A NEW APPROACH TO ASSESSMENT  
USING VIDEO ANALYSIS**

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## **Abstract**

The study of engagement in people with dementia is important to determine the effectiveness of interventions that aim to promote meaningful activity. However, the assessment of engagement for people with dementia in relation to our current work that uses social robots is fraught with challenges. The Video Coding – Incorporating Observed Emotion (VC-IOE) protocol that focuses on six dimensions of engagement: emotional, verbal, visual behavioural, collective and signs of agitation was therefore developed. This paper provides an overview of the concept of engagement in dementia and outlines the development of the VC-IOE to assess engagement in people with dementia when interacting with social robots.

**Keywords: Behaviour, Dementia, Engagement, Video Analysis**

## **Highlights**

- VC-IOE is developed to assess engagement in people with dementia
- VC-IOE is unique in its consideration of collective engagement
- VC-IOE is designed to assess the presence and absence of engagement
- VC-IOE is designed to assess the nature (i.e. positive or negative) and target of engagement

## **Introduction**

Dementia is a growing international epidemic with no imminent cure (1). As the disease progresses, an individual experiences a reduction in their ability to communicate. They are unable to express themselves clearly and as a result they spend most of their time alone, doing little and not being engaged in meaningful activity (2-5). Prolonged lack of stimulation can increase the risk of loneliness and social isolation (6, 7), as well as increase cognitive decline (8). Furthermore, limited social connection increases the risk of behavioural and psychological symptoms of dementia (BPSD) such as apathy, depression, aggression and agitation (9, 10). Engaging a person with dementia in meaningful activity is therefore important and a priority in care provision, and in particular to improve wellbeing through an increase in positive emotions (11-14) and an improvement in quality of life (12, 14, 15). Consequently, the study of engagement (also called social interaction/connection)

in people with dementia is important to determine the effectiveness of interventions that can promote meaningful activity. Furthermore, engagement is important in people with dementia as engagement in social activities may be beneficial in preventing or delaying cognitive impairment. In addition, a reduction in engagement may also be a marker of cognitive decline. For example, poor social connections, infrequent participation in social activities, and social disengagement are predictors of the risk of cognitive decline (16). Low levels of social engagement are also known to be associated with poor quality of life. Depression is one of the most potent predictors of engagement (17).

Cohen-Mansfield and colleagues (18) reported that the analysis of engagement displayed by a person with dementia can help determine person-centred activities to reduce boredom and loneliness, and thereby improve quality of life. However, analysis of engagement is challenging for people with dementia as they have reduced emotionality (i.e. affective blunting), making the analysis of facial expression very challenging in this population.

Our current research involves the use of social robots such as mobile telepresence (19, 20) and companion robots (14), and the examination of their effect in engaging people with dementia living in nursing homes in meaningful activity while reducing BPSD. Telepresence robots are focused on telecommunication and remote presence. Telepresence robots enable a remote user to virtually see into another space through a two-way camera and to move around the environment using software on the remote user's computer. This allows the remote user to feel as though they are physically present at the location of the telepresence robot, no matter where the robot is located (21). Telepresence enables dialogue between a local user (a person at the robot's location – in our research this is a person with dementia) and remote user (in our research this is a family member or friend) by transmitting audio and video display including gestures. On the other hand, companion robots such as PARO, a therapeutic animal shaped as a baby harp seal (22) are a comparatively new field of robotics. Such research focuses on user's social interaction with the robot as a means to encourage social inclusion, reduce BPSD and improve quality of life (QOL). The physical embodiment of social robots leverages the inherently human tendency to engage with the robot's life like social behaviour. People ascribe intention, personality, and emotion to even the most simplest robot and the social robot uses this interaction as a

means to motivate, encourage and improve human engagement (23). Social robots can therefore help to improve the social function of people with dementia by embracing and augmenting the social and emotional connection between the human and the robot. Such robots have also been shown to improve BPSD outcomes in people with dementia (14, 24-26). The simple presence of a social robot that a person can touch and hold and that is able to respond even if in a minimal way has been shown to defuse the behaviour of the most hostile and angry adult (27).

The approach to our dementia research includes exploratory designs, feasibility frameworks, pre-post surveys, mixed methods including qualitative and quantitative measures, randomised controlled trials and direct observation and observational video data to determine a person with dementia's engagement with a telepresence or social robot (14, 19, 20). Several concerns, however, arise with the use of traditional methods where an observer is sent into the field to assess engagement of the person with dementia. These include: (i) the effect of the observer's presence on the person with dementia, (ii) selective inclusion and omission of information (i.e. observer bias), (iii) missing information during the period of observation due to the complex construct of engagement and (iv) no means of validating the observed events without a minimum of two observers and validation methods post observation (28). To reduce these concerns in our research, we always use video (with audio) footage recorded using a small wide angled and light sensitive camera to reduce the observer presence effect and allow for improved quantifiable data for assessment with increased reliability and validity. We attach a small discrete camera to the telepresence robot in such a way that it appears to be part of the robot technology and use cameras attached to furniture or discreetly hand-held to capture video footage of participants.

This paper provides an overview of the concept of engagement in dementia and describes an existing measure of engagement for people with dementia. The challenges of assessing engagement for people with dementia are discussed in relation to our current work that uses social robots. Finally, this paper presents a video coding scheme that is based on existing literature on engagement and validated in our research to assess engagement in people with dementia. The video coding scheme is not a scale instrument, instead, it facilitates researchers and practitioners to objectively and quantitatively assess the overall experience of engagement of people with dementia observed in video data. The coding

system described could also be used in clinical situations where psychiatric nurses want to understand a patient's response to an intervention or therapy.

## **Assessing Engagement in People with Dementia**

### *"Dual-Channel" Hypothesis*

Lawton (29) introduced the dual antecedent pattern for positive and negative aspects of psychological well-being (i.e. quality of life and depression) and termed this as the "dual-channel" hypothesis for older people. Positive affect is hypothesised to be influenced by externally engaging phenomena such as socializing and engaging in recreational activities. External engagement is behaviour, cognition, or affect whose object lies outside the person. On the other hand, the origin of inner phenomena is where the person's attention is some internal object, such as a memory, a thought, or some internal stimulus such as a physical symptom. Intrapersonal factors including health, self-esteem, and personality factors such as neuroticism, contribute to negative affect states. The "dual-channel" model of engagement is thought to be relative, rather than an absolute congruence between the valences of antecedent events and affective consequences (30).

### *Comprehensive Process Model of Engagement*

Engagement is also defined as *'the act of being occupied or involved with an external stimulus'* (31). Although Lawton's work has been instrumental in helping researchers understand engagement, to date there has been a dearth of work that has examined engagement for people with dementia; therefore the difficulty in quantifying engagement in this population remains. The most notable and recent work in this area is that of Cohen-Mansfield and colleagues (31) who introduced a theoretical framework called the Comprehensive Process Model of Engagement. This model indicates that engagement with a stimulus is influenced by environmental, person and stimulus attributes. Environmental attributes refer to the location, the people around, the timing, the level of lighting, noise and temperature as well as the way to which the stimulus is presented to the person. Person attributes include characteristics and traits such as demographic features, past activities and hobbies, cognitive ability and level of concentration, apathy and interest. The attributes of the stimulus in terms of its appearance, texture, movement, and the sound it makes and social qualities (if any) may also affect level of engagement. The interactions

between environmental-stimulus and person-stimulus will influence engagement leading to a change in affect which then in turn change the presentation of behavioural symptoms. This model is subsequently conceptualised into five dimensions of engagement (known as the Observational Method of Engagement) that are then measured via:

1. Rate of refusal of the stimulus (*i.e. frequency*)
2. Duration of the time that the resident was occupied or involved with the stimulus (*i.e. duration*)
3. Level of attention to the stimulus (*4-point scale ranging from not attentive to very attentive*)
4. Attitude towards the stimulus (*7-point scale ranging from very negative to very positive*)
5. Action towards the stimulus (*4-point scale ranging from none of the time to most of the time*)

#### *The Observational Method of Engagement*

Unlike earlier research on engagement in people with dementia that merely suggested that a stimulus which reduced agitation must have produced engagement or showed promise in the effect of stimuli to engage the person (32), the Observational Measurement of Engagement (OME) specifically addresses the experience of engagement (31) with quantifiable measures. The OME conceptualizes engagement as a construct beyond the simple absence of agitation or agitated behaviours. While the OME has frequently been used as a direct observation measure in studies focusing on activity engagement in people with dementia (32), there are also a number of considerations when using the OME. Firstly, the OME comprises of five dimensions of engagement with different units of measurement. To assess the relationship between the five dimensions of engagement, inter-correlations of the dimensions of engagement are computed. The lack of a total OME score makes it difficult to understand the experience of engagement for people with dementia. People with dementia can have fluctuating affect and receptivity to stimulus and may refuse or accept the stimulus in the same setting and/or on different occasions. For example, a person with dementia may refuse the stimulus the majority of the time. However, when the person with dementia accepts the stimuli on another occasion, he or she may spend a substantial amount of time with the stimulus. Therefore, the individual

dimensions of OME do not provide a coherent and comprehensive assessment of engagement. Secondly, expressed emotion and behaviours towards the stimulus are measured together in the dimension of 'Attitude' in the OME. However, reduced emotionality (affective blunting) is common in dementia especially in individuals with frontotemporal dementia (33). It is possible for a person with dementia to be observed as being emotionless but to still remain behaviourally engaged with the stimulus through stroking, holding and handling the stimulus. Thus, to avoid this situation, we advocate that affect and behaviours should be examined separately when accessing engagement in dementia. Lastly, but most importantly, the OME does not appear to sufficiently allow for the measurement of social engagement where a person with dementia may use the stimulus as a communication channel to engage, interact and talk with others (e.g. family members, staff and other residents).

#### *Observed Emotion Rating Scale (OERS)*

A dimension of the OME is the person's attitude toward the stimulus and this can be assessed by the positive and negative emotions of the person with dementia. A commonly adopted scale to assess emotion for people with dementia is the Observed Emotion Rating Scale (OERS) (34). The OERS rates the extent or duration of five dimensions of affect (Pleasure, Anger, Anxiety/Fear, Sadness and General Alertness) over a ten-minute period on a scale rating from not in view, never, less than 16 sec, 16-59 sec, 1-5 min to more than 5 min. However, the scale was developed for nursing home residents rather than specifically people with dementia. Our early work (14) found the scale was limited, as it did not take into account the blunted emotionality (i.e. reduced expressivity) often seen in people with dementia. Nevertheless, elements of the scale are useful and have been used in our current work on video coding described below.

#### **Video Coding of Engagement**

There are a number of existing papers where video recordings are made to assess agitation (35, 36); mood and affect (36, 37); engagement (36, 38); passivity (36); care resistance (37); and posture, movement and sensory awareness (39) in people with dementia. Of the two studies that examined engagement, Cruz et al. (38) focused on the frequency and duration of the behavioural aspect of engagement (i.e. a person's level of



attention to the stimulus and attitude/action towards stimulus using the OME). On the hand, Kolanowski et al. (36) measured the time spent by a person with dementia on participating in an activity and the intensity of their participation together with a modified version of Nolan et al.'s (40) molar coding scheme, which models closely to naturally occurring behaviours, that depicted time use as 'asleep', 'doing nothing' and 'formal/informal activity'. Although agitation, mood, affect and passivity were also assessed, they were analysed as stand-alone constructs separate from engagement. Given the limited measures of engagement of people with dementia, the shortcomings of the OME and the challenges of video recordings with variations in coding, a new approach to assess engagement in people with dementia using video recordings is proposed. Such an approach is useful when trying to understand the impact of social robots.

#### *The Video Coding Protocol - Incorporating Observed Emotion (VC-IOE) Scheme*

Based on the existing literature on engagement in people with dementia (i.e. the "Dual-Channel" hypothesis and the Comprehensive Process Model of Engagement framework) and our experience and expertise, we developed a video coding scheme (VC-IOE) to code engagement in people with dementia and as a means of understanding the impact of social robots. The VC-IOE Scheme was developed for research purposes to use with people with dementia across settings and is particularly useful for pre-post intervention research designs. In line with the OEM and OERS, the VC-IOE focuses on six dimensions of engagement: emotional, verbal, visual behavioural, collective and signs of agitation (see below and Table 1). Each dimension of engagement should be assessed separately but interpreted conjointly to generate a comprehensive overview of the person with dementia's experience of engagement toward the stimulus. Furthermore, every dimension consists of certain emotional and behavioural responses that assess the presence or absence, the nature, and/or the target of engagement. Criteria for coding these emotional and behavioural responses are set out in the VC-IOE and missing data is coded when evidence of the engagement dimension cannot be determined (i.e. not in view). To assess level of engagement, the VC-IOE assesses the duration of the manifestations of engagement during a video recording and the result is interpreted as the proportion of the video recording of which the manifestations of engagement are evident. An alternative unit of assessment for the VC-IOE is the frequency of the manifestations of engagement. However, the frequency

of responses may not be meaningful and accurate given that the duration of an instance of engagement can vary significantly.

#### A. Emotional Engagement

Following the OME, emotional engagement in people with dementia is assessed via facial emotional responses. However, the OME does not include a benchmark to code facial emotional responses. Therefore, the VC-IOE is based on a modified version of the OERS (34). The facial expression of the resident is coded as displaying pleasure, anger, anxiety or fear, sadness or neutral affect. Although the OERS aimed to differentiate the duration of five different dimensions of affect (i.e. pleasure, anger, anxiety/fear, sadness, and general alertness), we simplified the elements of the scale to allow for the blunted affect of a person with dementia and to focus on the duration of three clearly defined dimensions of affect (i.e. pleasure, neutral, negative affect) whereby negative affect consists of anger, anxiety or fear, and sadness. Facial expression of the resident is coded as missing if the face of the resident is not in view.

#### B. Verbal Engagement

Aphasia is an acquired language deficit resulting from damage to the brain and is a common symptom in a person with dementia. Language is an important element of engagement that needs to be taken into consideration. In our coding scheme, evidence of positive verbal engagement is assessed as the duration to which the person with dementia is participating in and maintaining a conversation. The target of the verbal engagement is also identified to determine the effect of a stimulus on engagement from other stimuli or the surrounding environment (e.g. the presence of staff). For example, we examine whether the person with dementia is talking to the stimulus, talking about the stimulus with others, or holding a general conversation with others not about the stimulus. The absence of this is coded as verbally not engaged. Furthermore, the distinction of negative verbal engagement from positive verbal engagement is important it can reflect an unfavourable attitude, distress, or discomfort for people with dementia (e.g. complaints). Lastly, verbal engagement is coded as missing data when the voice of the person with dementia is not audible.

#### C. Visual Engagement

Visual alertness is an important indicator of non-verbal engagement and is examined in both the OME (31) and OERS (34). In our coding scheme, we examine the duration of visual engagement (i.e. visual alertness and eye gaze) and the lack of visual engagement. Visual engagement is coded as missing data if the eyes of the person with dementia are not in view. Importantly, we are interested to differentiate between visual alertness (focused) on the stimulus or others.

#### D. Behavioural Engagement

Behavioural engagement in our coding scheme is modified from the work of Cohen-Mansfield et al. (31) and Kolanowski et al. (36). We assess the duration of positive or negative behavioural engagement, the lack of behavioural engagement or not in view behaviours. Observations of positive behavioural engagement include touching or attempting to touch the stimulus as well as stroking, petting, nuzzling, holding and handling the stimulus appropriately. On the other hand, behaviours related to negative engagement consist of hitting, shaking and handling the stimulus inappropriately and pushing away or pulling back from the stimulus or facilitator and maintaining stiff extremities and posture.

#### E. Collective Engagement

In our early work with social robots, we observed people with dementia used the stimulus as a communication channel to engage, interact and talk with others (e.g. family members, staff and other residents). For example, the person with dementia may introduce the stimulus to others; initiate a conversation with others about the stimulus; and encourage others to interact with the stimulus. Consequently, in our coding scheme, we assess the duration of this unique phenomenon and label this as collective engagement to reflect the specific use of the stimulus by people with dementia as a communicative platform to engage with others.

#### F. Agitation

Where a stimulus reduces agitation this can result in a positive change in affect (31). We assess agitation in our coding scheme via the duration of agitated behaviours presented and based on the Cohen-Mansfield Agitation Inventory (CMAI). Agitation is defined by Cohen-Mansfield as an inappropriate verbal, vocal, or motor activity that is not judged as directly a result of the needs or confusion of the individual. Agitated behaviour is deemed as socially inappropriate and unlikely to result in positive engagement. Agitation in this

population often occurs through unmet needs such as the need for meaningful activity. In our coding scheme, the duration of signs of agitation such as restlessness, repeated/agitated movement (frequent non-purposeful movement), moving repetitively in a chair, picking and/or fiddling with clothes; repetitive rubbing of limbs or torso; appears anxious; repetitively repeating words or phrases; and being abusive or aggressive towards self or other.

Video recordings of engagement are analysed using the Noldus Observer XT 11.5 program (41) that allows users to code observational data in millisecond intervals. To gain a comprehensive overview of a person with dementia's typical behavioural and emotional responses, the coders view the first (baseline) video recording of each person with dementia. This serves as a calibration for the coding to enhance reliability and validity of the analyses. To date, the combined inter-rater reliability of the video analyses has been exceptionally high across ten different video coders (95.25%) when comparing within a one-second-tolerance interval. The researchers are mindful that visual expression is just one part of the human picture and therefore, the coders' observations are usually interpreted in the context of qualitative data (e.g. interviews) and a coding data log. An optimal intra-rater reliability of 95% has also been obtained across dependent measures.

## **DISCUSSION AND CONCLUSION**

This paper lays the foundation for a new approach to analyse video recordings of engagement in people with dementia and in particular when researchers are interested in the impact of social robots in this population. Given the importance of engagement in meaningful activity for people with dementia there has been an increase in the number of studies with engagement as one of the key outcome measures of psychosocial interventions to improve quality of life and care provision (32). Our video coding scheme offers the opportunity for researchers to incorporate video data rather than the traditional on-site direct observational method of analysis.

Our work involves the observation of people in a long-term care setting where we have introduced a social robot and we want to understand the impact of that robot. Choosing to use video observation rather than non-participant observation allows us to analyse what occurs in the setting, the opportunity to play it over and over again allows

greater control over the quality of the data analysis, and to validate the analysis process using inter-rater reliability methods. Furthermore, the use of video observations can provide greater confidence in the findings through the triangulation of for example qualitative data.

The VC-IOE is unique, as it has been developed specifically for people with dementia with a focus on assessment of engagement. Dementia involves progressive decline in cognition, function, and behaviour. The person with dementia often having blunted emotionality challenges traditional methods of analysis of engagement. A coding scheme such as the VC-IOE is used to reduce uncertainty in decision-making and to increase objectivity of the dimensions of engagement. Specifically, the VC-IOE extends the OME by incorporating and adopting a different means of assessment of behavioural and emotional responses such as those used in the OERS and CMAI that have been designed, previously validated and commonly used for people with dementia. Furthermore, the VC-IOE is not only distinct in its consideration of collective engagement; it also collates different prior conceptualizations and assessment of engagement into a total score to allow for more meaningful interpretation of engagement outcomes for people with dementia. A novel contribution of the VC-IOE is that it is designed to assess not only the presence and absence of engagement but also the nature (i.e. positive or negative) and target of engagement. Identifying the nature and target of engagement provide a more comprehensive, valid and reliable assessment of the effect of a stimulus on engagement in people with dementia and the quality of the experience. Importantly, VC-IOE has been cross-validated with other staff/family ratings of engagement and interviews (qualitative measures) where congruent and comparable data has been yield.

Although the VC-IOE is a relatively new coding scheme, it performs well and shows excellent inter-rater and intra-rater reliabilities. In our work, we frequently have video recordings of 30 to 45 minutes duration for hundreds of participants over several sessions, and for every minute of video, we require video coders to take approximately between 3 to 4 minutes to code the various aspects of engagement. It is therefore essential that the VC-IOE is practical for use and can be easily used by trained operators. The VC-IOE should be considered as a strategy to analyse video observation data of people with dementia in

intervention research where the aim of the intervention is to improve engagement and reduce BPSD.

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**Table 1: Video Coding Incorporating Observed Emotion (VC-IOE)**

**Facial Emotional Response**

<b>Emotion</b>	<b>Observation (<i>Duration</i>)</b>
<b>Pleasure</b>	Smiling, laughing, singing, responding to STIMULUS
<b>Anger</b>	Physical aggression, yelling, cursing, drawing eyebrows together, clenching teeth, pursing lips, narrowing eyes
<b>Anxiety or fear</b>	Voice shaking, shrieking, repetitive calling out, line between eyebrows, lines across forehead, tight facial muscles
<b>Sadness</b>	Crying, frowning, eyes drooped, moaning, sighing, eyes/head turned down
<b>Neutral</b>	Relaxed or no sign of discrete facial expression
<b>Missing facial expression</b>	Cannot see face to determine expression

**Verbal Engagement**

<b>Behaviour</b>	<b>Observation (<i>Duration</i>)</b>
<b>Positive verbal engagement with STIMULUS</b>	Target: STIMULUS or others (talking about STIMULUS). Participating and maintaining conversation, verbally responding to statement/ questions specifically to STIMULUS and about STIMULUS. Using general leads such as “yes” or “uh hum”. Maintaining conversation with STIMULUS or about STIMULUS while responding with “hmm” and “ah”.
<b>Positive verbal engagement with Facilitator</b>	Target: others (not talking about STIMULUS). General talking. Participating and maintaining conversation, verbally responding to statements/ questions that are not relevant to STIMULUS. Using general leads such as “yes” or “uh hum”. Maintaining conversation that is not relevant to STIMULUS while responding with “hmm” and “ah”.
<b>Negative verbal engagement</b>	Verbalises the desire to leave. Refuses to participate in the activity by verbalising “no”, “stop”, etc. Makes repetitive generalised somatic complaints. Cursing and swearing.
<b>No verbal engagement</b>	Not participating and maintaining conversation. Not responding or talking to the facilitator when prompted.
<b>Missing verbal</b>	No audio or distorted audio

**Visual Alertness / Engagement**

<b>Behaviour</b>	<b>Observation (<i>Duration</i>)</b>
<b>Visually engaged with STIMULUS</b>	Appears alert and maintaining eye contact with STIMULUS. Eyes following STIMULUS or looking at STIMULUS.
<b>Visually engaged</b>	Appears alert and maintaining eye contact with facilitator or others.

<b>with facilitator or others</b>	Eyes following facilitator or others. Looking at facilitator or others.
<b>No visual engagement</b>	Appears inattentive. Blank stare into space. Does not make eye contact with STIMULUS, facilitator or others.
<b>Missing visual</b>	Cannot see face to determine visual engagement

### **Behavioural Engagement**

<b>Behaviour</b>	<b>Observation (<i>Duration</i>)</b>
<b>Positive behavioural engagement</b>	Touching or attempting to touch STIMULUS. Stroking, petting, nuzzling, holding and handling STIMULUS appropriately.
<b>Negative behavioural engagement</b>	Hitting, shaking and handling STIMULUS inappropriately. Shoving STIMULUS away. Pulls back from STIMULUS or facilitator. Maintains a stiffness of extremities
<b>No behavioural engagement</b>	No touching; no physical contact with STIMULUS or not handling STIMULUS. Rests STIMULUS on lap or on furniture, but not handling or interacting with STIMULUS.
<b>Missing behaviour</b>	Cannot see the body posture of the resident.

### **Collective Engagement**

<b>Coding</b>	<b>Observation (<i>Duration</i>)</b>
<b>Using STIMULUS for collective engagement</b>	Encouraging others to interact with STIMULUS. Introducing STIMULUS to others. Using STIMULUS as a communication channel to interact and talk with others (e.g. family members, staff and other residents)
<b>No evidence of collective engagement</b>	No sign of collective engagement

### **Agitation**

<b>Coding</b>	<b>Observation (<i>Duration</i>)</b>
<b>Evidence of agitation (Verbal, vocal, motor activity)</b>	Restlessness, repeated/ agitated movement (frequent non-purposeful movement), moving in chair, picking and fiddling with clothes; repetitive rubbing own limbs or torso; appears anxious. Repeats words or phrases (exclude stumbling over word/phrase), abusive or aggressive towards self or other.
<b>No evidence of agitation</b>	No sign of agitation as described above