Neuropsychologia 104 (2017) 157–167

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Should I trust you? Learning and memory of social interactions in dementia

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ARTICLE INFO

Keywords:
Alzheimer's disease
Frontotemporal dementia
Memory
Social cognition
Trust game
Financial exploitation

ABSTRACT

Social relevance has an enhancing effect on learning and subsequent memory retrieval. The ability to learn from and remember social interactions may impact on susceptibility to financial exploitation, which is elevated in individuals with dementia. The current study aimed to investigate learning and memory of social interactions, the relationship between performance and financial vulnerability and the neural substrates underpinning performance in 14 Alzheimer's disease (AD) and 20 behavioural-variant frontotemporal dementia (bvFTD) patients and 20 age-matched healthy controls. On a "trust game" task, participants invested virtual money with counterparts who acted either in a trustworthy or untrustworthy manner over repeated interactions. A non-social "lottery" condition was also included. Participants' learning of trust/distrust responses and subsequent memory for the counterparts and nature of the interactions was assessed. Carer-rated profiles of financial vulnerability were also collected. Relative to controls, both patient groups showed attenuated learning of trust/distrust responses, and lower overall memory for social interactions. Despite poor learning performance, both AD and bvFTD patients showed better memory of social compared to non-social interactions. Importantly, better memory for social interactions was associated with lower financial vulnerability in AD, but not bvFTD. Learning and memory of social interactions was associated with medial temporal and temporoparietal atrophy in AD, whereas a wider network of frontostriatal, insular, fusiform and medial temporal regions was implicated in bvFTD. Our findings suggest that although social relevance influences memory to an extent in both AD and bvFTD, this is associated with vulnerability to financial exploitation in AD only, and is underpinned by changes to different neural substrates. Theoretically, these findings provide novel insights into potential mechanisms that give rise to vulnerability in people with dementia, and open avenues for possible interventions.

1. Introduction

In everyday life, we draw upon memories of past social experiences to guide current or future social interactions. These include memories of the people with whom we have interacted, and whether these interactions led to socially rewarding outcomes, such as approval, acceptance and reciprocity (Fareri and Delgado, 2014). Converging evidence from neuroimaging studies in healthy adults implicates a network of frontostriatal and medial temporal lobe (MTL) regions, pointing to the involvement of both social reward processing and memory functions to support socially relevant memories (Delgado et al., 2005; Tsukiura and Cabeza, 2008; Vrtička et al., 2009). In healthy older adults, increased susceptibility to financial exploitation is associated with memory decline (James et al., 2014). Although such mistreatment is commonly reported across a range of neurodegenerative conditions, it is unclear whether financial vulnerability is related to impaired memory for social interactions in people with dementia.

Here, we focus on behavioural-variant frontotemporal dementia (bvFTD) and Alzheimer's disease (AD). Patients with bvFTD show progressive changes in personality and social interactions, with

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http://dx.doi.org/10.1016/j.neuropsychologia.2017.08.016
Received 26 May 2017; Received in revised form 10 August 2017; Accepted 10 August 2017
Available online 12 August 2017
0028-3932/

disturbance in emotion processing (Kumfor et al., 2013a), empathy (Dermody et al., 2016), Theory of Mind (Le Bouc et al., 2012), social reward processing and decision making (Grossman et al., 2010; Perry et al., 2015), compliance with social norms (O'Callaghan et al., 2016) and strategic social bargaining (Melloni et al., 2016). Of particular relevance, overly friendly or gullible behaviours are frequently reported in bvFTD (Pressman and Miller, 2014), suggesting distinct alterations in processing socially relevant information. Episodic memory impairments in bvFTD can be commensurate with those seen in AD (Hornberger et al., 2010; Pennington et al., 2011). Notably, in AD socio-emotional functions remain relatively intact, particularly during the mild-moderate stages of the disease (Bertoux, et al., 2015a; Shany-Ur and Rankin, 2011). The divergent patterns of social-emotional dysfunction in bvFTD and AD reflect underlying differences in brain regions that are affected in each syndrome, with selective vulnerability of frontostriatal and insular regions in bvFTD, versus MTL and parietal regions in AD (Landin-Romero et al., 2017; Seeley et al., 2007). Nevertheless, it remains unclear how this frontostriatal-insular versus MTL-parietal dissociation potentially disrupts learning and memory of social interactions in these syndromes.

The trust game, an experimental paradigm drawn from the neuroeconomics literature, offers a means of assessing learning and memory for social reciprocity (Johnson and Mislin, 2011; Tzieropoulos, 2013). Originally developed by Berg et al. (1995), the trust game involves an exchange where the participant may choose to transfer a sum of money to another player, who will either reciprocate or violate their trust. Over multiple rounds, participants typically learn whether to trust or distrust players based on their previous experience of social reciprocity (Anderhub et al., 2002; King-Casas et al., 2005). On subsequent memory tests, healthy adults show enhanced face recognition and source memory for the associated behaviours of trustworthy and untrustworthy players encountered during the trust game (Bell et al., 2010), in keeping with evidence which suggests a distinct memory advantage for socially relevant information (Cassidy and Gutchess, 2014; Mitchell et al., 2004; Rule et al., 2012).

The current study sought to assess learning and memory of trust behaviour in AD and bvFTD patients using a trust game paradigm. We hypothesised that the use of social reciprocity as a form of feedback would improve learning over trials in AD patients but not bvFTD patients, in line with the well-documented impairments in social and monetary reward processing in bvFTD (Melloni et al., 2016; Perry et al., 2015; Torralva et al., 2009). Secondly, we aimed to explore whether memory for social interactions would be differentially enhanced in AD and bvFTD. We hypothesised that in bvFTD, the capacity for social enhancement of memory may be reduced, whereas the relative preservation of social cognition in patients with AD may facilitate their memory of social interactions. While no previous research has explored social memory enhancement in these patient groups, evidence of successful emotional memory enhancement in AD, but not bvFTD, supports this prediction (Kumfor et al., 2013b; 2014). We anticipated that learning and memory of social interactions would correlate with atrophy in frontostriatal regions in bvFTD, reflecting the predominant social reward processing deficits in this patient group. In contrast, we expected that social learning and memory would correlate with the degeneration of predominantly MTL regions in AD, consistent with the primary deficit in memory mechanisms underpinning performance in this group. In addition, we aimed to examine the relationships between learning and memory for social interactions and day-to-day financial vulnerability in AD and bvFTD patients.

2. Materials and methods

2.1. Participants

Thirty-four dementia patients (bvFTD = 20; AD = 14) and 20 age-matched healthy controls were recruited through FRONTIER at Neuroscience Research Australia, Sydney. All bvFTD and AD patients fulfilled clinical diagnostic criteria for probable bvFTD (Rascovsky et al., 2011) or probable AD (McKhann et al., 2011), respectively. Disease duration was estimated as the number of years elapsed since the reported onset of symptoms. The Frontotemporal Dementia Rating Scale (FRS; Mioshi et al., 2010) and Clinical Dementia Rating Scale (CDR; Morris, 1997) were used to determine disease severity in bvFTD and AD patients. All participants underwent general cognitive screening using the Addenbrooke's Cognitive Examination-III (ACE-III; Hsieh et al., 2013) to determine their overall level of cognitive functioning. Age-matched healthy controls were recruited from the FRONTIER research volunteer panel and scored > 88 on the ACE-III (Hsieh et al., 2013).

All participants provided written informed consent and this study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Human Research Ethics Committee of the South Eastern Sydney Local Health District and the University of New South Wales.

2.2. Background neuropsychology

All participants underwent a comprehensive neuropsychological assessment, including measures of attention (Castel et al., 2009, 2008), psychomotor speed (Trail Making Test (TMT), A time; Reitan and Wolfson, 1985), working memory (Digit Span Backward, total score; Wechsler, 1997) and cognitive flexibility (TMT, B – A time; Reitan and Wolfson, 1985). Verbal episodic memory (learning, recall and recognition) was assessed using the Rey Auditory Verbal Learning Test (RAVLT, sum of Trials 1–5, 30-min recall score and corrected recognition (hits – false positives) score; Schmidt, 1996) and short-term visuospatial recall was assessed using the Rey Complex Figure Test (RCFT, 3-min recall score; Rey, 1941).

2.3. Assessment of social vulnerability

The Social Vulnerability Scale (SVS; Pinsker et al., 2011) is a 15-item informant-rated questionnaire used to measure vulnerability to financial exploitation in older adults. The SVS comprises two subscales: credulity, the propensity to believe things that are unproven or unlikely to be true; and gullibility, the tendency to act upon these beliefs, usually in relation to outcomes of a financial nature. Each item is rated on a 5-point Likert scale, ranging from 0 (never) to 4 (always), with higher scores indicative of greater vulnerability. The SVS was completed by a relevant informant and was available for 16 bvFTD, 10 AD patients and 16 controls.

2.4. Trust game memory task

2.4.1. Stimuli and materials

To serve as trust game partners, images of 24 individuals (12 males, 12 females, age range 20–30 years) showing neutral facial expressions were selected from the Karolinska Directed Emotional Faces (KDEF) set (Lundqvist et al., 1998). Twelve faces were randomly allocated as target stimuli, with four faces (two males, two females) in each learning condition (trustworthy, untrustworthy, lottery). The remaining 12 faces were presented as distractor stimuli during the face recognition memory test. Stimuli assigned per condition were counterbalanced across participants.

2.4.2. Practice phase

The trust game payoff structure and procedures for the learning and test phases are illustrated in Fig. 1. Following presentation of instructions, participants were shown examples of payoff outcomes for each possible response combination on the trust game (you 'keep', partner 'shares'; you 'keep', partner 'steals'; you 'invest', partner 'shares'; you 'invest', partner 'steals'). Participants only proceeded to the learning