D3.1

Emotion & Performance

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Editor	**Ernst Koster (GEU)**
Co-authors	**Ivan Grahek (GEU), Ladislas Nalborczyk (GEU)**
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Project PLAYTIME

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PLAYTIME partner			organisation
01	JR		JOANNEUM RESEARCH Forschungsgesellschaft mbH DIGITAL – Institut für Informations- und Kommunikationstechnologien, 8010 Graz
02	FAM		FameL GmbH Steinbruchweg 20, A-8054 Seiersberg
03	LEF		Lefkopoulos KG Jakob-Redtenbacher Gasse 9, A-8010 Graz
04	SVD		Sozialverein Deutschlandsberg Kirchengasse 7, A-8543 Deutschlandsberg
05	GGZ		Geestelijke Gezondheidszorg Eindhoven en de Kempen Postbus 909, 5600 AX Eindhoven, The Netherlands
06	TIU		Stichting Katholieke Universiteit Brabant, Tilburg University PO Box 90153, 5000 LE Tilburg, The Netherlands
07	MCR		McRoberts BV. Raamweg 43, 2596 HN The Hague, The Netherlands
08	MBY		MindBytes F. Roosseveltlaan 348-349, B8, 90600 Ghent, Belgium
09	GEU		Ghent University Sint-Pietersnieuwstraat 25, 9000 Gent, Belgium

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Contents

1 Executive Summary

We know that the earliest neuronal consequences of Alzheimer Disease (AD) usually occur in medial temporal lobe structure (e.g., hippocampus, see Braak & Braak, 1991), disrupting the neural network critical for episodic memory. These neuronal changes entail impairments in immediate recall, recognition memory and increased proneness to intrusions during memory tasks (false memories). Although memory impairments represent the core of cognitive dysfunctions reported in dementia, recent insights suggest that executive functions (or “cognitive control”) would be impaired, even at the MCI stage (for a review, see Weintraub, Wicklund, & Salmon, 2015). Moreover, recent attempts to enhance cognitive control in older adults showed that gamification approach training was efficient to slow down the decline of multitasking abilities (Anguera et al., 2013). Interestingly, the beneficial effects of the training were not limited to multitasking but extended to other (non-trained) cognitive control abilities (e.g., sustained attention and working memory), and were associated with modified cerebral functioning in the prefrontal areas. This positions cognitive control abilities as a particularly relevant target for rehabilitation in dementia.

2 Introduction

Aim. *Training executive functions can have important effects on emotion regulation and well being (Hoorelbeke, Koster et al., 2015), with wellbeing also being an important target in PLAYTIME. In PLAYTIME it is important to examine whether the game elements are of importance for the motivation of the participants to continue with the training. It will be examined whether mood during and after training is a predictor of the engagement in training. Further research on emotion variation will be applied in the frame of serious game based interaction, i.e., on which baseline characteristics could predict sustained training and improvement. Another focus will investigate mechanisms of crucial relevance in predicting training-related improvement in executive functions and wellbeing as well as affective influences on sustained training.*

Theoretical background. In the context of encouraging the use of executive functions and training cognitive control, a crucial novel theory of cognitive control considers emotions as a key factor in signalling the need for implementation of cognitive control (Inzlicht, Bartholow, & Hirsh, 2015). Specifically, this theory propose that cognitive control is initiated when goal conflicts evoke phasic changes to emotional primitives that both focus attention on the presence of goal conflicts and energize conflict resolution to support goal-directed behaviour. Thus, emotion is not a by-product of conflict but is instrumental in recruiting control. Crucially, emotions and cognitive conflict are considered necessary but not sufficient conditions to elicit cognitive control in AD individuals. The nature of the data collected as well as the detailed understanding of cognitive control implementation allows for sophisticated diagnostics as well as training of cognitive control deficits in serious games.

Potential enhancement of efficacy for serious game in dementia by including emotional elements.

Emotion plays a major role in the frame of process- or outcome-focused motivation (Touré-Tillery & Fishbach, 2014). Emotion-oriented care can be more effective than standard care regarding positive emotion in nursing homes residents with mild to moderate dementia (Finnema et al., 2005). Emotion-oriented care approaches are in principle known to offer the opportunity to tailor the care to the individual needs of dementing elderly. Emotion and cognition not only strongly interact in the brain, but are often integrated so that they jointly contribute to behaviour (Pessoa, 2008). In his line of research, he proposed that emotion and executive control (Norman & Shallice, 1986) rely on shared resources and hence emotion can interfere with executive processes. Executive dysfunction is characteristic in Alzheimer's disease (Collette, Van der Linden, Bechet, & Salmon, 1999) in particular, referring to inhibition abilities and the capacity to coordinate simultaneously storage and processing of information.

These observations have led to the inclusion of affective states and emotional information within the PLAYTIME proposal. Below we specify the theoretical rationale and address the question on how these factors can be included in the PLAYTIME environment, specifically.

3 Theoretical perspectives on emotion and cognition

3.1 Emotion and Cognition

Emotion and cognition have for long been viewed as separate processes and have been studied in such a way. Emotion research has traditionally been focused on defining a set of basic, unique emotions such as fear, happiness, and sadness (Ekman, 1992). More recently, researchers have focused on investigating the components shared across different emotional experiences. For example, emotions vary in how positive or negative they are (valence) and how activating they are (arousal). This insight has led to the development of the concept of core affect – the basic emotional state of pleasure-displeasure marked by a certain degree of arousal (Barrett, 2006; Russell, 2003). Core affect represents the basic element of emotions, moods, and other emotionally charged states. Most of the contemporary theories see emotions as states emerging from a blend of core affect and other psychological processes including cognition.

Research on cognition has been focused on mapping various cognitive processes such as attention, working memory, and long-term memory that represent the basic elements supporting our ability to solve problems, reason, and plan. One of the important questions in this domain concerns the set of mental processes that allow for flexible adaptation of cognition and behaviour in accordance with an individual's current goals. This set of cognitive processes is often termed cognitive control or executive functions and they are thought to coordinate other processes in a goal-driven manner (Braver, 2012; Friedman & Miyake, 2017; Shenhav, Botvinick, & Cohen, 2013). These processes are crucial for healthy functioning and well being, and they are found to be impaired across a wide range of mental health disorders (Diamond, 2012; Millan et al., 2012). Research on cognitive control has recently started to uncover the necessity of considering emotional and motivational processes when studying cognition.

3.2 Integrative accounts of emotion and cognition

A growing number of researchers propose that emotion and motivation are crucial parts of cognitive control processes, and that the strong distinction between cognitive, emotional, and motivational processes is neither theoretically nor practically useful. Additionally, the strong division between emotion and cognition is not supported by the neurobiological data. The emotional and cognitive processes in the brain are highly interactive and it is very hard to localize them to specific regions (Pessoa, 2008). Pessoa's dual competition model (2009), for example, posits that emotionally salient stimuli (here referring to emotional or motivational saliency) can influence human behaviour (e.g., approach or avoidance of stimuli) via attention and cognitive control. The model predicts that emotion and motivation can exert both positive and negative effects on cognitive control and attention, depending on how the emotional and the motivational value of stimuli interact. This model highlights the importance of emotional factors in cognitive processes.

A more recent model proposed by Inzlicht and associates (Inzlicht, Bartholow, & Hirsh, 2015) conceptualises emotional and cognitive processes not as interacting, but as integrated processes. They proposed that cognitive control processes rely on emotional processes, and especially on core affect. In their model cognitive control processes, which direct other cognitive processes, are initiated when there is a conflict between two goals, which leads to a change in core affect. This conflict is emotionally negative and thus initiates and supports further goal-directed behaviour in order to resolve the conflict. According to this model, emotion is a critical component of cognitive processing.

In conclusion, most contemporary models of cognitive processes recognize the importance of emotion. It seems that cognitive and emotional processes are highly interactive and that they (at least in part) rely on each other. This conclusion has important implications for many disorders in which cognitive processes are impaired. From the basic science point of view, changes in emotion could have positive effects on cognitive processes, while cognitive processes can influence emotion.

4 Performance

We know that the earliest neuronal consequences of AD usually occur in medial temporal lobe structure (e.g., hippocampus, see Braak & Braak, 1991), disrupting the neural network critical for episodic memory. These neuronal changes entail impairments in immediate recall, recognition memory and increased proneness to intrusions during memory tasks (false memories). Although memory impairments represent the core of cognitive dysfunctions reported in dementia, recent insights suggest that executive functions (or “cognitive control”) would be impaired, even in MCI stage (for a review, see Weintraub, Wicklund, & Salmon, 2015). Moreover, recent attempts to enhance cognitive control in older adults showed that gamification approach training was efficient to slow down the decline of multitasking abilities (Anguera et al., 2013). Interestingly, the beneficial effects of the training were not limited to multitasking but extended to other (non-trained) cognitive control abilities (e.g., sustained attention and working memory), and were associated with modified cerebral functioning in the prefrontal areas. This positions cognitive control abilities as a particularly relevant target for rehabilitation in dementia.

Below we discuss some of the key performance areas that are disrupted in PwD.

4.1 Executive functioning and attention in dementia

4.1.1 Executive functions

Executive functioning refers to a set of cognitive capabilities that allows to formulate, initiate, select, and maintain goal-directed behaviours. Consequently, it includes many stages. One should first be able to identify a goal and to form an intention to reach it. Then, possible problems should be identified and solutions must be planified to overcome them. Afterwards, the subject should be able to maintain a clear description of its goals, should stay flexible concerning the means of its realization and should update state of achievement (continual monitoring). The subject might finally be able to judge whether the goal has been reached and to judge the effect of his actions relative to the original goal.

Daily-life tasks that intuitively appear to rely on executive functions (e.g., choosing the appropriate clothes to wear, planning and cooking a meal, walking whilst talking) are known to cause problems for PwD even at relatively early stages of the disease (e.g., Colette, van der Linden, & Salmon, 1999). It is however possible to investigate the relative degradation or preservation of each function. For instance, Brugger et al. (1996) examined the ability of AD patients to generate random sequences of numbers and observed that AD patients responses were more stereotyped than those of controls, and that the prevalence of these stereotypes were positively correlated with overall severity of dementia. The ability to generate random numbers sequences relies on the ability to switch retrieval strategies in order to avoid redundancy, which seems to be impaired in AD patients.

Executive functions deficits can also be made apparent using classic tasks evaluating problem solving that require mental manipulation. For instance, the Tower of London test (Lange et al.,

1995) can be used to assess planning abilities, or the modified Wisconsin Card Sorting Task (WCST, Bondi et al., 1993) can be used to evaluate "set-shifting" (i.e., the ability to adapt flexibly to a set of changing rules). Using a set of six different tasks, Collette, Van der Linden, Bechet, & Salmon (1999) showed that performance of AD patients was impaired on all of these six tasks, as compared to a control group. These tasks were assessing the ability to divide attentional resources (the dual-task paradigm), and to manipulate information stored in working memory (the alpha-span task), the short-term preparation for a specific event (the delayed alternation task), the capacity to retrieve information in semantic memory (the phonemic fluency task), the inhibition capacity (the Hayling task) and the monitoring of self-generated responses (the self-ordered pointing task). Following with a principal component analysis, authors of this study showed that the executive tasks they administered to patients load mainly two factors, which could be associated to *inhibition processes* and the *co-ordination between the storage and processing functions*. A correlation analysis between these two factors and cerebral metabolism at rest also shown that performance on each factor is associated with different cerebral areas. The inhibition factor was positively associated with a region including the left middle and superior frontal gyrus (BA 9/46 and BA 8), while performance on the coordination factor showed a negative association with rest metabolism in the posterior cingulate are (BA 31), a right middle temporal region (BA 21) and a left- and right-side parietal region (BA 40/7).

4.1.2 Attention(s)

AD was historically considered a dementia characterised by a global cognitive impairment with global deficits in memory abilities. With progress in neurosciences and cognitive psychology, memory deficits in AD has been studied in the light of new models of memory that postulates different subtypes of memory, each of which can be impaired or relatively preserved at different stages of the disease. The study of attention has followed a similar development, with converging lines of evidence suggesting that it can be divided into separate but interrelated subsystems. Perry & Hodges (1999) have examined the relation between AD and three subtypes of attention, namely the selective, sustained, and divided attention (see Table 1). According to these authors, attention would be the first non-memory domain to be affected by the disease, before language and visuo-spatial functions deficits.

Attention subtype	**Defining characteristics**	**Possible neural substrates**
Selective attention	Focusing on single relevant stimulus or process at one time while ignoring irrelevant or distracting stimuli	Posterior parietal systems for orienting and shifting modulated by anterior midline and basal ganglia system for response selection
Sustained attention	Maintenance of abilities to focus attention over extended periods of time	Right-sided fronto-parietal system
Divided attention	Sharing of attention by focusing on more than one relevant stimulus or process at one time	Dorsolateral prefrontal cortex and anterior cingulate cortex

Table 1. Characteristics and possible neural substrates of subtypes of attention (from Perry & Hodges, 1999).

Selective attention refers to the ability to screen out (to ignore) irrelevant stimuli. The model of spatial attention described by Posner & Petersen (1990) differentiates between three separate sub-components, related to different cerebral structures: i) disengaging attention from a spatial location (posterior parietal lobe), ii) shifting attention to a target at a new spatial location (superior colliculus), and iii) engaging attention on a new target (thalamus). Using a spatial cueing task (Posner, 1980) to evaluate selective attention, Parasuraman et al. (1992) demonstrated that AD patients were as effective as non-affected individuals in engaging attention to a spatially cued visual stimulus, but that they showed higher cost (longer RTs) in response to invalid cues, as compared to control, suggesting a deficit in disengaging attention. In summary, current evidence points to an early defect in selective attention in AD, sparing the focusing of attention but predominantly impairing the ability to disengage and shift attention.

Sustained attention is defined as the ability to focus attention on a task during a prolonged period of time, and is frequently measured by the speed of detecting rare and unpredictable target events (which refers to a state of *alertness*). Clinical observations of AD patients in daily-life situations suggest that there are problems in maintaining attention whilst performing tasks, quite early in the course of the disease. However, studies by Nebes & Brady (1993) and Brazzelli et al. (1994), evaluating the evolution of sustained attention throughout short periods of time (20-60min), showed no differences in sustained attention evolution between AD patients and a control group, though AD patients were on average slower than participants from the control group. This is coherent with the view that while divided and selective attention seem to be degraded even at early stages of the disease, sustained attention seem to be relatively preserved (Perry & Hodges, 1999).

Executive functions deficits have been hypothesized to reflect neurofibrillary tangle burden in prefrontal cortex, while this regional prefrontal cortical pathology is particularly observable in AD patients who present early impairments of executive dysfunction (Waltz et al., 2004; Weintraub, Wicklund, & Salmon, 2015). These deficits in mental manipulation are also apparent in tasks evaluating working memory, where “working memory” refers to a putative processing system whereby information needed for current task is temporarily held in a limited-capacity immediate memory buffed while being “manipulated by a “central executive” (Baddeley, 2003). Studies indicate that the working memory deficit observed in AD in initial stages primarily involves disruption of the central executive with relative sparing of immediate memory (Baddeley et al., 1991; Collette et al., 1999). Consistently, the ability to focus and sustain attention is usually relative spared in mildly emanated AD patients, but becomes apparent in later stages of the disease (e.g., Perry and Hodges, 1999).

4.1.3 General neuropsychological profile

The present section describes the profile of neuropsychological deficits associated with the dementia subtype of AD and contrasts it with cognitive changes that occur in “normal” ageing. The earliest neurofibrillary changes in AD occur in medial temporal lobe structures, interrupting the neural network critical for episodic memory function (see Braak & Braak, 1991). However, the amyloid pathology that precedes from several years the behavioural symptoms is mostly abundant in the regions comprising the “default mode network” (DMN). This network comprises a set of functionally interconnected cortical areas (posterior cingulate, inferior parietal lobule, lateral temporal neocortex, ventromedial and dorso-medial prefrontal cortex) that project heavily to medial temporal lobe structures (Buckner et al., 2008).

Deficits in executive functions occur early in the course of AD and are often evident from the MCI stage on (Perry & Hodges, 1999). Moreover, overall executive functions deficits in addition to difficulties with delayed memory recall appear to be a good predictor of subsequent progression of AD in the MCI stage (Albert, 1996). Aside from executive functions deficits, mildly demented AD patients often show impairments in object naming tasks (e.g., Bowles et al., 1987; Hodges et al., 1991) verbal fluency tasks (e.g., Butters et al., 1987; Monsch et al., 1992) and semantic categorisation (Aronoff et al., 2006). Concepts knowledge and the associations between them may be disrupted as the neuropathology of AD extend upon the temporal, frontal, and parietal association cortices in which they are thought to be diffusely stored (for review, see Hodges & Patterson, 1995). In parallel, patients with AD often exhibit deficits in visuospatial abilities. Deficits in visual information processing and in selective and divided attention (see section 4.1.2) are exacerbated in PwD, as compared to the course of normal ageing (e.g., Parasuraman et al., 1992). Additionally, visual motion detection has been shown to decline in some individuals with MCI, and more stronger in PwD, positioning this symptom as a potential behavioral marker (Mapstone, Steffenella, & Duffy, 2003). Using the useful field of view (UFOV) paradigm allowed to show that older individuals react more slowly to peripheral stimuli compared to younger controls, and that patients with AD shows an even greater impairment (Weintraub, Wicklund, & Salmon, 2015).

Figure 1 shows how the neuropsychological profile of dementia reflects the impact of disease on distinctive neuroanatomical networks, which are associated with complex cognitive domains. The thickness of the lines connecting the clinical and neuropathological levels represents the strength of associations between them (Mesulam 2000; Weintraub, Wicklund, & Salmon, 2015).

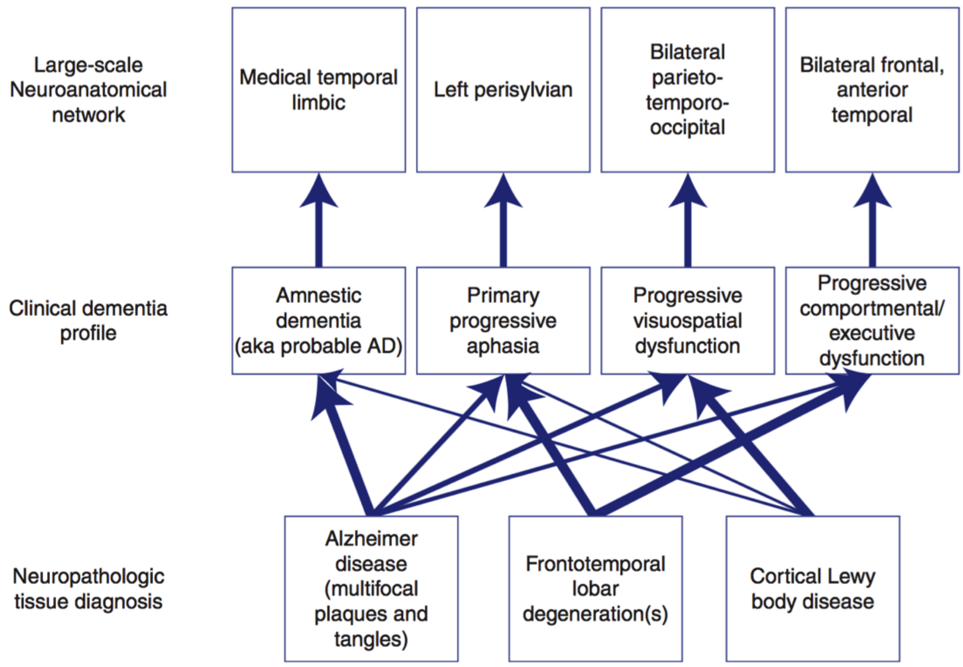

Figure 1. The neuropsychological profile of dementia reflects the impact of disease on distinctive neuroanatomical networks, which are associated with complex cognitive domains (from Weintraub, Wicklund, & Salmon, 2015).

Figure 2 illustrates the cognitive profile of different types of dementia (from Weintraub, Wicklund, & Salmon, 2015), contrasting early and late stage of disease developments. The height of the bars represents the level of impairment from mild to severe. In late stages of AD (represented by grey bars), cognitive functions are similarly impaired in an undifferentiated manner and it is difficult to pinpoint one single domain that characterizes the syndrome. However, in early stages (represented by black bars), it is possible to differentiate among domains that are unimpaired or mildly impaired and those that are distinctly abnormal. In other words, as dementia progresses from early to late stages, symptom domain boundaries become blurred and distinctive profiles are difficult to discern.

The analysis of the cognitive disruptions related to performance in early stage PwD suggests that a one-size-fits-all stimulation/training is unlikely to be the most useful approach. Instead, There is merit to a more fine-grained assessment of functional impairments that is used to inform which aspects of cognitive performance could be targeted through training.

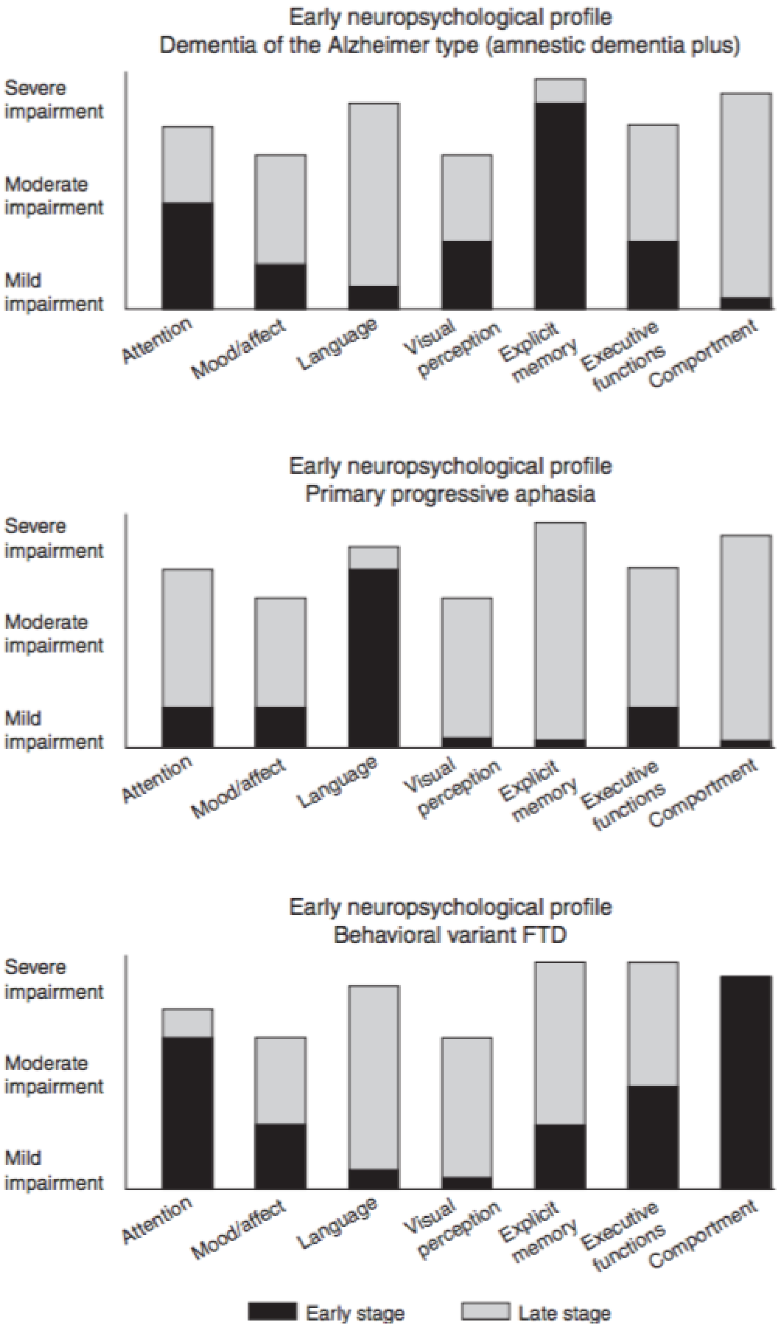

Figure 2. Three graphs, each schematically representing early- and late-stage cognitive/behavioural profiles of three neuropsychologically distinct dementia syndromes.

4.2 Integration of emotion and performance in dementia

In addition to cognitive impairments, neuropsychiatric and behavioural symptoms such as depressive mood, anxiety or apathy are common in PwD (Waanders-Oude Elferink et al., 2015). According to Kitwood (1993, quoted in Woods, 2001), the presentation (i.e., the apparent manifestations) of dementia would be the result of the mixed influence of personality factors (P), personal history (biography, B), physical health (H), neurological impairments (NI) and social psychology (SP). We can summarise this idea in the following equation:

$$D = P + B + H + NI + SP$$

Highlighting the need for consideration of multiple sources of influences in understanding dementia presentation. However, a more elaborate description of the reality though would also require including interaction terms between each of these components (e.g., PxB, NIxSP, BxHxNI).

We know that many PwD have also symptoms of depression and/or anxiety. Reifler & Larson (1990) report a prevalence of between a quarter and a third of PwD with a co-existing depression status, and Ballard et al. (1996) reported that 30% of PwS had one or more anxiety symptoms. The origins of these comorbid behavioural impairments are unclear, but it has been linked to impaired emotional processing. Phillips, Scott, Henry, Mowat, & Bell (2010) identified three important processes for affective processing: i) identification of the emotional significance of a stimulus, ii) production of an affective state in response to this identification and iii) regulation of the affective state. In the next sections we review and describe how the abilities of perceiving, maintaining (manipulating) and regulating emotion are affected or preserved in PwD.

4.2.1 Emotional working memory

4.2.1.1 Behavioural results

Emotional stimuli can have a strong impact on memory functions. In the context of normal ageing, several studies reported that emotional content might improve memory performance as compared with non-emotional content, a phenomenon called the *emotional enhancement effect* (EEE, see Broster, Blonder, & Jiang, 2012). In their review of the EEE, Klein-Koerkamp, Baciu, & Hot (2012) suggest that this effect could be preserved under specific retrieval instructions in patients with AD. Other results seem to suggest that emotional-content working memory would be relatively preserved in AD as well, when using instruction with lowered task-demands (Döhnel et al., 2008). In their study, Döhnel et al. (2008) observed that though working memory abilities in patients MCI were lower than healthy aged controls for positive and neutral stimuli on average, patients with MCI performed equally than control on negative stimuli, and remembered negative stimuli better than positive or neutral stimuli. The association of an emotional content (and specially a negative one) to a stimulus may thus help patients with MCI to compensate for the disease-induced memory impairments. This proposal is coherent with previous results showing that memory in PwS was relatively preserved when task-demand was simplified or when the negative stimuli was salient. This *negativity bias* in patients with MCI may be due to the arousal value of negative stimuli as compared to positive or neutral (they were rated as such by the participants of this study).

In their review, Mammarella & Fairfield (2014) identified several studies that showed enhanced recall performances for negatively valenced words or stories in comparison to positive or neutral ones. Using an emotional version of the working memory Span Test, Mammarella et al. (2012) found that while healthy adults performed better on valenced words, people with AD did not show any emotional benefits. In contrast, Doninger & Bylsma (2007) observed that moderate AD patients shown larger interference effects in a Stroop task when using valenced words, suggesting that suppression of the emotional valence of items was more difficult, and so that

AD patient performance was influenced by the emotional content of the words. The ability to manipulate valenced information in working memory is a critical component of emotion regulation processes (Mammarella & Fairfield, 2014). For instance, Henry et al. (2009) compared the ability of AD patients and control participants to apply different emotion regulation strategies. Authors of this study asked participants to either suppress (hide their feelings as much as possible) or amplify (showing an exacerbation of the feelings, as much as possible) while watching a video clip. They observed that behavioral amplification of expressed emotion was disrupted in AD patients, while the ability to inhibit these expressions was relatively preserved. This suggests that AD patients might have impaired abilities to adaptively regulate their emotion, while these impairments might be modulated by working memory abilities (Mammarella & Fairfield, 2014).

4.2.1.2 A plausible neural mechanism

The above results supporting a beneficial (enhancement) effect of emotion, are usually explained in terms of a positive interaction between the amygdala and brain regions that involved during encoding and retrieval of emotional events. Specifically, memory for emotional content relies on a fronto-amygdala-hippocampal circuit with the amygdala modulating the activity of the prefrontal cortex (orbital and dorsolateral). For instance, Döhnel et al. (2008) have observed a greater activity in prefrontal and parietal regions during an *n-back* WM task with emotional faces associated with greater amygdala activation. It is likely that emotionally valenced material is remembered better partly because it captures a greater amount of perceptual and attentional resources (Mammarella & Fairfield, 2014).

4.2.2 Apathy and attentional biases

Apathy is characterised by reduced motivation, social disinterest, and emotional blunting in the absence of mood-related changes. Apathy and passivity are frequent features associated with AD (Moss & Albert, 1992; Gilley, 1993), though assessment of apathy might be problematic in dementia, due to the difficulty to separate a reduction in activity due to cognitive decline and a reduction of activity linked to a loss of interest (Gilley, 1993). Chau et al. (2016) compared the visual scanning behaviour of apathetic and non-apathetic AD patients in order to characterise the effect of apathy on attentional biases in the presence of emotional stimuli. They observed that apathy in PwD was associated to biased attention toward social stimuli compared with non-apathetic patients, and that the more severe apathy, the more severe attentional biases were. This finding was thought to reflect the lost of interest to social activities, and is similar to biases observed in young adults with clinical depression obtained using eye-tracking (e.g., Eizenman et al., 2003, Kellough et al., 2008). The measurement of attentional biases may thus provide a nonverbal, direct and objective approach to assessing symptoms of AD and may represent a reliable marker of behavioral changes (Chau et al., 2016).

4.2.3 Emotion recognition

It is generally admitted that the ability to recognize emotions is affected by cognitive impairments (such as working memory deficits), which can in turn lead to poorer interpersonal relationships (Virtanen et al., 2017). For instance, in their review of social cognition in neurodegenerative disorders, Elamin et al. (2012) showed that abnormalities in visual and/or auditory recognition of basic emotions are frequently reported in PwD, and that these impairments can lead to social exclusions and exacerbated cognitive deficits. A recent review (Waanders-Oude Elferink, Tilborg & Kessels, 2015) identified that AD patients overall performance in identifying emotion was lower than control in two thirds of the reviewed studies. Interestingly, a study of McCade et al. (2013) revealed that impaired emotion recognition in AD patients (of the amnestic subtype) extended beyond facial emotion expression but that AD patients were also less accurate in their ability to use non facial, peripheral cues (e.g., head and body posture, or hand gestures) to recognise the emotional content of scenes, compared with controls. They also observed that the burden of MCI caregivers was associated with worse recognition of anger in the MCI patients themselves. It should be noted that controlling for general decline in cognitive functions is not sufficient to explain the impairments observed in emotion discrimination in AD patients (i.e., emotion recognition deficits cannot be explained by impairments in general cognitive abilities only). Overall, these results suggest that AD patients have more severe impairments in emotion perception than MCI patients and than healthy older adults, while the recognition of negative emotions (anger, sadness, and fear) being more affected than the recognition of positive emotions (Waanders-Oude Elferink, Tilborg & Kessels, 2015).

4.3 Cognitive control training in dementia

Cognitive trainings typically involve guided practice on a set of standardized tasks designed to reflect certain cognitive processes such as attention, memory, or cognitive control (Bahar-Fuchs, Clare, & Woods, 2013). These trainings are aimed at improving specific cognitive processes and they are being used to improve cognitive functioning in various populations. Trainings aimed at improving cognitive control processes are currently being investigated as a potential tool in therapy for various disorders.

Deficits in cognitive control processes are commonly observed in a wide range of psychiatric disorders (Millan et al., 2012). Recently there has been a growing support for the idea that cognitive trainings aimed at improving cognitive control can lead to various positive outcomes in individuals suffering from psychiatric disorders. For example, research is starting to demonstrate that improving cognitive control through training in depressed and at-risk populations helps to reduce depressive symptoms (Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017; Siegle, Ghinassi, & Thase, 2007).

Current literature on cognitive trainings aimed at improving the cognitive and performance impairments in individuals with dementia provides only mixed evidence for the efficacy of these trainings (Bahar-Fuchs et al., 2013; Huntley, Gould, Liu, Smith, & Howard, 2015; Kallio, Öhman, Kautiainen, Hietanen, & Pitkälä, 2017). Importantly, different studies in this domain have used a wide range of cognitive trainings aimed at improving different cognitive processes. Also, these studies have used different outcome measures. Most of the studies have assessed the impact of the trainings via measuring the changes in cognitive functioning, while neglecting the measures of the potential functional improvements and changes in the quality of life.

To the best of our knowledge, there are currently no randomized control trials investigating the effects of cognitive control training in individuals with dementia. Although there is some evidence that cognitive training can be used in this context, no studies to date have specifically focused on improving cognitive control processes. Importantly, no studies have focused on influencing both emotion and cognitive control in individuals with dementia. As we have previously outlined in this report, the interaction between emotional processes and cognitive control is crucial for improving both cognitive and behavioral performance. In this context, there are interesting results suggesting that older adults with high motivational abilities (motivation regulation, decision regulation, activation regulation) are less likely to develop mild cognitive impairment and there is some evidence that they are less likely to develop Alzheimer's disease (Forstmeier et al., 2012). These results provide first evidence suggesting the possibly important role of motivational and emotional factors in developing dementia. Further research aimed at investigating the potential of cognitive control training as a treatment for dementia is needed. This research should be focused not only on targeting cognitive control processes, but also influencing emotional and motivational processes in order to achieve optimal results.

5 Measurement

Provided that our analyses of emotion and performance clearly suggest that emotional states influence performance and cognitive operations in PwD, we now briefly consider the measurement of emotional states within the PLAYTIME environment.

5.1 Measurement of emotional states

Intuitively, it appears that measurement of emotion should be straightforward; one simply needs to have an access to an internal state and to report it. However, measurement of discrete emotional states represents one of the major issues in affective science. A general, consensual, component model suggests that emotional responses begin with appraisal of the personal significance of an event, which in turn gives rise to an emotional response involving subjective experience, physiology, and behaviour (Mauss & Robinson, 2009).

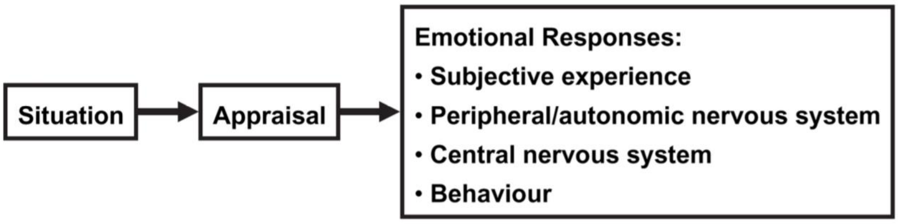

Figure 3. A consensual component model of emotional responding (from Mauss & Robinson, 2009).

In measuring affective states, several questionnaires and measures have been well investigated and we will prove a brief description of measures that could be considered suitable within the context of measuring affective states within PLAYTIME training.

Validated measures

The *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988) is a well-validated and brief scale that can be administered multiple times. The *Brief Mood Introspection Scale* (Mayer & Gaschke, 1988) is used to assess broad dimensions of valence arousal, and dominance, the *Profile of Mood States* (POMS; McNair, Lorr, & Droppleman, 1981) is a measure of emotion blends (e.g., anger-hostility, tension-anxiety) and other affective states (e.g., fatigue-inertia, confusion-bewilderment). **These measures are not suitable for frequent administration during a single task but could be interesting to include at the start or end of a training session. For such purposes, the PANAS as well as the POMS are the most well validated measures.**

A specific type of measure that is most suitable for repeated assessment of emotional states are Visual Analogue Scales (VAS). The Visual Analogue Scales have been introduced in 1923 by Max Freyd, for the purpose of achieving an unbiased judgment of psychological or behavioural characteristics (Rossi & Pourtois, 2012). A VAS is composed by a line whose limits are anchored by two terms representing the extremes of the addressed sensation, and by an introductory question (e.g., *How anxious are you right now?*).

Figure 4. A visual analogue scale evaluating state anxiety.

This form of self-rated measure can be used in combination with several adjectives or statements (e.g., tense, shaky, restless) in order to obtain a measure of these attributes, which is at the same time precise, accurate, sensitive to change, but also not very burdensome in completion for clinical populations. Additionally, due to its intrinsic simplicity, the VAS is a suitable instrument for repeated measurements (Rossi & Pourtois, 2012). The patient is usually requested to mark the point, along the line, that corresponds best to the perceived intensity of the feeling that is mentioned in the question. This procedure has proven to be also suitable for patients with motoric or linguistic problems, or in state of acute stress, where omissions in more burdensome inventories (such as STAI or POMS) are frequent in clinical practice. The most commonly used VAS for the measurement of state changes in anxiety is the so-called VAS-A, composed by one single item proposing the question ''How anxious do you feel right now?'' followed by a line delimited by two anchors ''Not anxious at all'' on one side and ''As anxious as I could be'' on the other side (Rossi & Pourtois, 2012). In the context of PwD the VAS can be further simplified by adding schematic faces as anchors (smiley vs. frowning faces).

5.2 Measurement of cognitive performance

The armamentarium of the psychologist to evaluate cognitive performance ranges from the use of neuropsychological tests (e.g., the WCST, the Tower of London test) and computer-based cognitive tasks (e.g., antisaccade tasks, n-back tasks), to functional imaging (e.g., PET, IRMf) and physiological measures (e.g., EEG, ERP, EMG). A recent study using eye tracking has shown that data issued from eye tracking paradigms can predict higher order visuospatial abilities, and that these data could be used as important markers during the diagnostic phase. In cognitive psychology, eye tracking has frequently been used to study higher order cognitive functions. However, few studies in the field of dementia have utilized this potential to date. Crutcher et al. (2009), and Richmond, Sowerby, Colombo, & Hayne (2004) used a visual paired-comparison task and showed that eye movement metrics, such as number of fixations and fixation duration, can be indicative of short-term memory difficulties in a group of patients with mild cognitive impairment (MCI) as compared to age-matched controls.

A key challenge for the measurement of cognitive performance is to distinguish general performance deficits (observed through reaction times and accuracy) from more specific cognitive operations such as conflict resolution in a stroop task (based on the subtraction of congruent from incongruent trials). The latter approach requires a sufficiently large number of observations per trial type, which can be problematic in PwD because of the time investment needed. Below we briefly describe some of the key considerations within the general vs. specific approach.

5.2.1 Measuring global cognition

Bossers et al. (2012) performed a systematic review of the tools used to assess overall cognition, executive functioning, memory and physical activities in PwD. They showed excellent reliability and validity of the MMSE, the ADAS-cog and the SIB to evaluate overall cognition. However, sensitivity to change of these three tests was relatively low. With regard to sensitivity other neuropsychological tests have been proposed to be more sensitive and easy-to-administered such as the MOCA or the Freund Clock-drawing task. It is noteworthy that this type of tasks does not lend themselves well for repeated administration in a short period of time.

In the context of the PLAYTIME environment, general performance outcomes that an be calculated fairly straightforward are response times and accuracy during specific tasks (that tap into different cognitive operations). This could provide an initial idea about cognitive performance that can be easily assessed. One can analyse whether there is improvement on these dependent variables in function of amount of practice. Moreover, these variables can be related to mood and motivation.

5.2.2 Examining executive functioning

Recommended measures for the assessment of executive functioning in PwD are the Verbal Fluency Test Category, the Clock Drawing Test, the Verbal Fluency Test Letters and the Trail Making Test-B (Bossers et al. (2012). The Digit Span Forward, the Digit Span Backward and the Trail Making Test-A are also recommended to assess attention, because of their frequent use in high-quality studies.

Global Functioning	**Executive Functioning**	**Memory**	**Attention**
SIB	Verbal Fluency Test Category	Visual Reproduction Test	Digit Span Forward
MMSE	Clock Drawing Test	Eight Word Test	Digit Span Backward
ADAS-cog	Verbal Fluency Test Letters	Logical Memory Test	Trail Making Test-A
Rapid evaluation of Cognitive Functioning	Trail Making Test-B		

Table 2. Recommendations of global and specific neuropsychological tests (from Bossers et al., 2012).

Instead of generic ways to examine stable neuropsychological deficits, other tasks can also prove useful to evaluate and train cognitive control, including the Stroop task (MacLeod, 1991), the Simon task (Hommel, 2011), the Flanker task (Eriksen & Eriksen, 1974; Mullane et al., 2009), antisaccade tasks (Luna 2009, Munoz & Everling 2004), delay-of-gratification tasks (Kochanska et al. 2001, Sethi et al. 2000), go/no-go tasks (Cragg & Nation 2008), and stop-signal tasks (Verbruggen & Logan 2008). Each of these tasks can be relatively easily implemented in a gamified manner. One important aspect in integrating these tasks within PLAYTIME is that they require computing specific scores that are dependent on reaction times and/or accuracy. Especially dependent variables based on reaction times can prove tricky since (a) sufficient numbers of trials need to be included to be able to compute a stable score; (b) large variability and high error rates can be expected in PwD which could comprise calculating specific scores in a reliable fashion.

In conclusion, there is a host of different options to assess cognitive performance where neuropsychological tests can be interesting to administer before and after an extended period of training. General as well as specific cognitive performance variables can be assessed online, during training. Here a key consideration will be an examination of which variables can be computed in a reliable manner.

6 Conclusions and Outlook

Based on our brief review of the current literature on emotion and performance in general and in PwD, the following conclusions can be made with regard to the assessment and training of cognitive operations within PLAYTIME:

-There is strong heterogeneity in the impairments displayed by people with early-stage Dementia, where cognitive performance is more generally impaired in later stage Dementia. This suggests that specific assessment and targeted training seems most suitable for individuals with early stage Dementia.

-There are good theoretical and empirical reasons to include motivational and emotional aspects within the cognitive exercises of PLAYTIME due to several bidirectional links between emotions and performance:

> -Examination of emotions are key to understand which elements of the game encourage motivation and well-being which is of key importance to stimulate patients to continue practicing
>
> -Provided that specific impairment may be associated with specific emotional states that impact daily functioning of the patient and their caregivers, examination of the interplay between cognitive impairments and its influence on affective states can have diagnostic value. (i.e., how does the patient deal with making errors)
>
> -Current theories of cognitive control stress that affective states provide the impetus for allocating cognitive control. Examining the affective states that are associated with successful vs. less successful cognitive performance can provide useful information at the individual patient level.

-We have described some of the key measures of affective states that are suitable to be implemented and administered multiple times within PLAYTIME. POMS and PANAS could serve useful at the end and start of a training session. Visual analogue scales seem most appropriate to assess emotions after specific tasks within the training.

-At the level of cognitive performance, general and specific performance outcomes can be examined within PLAYTIME. Here general reaction times and accuracy are the most readily available dependent variables. Other, more specific, cognitive operations can also be examined but here several boundary conditions need to be respected (sufficient number of trials, enough correct responses), in order to be reliably used.

-There is emerging work that examined the effects of cognitive trainings in PwD. The effects of this type of training seem small to moderate. Literature examining whether training can improve executive functions is rather scarce, especially since this requires highly intensive training, which can be challenging in PwD. Here, the active use and training of executive functions seems most important to reduce a steep decline in these functions (rather than to restore executive functions). Adding affective information during training seems a fruitful yet largely unexplored avenue to increase interest in and potential effects of cognitive training.

7 Glossary

Notion	Description
Emotional primitive	The most basic and simple building blocks of emotion, including changes in core affect, physiology, and subjective conscious experience.
Cognitive control	Cognitive control is defined by a set of neural processes that allows interacting with our complex environment in a goal-directed manner.
Working Memory	Holding information in mind and mentally working with it.

Table 3. Glossary.

8 Abbreviations

Abbreviation	Description
PANAS	Positive And Negative Affect Scale
VAS	Visual Analogue Scale
MMSE	Mini Mental Status Examination
STAI	State Trait Anxiety Inventory
AD	Alzheimer’s disease
ADL	Activity of Daily Living
RT	Reaction Time
MCI	Mild Cognitive Impairment
WCST	Wisconsin Card Sorting Task
BA	Brodmann Area
PwD	People with Dementia
WM	Working Memory

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