Social Cognition in Frontotemporal Dementia, Motor Neurone Disease, and Alzheimer's Disease

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Abstract

The orbitofrontal cortex and ventromedial prefrontal cortex have been implicated in many aspects of social cognition, and conditions that affect these regions are thereby accompanied by deficits in interpersonal behaviour. In order to assess social cognition across a number of neurodegenerative diseases, a test battery and two questionnaires were administered to frontal variant frontotemporal dementia (fvFTD), motor neurone disease (MND), Alzheimer`s disease, and healthy control participant groups. This included the newly developed Social Rule Break Cartoons task, which is a visually presented test tapping several aspects of social cognition. An exercise-smoking Implicit Association Test (IAT) and sweets or alcohol-healthy food IAT were also administered to investigate whether an inability to automatically access associated social knowledge may underlie some of the behavioural alterations seen in fvFTD, and increased appetite, sweet food preference, and drinking and smoking in particular. The FTD patient group was found to score significantly lower than the MND and control groups on faux pas detection and theory of ming questions on the Faux Pas Test, as expected. Their scores on social rule knowledge questions of the Social Rule Break Cartoons task also tended towards being significantly lower, and they demonstrated overall behaviour changes on the family-rated Frontal Systems Behavior Scale. This pointed towards a social cognition deficit in the FTD group, possibly seated in social knowledge impairments. No other significant differences were found across patient groups on the social cognition tests or the IATs, though individual patient performance fell in line with previous findings in terms of neural substrates, behavioural manifestations, and disease progression. Future studies including larger patient groups may provide further insight into the specificity and sensitivity of the Social Rule Break Cartoons task, and allow for a pattern in IAT performance to emerge.

Social Cognition in Frontotemporal Dementia, Motor Neurone Disease, and Alzheimer's Disease

Introduction

Social cognition is a crucial component of daily life, enabling humans to behave appropriately in individual and group interactions, and as members of society as a whole. The orbitofrontal cortex (OFC) and ventromedial prefrontal cortex (VMPFC) have been implicated in many aspects of social cognition. For example, damage to these regions has been found to result in a loss of theory of mind (ToM), empathy, and insight, altered personality, and disinhibited behaviour (Lund & Manchester Groups, 1994). Conditions that affect the OFC and/or the VMPFC are thereby accompanied by deficits in interpersonal behaviour. Accordingly, this study focuses on the degree to which social cognition is affected in different neurodegenerative diseases. Evidence for the role of the VMPFC and OFC in social cognition will be presented first, drawing from behavioural, neuroimaging, and lesion studies. Overviews of what is currently known about social cognition in the frontal variant of frontotemporal dementia (fvFTD), motor neurone disease (MND), and Alzheimer's disease (AD) will follow. The possibility that a new Social Rule Break (SRB) Cartoons task and the Implicit Association Test (IAT) may assist in the detection of deficits underlying impairments in social behaviour, and thereby contribute to differential diagnoses of these conditions, will then be explored. Finally, aims and predictions of the present investigation are presented.

Social Cognition and the Orbitofrontal and Ventromedial Prefrontal Cortex

Within the prefrontal cortex (PFC), the VMPFC and OFC are generally associated with social cognition and affect, whereas the dorsolateral PFC (DLPFC) is crucial for executive functioning (Lamar & Resnick, 2004). The VMPFC and OFC are often used interchangeably in the clinical literature, though they are not identical. The ventral surface of the PFC constitutes the OFC, whereas the VMPFC generally comprises the lower segment of the medial wall of the frontal lobe, overlapping the medial OFC (Zald & Andreotti, 2010). Due to this partial overlap, pathologies affecting one of these regions often affect the other, making OFC and VMPFC damage difficult to dissociate (Zald & Andreotti, 2010). The OFC has connections with the hippocampus, amygdala, and visual association areas, suggesting that it may act as an integration centre for information about memory, emotion, and the environment, to govern social cognition (Wood, 2003). For this particular study, within the

realm of social cognition, ToM, which refers to the ability to infer other people's mental states (Premack & Woodruff, 1978), and emotion recognition, are of particular concern. Behavioural manifestations including apathy, disinhibition, and lack of empathy, and the role of implicit cognition in the form of attitudes and stereotypes are also of interest.

The most famous case of personality and behavioural alterations following PFC injury is probably that of Phineas Gage. He had a metal rod pass through his PFC, likely damaging the VMPFC bilaterally and generally sparing the DLPFC (Damasio, Grabowski, Randall, Galaburda, & Damasio, 1994), resulting in impulsiveness, inattention, and generally socially inappropriate behaviour (Harlow, 1868). Similarly, patient EVR had his orbital and lower mesial frontal cortices removed to excise a tumour (Eslinger & Damasio, 1985). Prior to the operation he was a married, successful businessman, and after he divorced his wife, engaged in risky business, and could not maintain a job. Notably, despite these deficits, his level of intelligence remained high, and he performed normally on most formal neuropsychological assessments (Eslinger & Damasio, 1985).

An abundance of subsequent studies focusing on VMPFC and OFC lesion patients have reported similar behavioural outcomes. For example, an investigation of VMPFC lesion, other prefrontal lesion, and non-prefrontal lesion patients using informant ratings of personality change revealed a syndrome of acquired behavioural disturbances specific to the VMPFC lesion patients (Barrash, Tranel, & Anderson, 2000). They were characterised by indecisiveness, lack of insight, inappropriate emotional responses, impaired decision-making, and social misconduct (Barrash et al., 2000). Also, during the Vietnam Head Injury Study (Grafman et al., 1996), army veterans with VMPFC injuries were found to have significantly higher self- and family-reported levels of aggression and violent behaviour, as compared to patients with lesions in other brain areas and controls (Grafman et al., 1996). This provides further evidence for a disposition towards inappropriate and disinhibited social behaviour following VMPFC injury. As well, OFC lesion patients, as compared to DLPFC lesion patients, non-frontal lesion patients, and controls, have been found to have severely and specifically low empathy scores according to self- and significant other-reports (Grattan, Bloomer, Archambault, & Eslinger, 1994).

Neuropsychological tests designed to evaluate social cognition have uncovered specific deficits in ToM and emotion recognition that may underlie these alterations in social behaviour.

ToM and the OFC and VMPFC. ToM is crucial in social interactions because it allows us to predict and reason about other people's behaviour, and respond to their intentions, beliefs, and knowledge, instead of reacting merely to their actions (Premack & Woodruff, 1978). Damage to the VMPFC and/or OFC has been found to result in ToM deficits (Wood, 2003). For example, it has been shown using single photon emission computerised tomography (SPECT) in healthy adults that there is increased blood flow in the right OFC during recognition of mental state terms, proposed to be a component process underlying ToM (Baron-Cohen et al., 1994). Shamay-Tsoory et al. (2009) also showed that VMPFC lesion patients with deficits in cognitive empathy demonstrate impaired ToM on a second-order false belief task. As well, bilateral OFC lesion patients have been found to have difficulty with faux pas recognition in the Faux Pas Test, which is a more advanced verbal test of ToM, as compared to DLPFC lesion patients and normal controls (Stone, Baron-Cohen, & Knight, 1998). Similarly, patients with VMPFC damage have shown deficits in faux pas detection and understanding ironic meaning as compared to DLPFC and posterior lesion patients, despite performing normally on a second-order false belief task (Shamay-Tsoory, Tomer, Berger, Goldsher, & Aharon-Peretz, 2005). Lastly, a functional magnetic resonance imaging (fMRI) study done on healthy adults revealed increased activity in the medial PFC when participants internally answered questions about ToM passages or cartoons presented to them as compared to non-ToM stories or cartoons (Gallagher et al., 2000).

Emotion identification and the OFC and VMPFC. Also a critical component in interpersonal engagements, emotion recognition is often impaired in patients with VMPFC and/or OFC damage. Particularly, patient JS suffered trauma to the right frontal region including the OFC, resulting in aberrant behaviour and specific deficits in the recognition of facial expressions of anger and disgust (Blair & Cipolotti, 2000). Patients with ventral PFC lesions with confirmed socially improper behaviour have also been shown to perform significantly worse than patients with non-ventral damage and healthy controls on a test of emotional expression recognition (Hornak, Rolls, & Wade, 1996). More recently, Hornak et al. (2003) found that patients with bilateral OFC lesions, but not DLPFC lesions, had altered subjective emotional state and impaired social behaviour, though only some showed deficits

in emotional expression identification. The role of the VMPFC in emotion recognition has been further bolstered by another discovery that VMPFC lesion patients were impaired on an emotion identification task as compared to patients with other PFC lesions and normal controls (Heberlein, Padon, Gillihan, Farah, & Fellows, 2008). Though there are more frequently impairments in recognising negative emotions following VMPFC and/or OFC damage (Zald & Andreotti, 2010), in this case there was heightened confusion for all six of the emotions included (Heberlein et al., 2008). Finally, patients with VMPFC damage have shown a deficit in their ability to interpret nonverbal emotional expression on the Test of Social Intelligence, as compared to patients with DLPFC lesions and healthy controls (Mah, Arnold, & Grafman, 2005).

Implicit cognition and the OFC and VMPFC. The VMPFC has been implicated in implicit social cognition as well, referring to cognitive processes that are not under conscious control or awareness, related to stereotypes and attitudes (Greenwald & Banaji, 1995). Loss of these implicit associations may be responsible for some of the social misconduct exhibited by VMPFC and OFC lesion patients (Milne & Grafman, 2001). Increased recruitment of VMPFC areas has been observed in adults while learning associative and contextual information during an implicit learning task using positron emission tomography (PET; Peigneux et al., 1999). As well, impaired implicit cognition in comparison to healthy controls has been shown in patient LR, who suffered extensive PFC damage, including the VMPFC bilaterally, due to head injury (Barker, Andrade, & Romanowski, 2004). Further, Milne and Grafman (2001) used a modified version of the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) to evaluate the degree to which participants associated stereotypical attributes of weakness and strength (e.g., interdependent versus self-sufficient) with female and male names. A significantly lower association between the stereotypical attributes and the congruent gender concepts was demonstrated in patients with VMPFC lesions as compared to patients with DLPFC lesions and healthy controls, who both showed strong associations (Milne & Grafman, 2001). The fact that there were no differences between groups on explicit measures of stereotypical attributes related to gender suggests that VMPFC lesion patients had a specific deficit in accessing this associated stereotypic social knowledge automatically (Milne & Grafman, 2001).

Thus, the VMPFC and OFC have been shown to play a significant role in social cognition. It follows that individuals with conditions targeting this region of the brain will manifest deficits in the same aspects of social cognition, and evidence exists to support this.

Social Cognition in Neurodegenerative Diseases

Neurodegenerative diseases are characterised by deterioration of particular brain areas, resulting in different symptoms. The degree to which aspects of social cognition are affected in fvFTD, MND, and AD are considered.

Social cognition in frontal variant frontotemporal dementia. Changes in personality and behaviour, such as disinhibition and impulsivity, loss of insight, emotional blunting, decreased social awareness, and reduced empathy, are initially apparent in fvFTD (Neary et al., 1998). Loss of volition, stereotyped behaviours, distractibility, and poor judgment are also often seen (The Lund and Manchester Groups, 1994), along with hyperorality and dietary changes, including sweet food preference and overeating (Neary et al., 1998). As well, executive deficits arise as the DLPFC is affected, including impaired set shifting, poor attention, and impaired organisational skills, planning, and sequencing (Gregory, Serra-Mestres, & Hodges, 1999). This may not always manifest initially, such that fvFTD patients often perform normally on traditional frontal executive neuropsychological tests early in the disease (Gregory et al., 1999). Based on these observations, it is thought that the OFC is initially and predominantly affected in fvFTD, and it is not until later in the disease that there is DLPFC involvement. This has been confirmed by Perry et al. (2006), who used MRI to show significant degeneration in the medial, orbitobasal, and dorsolateral prefrontal areas in fvFTD patients compared to healthy controls. Notably, in the intermediate atrophy group, only the OFC was significantly affected (Perry et al., 2006). Alterations in interpersonal behaviour seen early in affected individuals coincide well with this finding. Also, despite a lack of significant frontal degeneration, behavioural manifestations of fvFTD were also observed in the mild atrophy group (Perry et al., 2006).

Accordingly, fvFTD patients have been shown to perform similarly to VMPFC and OFC lesion patients on social cognition tests. In particular, fvFTD patients have shown impairments in ToM as compared to AD patients and healthy controls (Gregory et al., 2002). They performed poorly on first- and second-order false belief tests, on recognition of faux pas, and on the Reading the Mind in the Eyes (RME) task, which involves recognition of

complex emotions (Gregory et al., 2002). Conversely, AD patients were only impaired on the second-order false belief test, likely due to the high demand it puts on working memory (Gregory et al., 2002). In the fvFTD patients, greater impairment on the ToM tasks corresponded with the degree of VMPFC damage, and increased impairment on faux pas detection correlated with the level of behavioural and psychiatric disturbance (Gregory et al., 2002). These findings have been partially replicated in the form of deficits in performance on both the Faux Pas Test and RME in early/mild fvFTD patients in comparison to healthy controls (Torralva et al., 2007). Patients with fvFTD have also demonstrated impaired ToM on the Judgment of Preference task involving mental state attribution, in comparison to Huntington's disease patients and healthy controls (Snowden et al., 2003). The fvFTD patients tended to ignore the direction of eye-gaze, on which task performance is based, responding instead based on their personal preferences, perhaps due to an inability to attribute mental states that differ from their own to others (Snowden et al., 2003). Impaired performance on a cartoon test of ToM by fvFTD patients as compared to healthy controls provides further evidence for a ToM deficit (Lough et al., 2006). As well, empathy was shown to be deficient in these fvFTD patients according to carer-ratings of empathic concern and perspective taking (Lough et al., 2006).

A deficit in identifying emotions has also been demonstrated in fvFTD patients. For example, using a facial emotion processing task, Lough et al. (2006) found that fvFTD patients were especially impaired at recognising disgust and anger as compared to healthy controls. Similarly, fvFTD patients have been shown to be significantly impaired in recognising facial expressions of sadness, disgust, and anger in comparison to AD patients that performed at the same level as controls (Lavenu, Pasquier, Lebert, Petit, & Van der Linden, 1999). These findings were replicated by Keane, Calder, Hodges, & Young (2002). Lastly, a deficit in recognising disgust, anger, and fear has also been demonstrated on two facial emotion recognition tasks in fvFTD patients in comparison to AD patients and controls (Fernandez-Duque & Black, 2005).

Social cognition in motor neurone disease. MND is a progressive degenerative disease involving deterioration of the upper and/or lower motor neurons. Specifically, amyotrophic lateral sclerosis (ALS) refers to MND in which both the upper and lower motor neurons are lost (Talbot, 2002). Initially, weakness in one limb, or bulbar symptoms such as slurring of speech, are often present (Leigh & Ray-Chaudhuri, 1994). More diffuse effects on

the motor system follow, with muscle wasting and weakness sometimes superseding cramps and fasciculations (Leigh & Ray-Chaudhuri, 1994). Until recently, MND was believed to strictly affect the motor system, but the existence of frontal atrophy and cognitive deficits in some patients has now been established. For example, atrophy in ALS patients has been shown to progress from the frontal and anterior temporal lobes to the pre- and post-central gyri, and the floor of the midbrain in a longitudinal study using serial CT and MRI (Kato, Hayashi, & Yagashita, 1993). As well, decreased white matter volume in regions coinciding with fronto-temporal association fibres has been found using structural MRI in non-demented MND patients with impaired verbal fluency (VF; Abrahams et al., 2005a). Abnormalities in the frontal lobes have also been demonstrated in MND patients using functional imaging (Ludolph et al., 1992; Talbot et al., 1995). Particularly, Abrahams et al. (1996) used PET to show deficient activation of areas including the DLPFC and medial PFC during a VF paradigm in ALS patients with cognitive impairment as compared to unimpaired ALS patients and healthy controls. Accordingly, deficits in executive functioning are commonly identified in MND patients, especially on tasks of VF (Abrahams et al., 2000; Abrahams, Leigh, & Goldstein, 2005b).

In a subset of MND patients, frontal impairment reaches criteria for FTD, with behavioural alterations including apathy and disinhibition, along with executive dysfunction (Neary et al., 1990; Lomen-Hoerth, Anderson, & Miller, 2002; Strong et al., 2009). It has been suggested that FTD/MND and MND with pure motor symptoms may exist on a continuum (Talbot et al., 1995), though this is a matter of debate (Bak, 2010). The apparent association between MND and FTD suggests that deficits in social cognition may also be present in some MND patients, and evidence is accumulating in support of this. Particularly, Gibbons et al. (2007) found that MND patient performance ranged from normal to quite impaired on a ToM task involving the interpretation of cartoons and stories. A subset of patients that exhibited bulbar symptoms showed deficits (Gibbons et al., 2007). Notably, MND patient scores on the Wisconsin Card Sorting Task were associated with their ToM task performance, indicating that executive issues may account for the observed deficits (Gibbons et al., 2007). A recent study of non-demented ALS patients also revealed deficits in ToM compared to healthy controls on the Judgment of Preference task, and via correctly recognising fewer emotions on the Facial Expressions of Emotion Test (Girardi, MacPherson, & Abrahams, 2011). As well, the difference in the number of correct responses on RME made by the MND patients compared to healthy controls tended towards significance, and

increased apathy was apparent (Girardi et al., 2011). Deficits in facial emotion recognition had also previously been demonstrated in bulbar ALS patients as compared to healthy controls (Zimmerman, Eslinger, Simmons, & Barrett, 2007). Lastly, Meier, Charleston, and Tippett (2010) found non-demented ALS patients to be impaired on faux pas recognition, as well as VF and planning tasks, as compared to healthy controls. Of the ALS patients, 50% had significant behavioural impairment according to informant ratings, with frequent behavioural changes including apathy, stereotypy, altered eating behaviour, and disinhibition (Meier et al., 2010).

Social cognition in Alzheimer's disease. Episodic and semantic memory impairments characterise AD, followed by the degeneration of visuospatial and perceptual abilities, as well as attentional deficits as the disease progresses (Gregory & Hodges, 1996). It has been shown using MRI that gray matter loss starts in the temporal and limbic regions and spreads to the frontal and occipital cortices over time in AD patients (Thompson et al., 2003). This progressive deterioration was found to correlate with increasing cognitive dysfunction (Thompson et al., 2003). As expected based on initial episodic memory impairment, the hippocampus and entorhinal cortex are affected earliest and most severely (Janke et al., 2001). Executive functioning has been found to be less affected in early AD as compared to fvFTD patients (Lindau et al., 2000), though this declines with disease severity in both conditions (Bozeat, Gregory, Ralph, & Hodges, 2000). Similarly, personality and social behaviour are generally not significantly altered early on in the disease (Bozeat et al., 2000).

Correspondingly, aspects of social cognition are often relatively intact in early AD. For example, family-rated empathy scores have not been found to differ significantly between AD patients and normal controls (Rankin, Kramer, & Miller, 2005). AD patients have also been shown to perform at the level of healthy controls on the first-order false belief test, RME, and faux pas recognition, demonstrating intact ToM (Gregory et al., 2002). Predictably, however, they were impaired on the memory-based control questions included in the Faux Pas Test (Gregory et al., 2002). As mentioned, they also showed deficits on the second-order false belief task, though it has been suggested that working memory demands could account for this (Gregory et al., 2002). Similarly, poor performance on a second-order false belief task has also been demonstrated in a subset of AD patients with more severe impairments in naming, comprehension, and abstract thinking as compared to the subset of patients that performed within normal limits (Cuerva et al., 2001). In another investigation,

AD patients were shown to perform at the level of healthy controls on tasks where they had to recognise their own previously held false beliefs or recognise a false belief held by someone else (Zaitchik, Koff, Brownell, Winner, & Albert, 2004). However, they were impaired on a false belief task where the information was contained in a story and corresponding drawings, but on both 'mental state' and 'control' conditions. As such, it was proposed that cognitive deficits may underlie impaired performance on this task rather than ToM difficulties (Zaitchik et al., 2004). With regards to emotion recognition, Lavenu et al. (1999) found that AD patients had difficulty recognising facial expressions of fear and contempt in comparison to normal controls. However, a more recent study revealed no difference in recognition for any of the emotions between AD patients and healthy controls (Fernandez-Duque & Black, 2005).

New Tools for Social Cognition Deficit Detection and Differential Diagnoses

It has been demonstrated that imaging techniques are not necessarily able to detect structural or functional discrepancies despite the manifestation of behavioural deficits in fvFTD (Gregory et al., 1999; Peter et al., 2006). As well, standard neuropsychological tests can be insensitive to deficits in fvFTD in the earlier stages (Gregory et al., 1999). This suggests that behavioural measures are still more diagnostically promising than neuroimaging, though new ones may need to be developed.

Consequently, a new social cognition task called Social Rule Break (SRB) Cartoons has been devised by MacPherson and Abrahams (unpublished; Karwig, MacPherson, & Abrahams, 2009). It is unique in that it examines social rule knowledge, emotion recognition, and ToM all within the same test, as compared to most social cognition tests that tap only one or two of these aspects. This allows for a direct comparison of performance across these domains and may be useful in determining whether they can be differentially affected. For example, in a ToM study done by Lough et al. (2006), fvFTD patients were found to be impaired in comparison to healthy controls on a cartoon ToM test, but their knowledge of social rules was intact. Accordingly, SRB Cartoons may help to determine whether these aspects of social cognition are dissociable, such that patients could be impaired in one but not another. Parsing apart these deficits could be critical for treatment and coping strategies, and perhaps differential diagnoses. As well, verbal stories have greater working memory demands, whereas cartoons do not and may provide additional clues for interpretation beyond what the stories can (Lough et al., 2006). Thus, the use of a visual social cognition task as

opposed to a verbal one may be preferable for patients with memory and attentional impairments.

Another test that may be useful in dissociating FTD from other dementia variants is the IAT. This task has been used very little with patient populations, and not at all with FTD, MND, or AD patients. It is a test of implicit social cognition in which participants respond to congruent and incongruent target concept-attribute pairings (Greenwald et al., 1998). Typically, when highly associated concept-attribute pairings, such as 'exercise + pleasant', share a response key, reaction times are faster as compared to when less associated words, such as 'smoking + pleasant', share the same key (Greenwald et al., 1998). These automatic associations are thought to underlie stereotypes and implicit attitudes that govern aspects of social behaviour (Greenwald & Banaji, 1995). The presence of VMPFC/OFC damage and impaired social conduct in fvFTD patients (Perry et al., 2006), along with evidence for deficient automatic priming of stereotypic social knowledge in patients with VMPFC lesions (Milne & Grafman, 2001), suggests that an inability to automatically access associated social knowledge may underlie some of the deficits in interpersonal behaviour seen in fvFTD. In addition to changes in social conduct and personality which often differentiate fvFTD from other types of dementia, eating behaviour is often affected, including increased appetite and sweet food preference (Ikeda, Brown, Holland, Fukuhara, & Hodges, 2002). As well, Ikeda et al. (2002) found that fvFTD patients increase their smoking behaviour or take up smoking again significantly more than semantic dementia patients, and drink more alcohol compared to AD patients. Factor analysis applied to responses on a questionnaire evaluating neuropsychiatric changes in both FTD and AD patients showed that only lack of social awareness and stereotypic and altered eating behaviour reliably distinguished FTD patients from AD patients regardless of disease severity (Bozeat et al., 2000). Similarly, through regression analysis, Bathgate, Snowden, Varma, Blackshaw, & Neary (2001) found that 95% of FTD, AD, and cerebrovascular dementia patients were correctly classified based on eating, stereotyped, and emotional behaviours. Thus, it seems plausible that modified versions of the IAT might serve to detect impaired automatic priming of stereotypic social knowledge which may be responsible for altered eating and smoking behaviour in fvFTD. Further, this could assist in the differential diagnosis of FTD due to the uniqueness of these altered behaviours.

The Present Study

The inclusion of three different patient groups is a novel aspect of this study, allowing for a comprehensive comparison of how social cognition is differentially affected across several neurodegenerative conditions. In particular, this study is aimed at investigating social cognition through the use of a single task that taps multiple aspects of it, referring to SRB Cartoons. It is also being conducted to determine whether patients with fvFTD and a subset of MND patients will exhibit a deficit in automatic priming of social knowledge related to eating and drinking behaviours, as well as exercise and smoking. Discovering how SRB Cartoons and IAT results compare with performance on traditional experimental tests of social cognition is also of interest.

Based on the literature, it is predicted that performance of the FTD and a subset of the MND patients will be significantly impaired on the SRB Cartoons task. Deficits in ToM, emotional understanding, and social knowledge have been documented in these groups, but whether or not patients will be deficient in all these aspects or variably affected is of interest. ToM and emotional understanding results from the new SRB Cartoons task are predicted to coincide with those aspects from the Faux Pas Test. These same patients are expected to show a decreased response bias for more typically compatible concept and attribute pairs in the IATs, suggesting that their ability to access inherent associations, between exercise/healthy food and pleasantness, and sweets or alcohol/smoking and unpleasantness, is impaired. As well, the FTD patients and the MND subset are predicted to show a general level of impairment across the social cognition tests in comparison to both the AD patients and controls. These include the Facial Expressions of Emotion Test, where a deficit in negative emotion recognition may be especially apparent. On the Faux Pas Test, the FTD patients and the MND subset are predicted to show deficits in identifying faux pas and emotional understanding, whereas AD patients are expected to struggle with the control questions. It is expected that the FTD patients and the MND subgroup will be preferentially impaired on RME and the Judgment of Preference task as well.

Overall, the expectation is that the performance of the FTD patients, and a MND subset, will confirm a deficit in inferring the thoughts and feelings of others, emotion recognition, and social conduct. This is thought to be a result of early atrophy of the VMPFC and/or OFC. SRB Cartoons task results may provide evidence for differential deficits across aspects of social cognition in these patients. As well, a deficit in automatically accessing

social knowledge, as demonstrated by the IAT, may be helpful in distinguishing fvFTD, AD, and MND. This also may provide an explanation for changes in choices related to health and eating habits seen in FTD patients, along with their impaired social conduct.

Methods

Participants

A total of 20 participants were included in the study, including 4 patients in the FTD group (2 males and 2 females, mean 62.8 $\pm$ 3.5 years), 5 patients with MND (3 males and 2 females, mean 63.2 $\pm$ 6.6 years), 2 patients with early onset AD (1 male and 1 female, mean 66.0 $\pm$ 1.4 years), and 9 healthy controls (5 males and 4 females, mean 61.6 $\pm$ 7.0 years).

The FTD and AD patients were recruited through the Scottish Dementia Clinical Research Network. Two FTD patients were also recruited through Dr. Sharon Abrahams, who is a Clinical Neuropsychologist within the Lothian Clinical Neuropsychology Unit at the Royal Edinburgh Hospital, both of whom were classified as 'FTD Query'. MND patients were recruited through participation in a concurrent study within the Department of Psychology, University of Edinburgh. Control participants were selected from a Department of Psychology, University of Edinburgh volunteer panel.

None of the healthy volunteers had a history of neurological illness, stroke, or head injury, or alcohol or drug dependence. One was taking anti-depressants, but their performance did not noticeably differ from other controls. There was no significant difference in age between the FTD, MND, AD, and control groups, though there was a significant difference in years of education between them (FTD mean 13 $\pm$ 3.4; MND mean 11 $\pm$ 1.0; AD mean 14.5 $\pm$ 4.9; Control mean 16.6 $\pm$ 2.7; $\chi^2 = 10.05$, $p < 0.05$), with the MND group having significantly fewer than controls ($p < 0.05$). Written informed consent was obtained from all control participants, as well as from each patient and a significant other where applicable. Ethical approval was attained from both the NHS Lothian Research Ethics Committee and the University of Edinburgh Philosophy, Psychology and Language Sciences Research Ethics Committee.

Procedure

All participants underwent a test battery including background neuropsychological tests and questionnaires, social cognition tests, and the new experimental tasks, referring to SRB Cartoons and the two versions of the IAT. These were performed over one or two interviews depending on the capabilities of the participant, and took approximately four hours to complete. For patients, significant others also completed family versions of the questionnaires, where applicable.

Measures

Background neuropsychological tests and questionnaires. The Addenbrooke's Cognitive Examination - Revised (ACE-R) was administered as a general cognitive assessment, examining language, visuospatial skills, fluency, attention and orientation, and memory (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006). The Wechsler Test of Adult Reading (WTAR) was used to evaluate premorbid intellectual functioning (Wechsler, 2001). The Vocabulary and Similarities subtests of the Wechsler Abbreviated Scale of Intelligence (WASI) were also administered to assess Verbal IQ in terms of word knowledge, concept formation, and verbal reasoning (Wechsler, 1999). The Graded Naming Test (GNT) was used to evaluate language via object-naming (McKenna & Warrington, 1983). Visuospatial abilities, including spatial pattern detection and non-verbal problem solving, were examined using the Brixton Spatial Anticipation Test (Burgess & Shallice, 1997) and the Number Location and Cubes components of the Visual Object and Space Perception (VOSP) Battery (Warrington & James, 1991). As well, written verbal fluency (VF) for words beginning with S (5 minutes) and C (4 minutes, 4-letter words), and spoken VF for words beginning with P, R, and W (1 minute each) were administered, all of which are word generation tasks and executive measures (Abrahams et al., 2000). The Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001) and the Interpersonal Reactivity Index (IRI; Davis, 1980; Perry et al., 2001) questionnaires were also given to assess changes in behaviour, such as apathy, disinhibition, and executive dysfunction, and dispositional empathy, respectively. These questionnaires were also completed by the significant others of patients where possible.

Social cognition tests.

Faux Pas Test. Participants were read 18 of the original 20 social situation stories from the Faux Pas Test (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999; Stone et al., 2002) as modified by Gregory et al. (2002), including 9 ToM stories containing a social

faux pas and 9 control stories without a faux pas. A faux pas (FP) constituted an individual unintentionally making a comment that could be upsetting to someone else present. The stories were read aloud to the participant and a copy was presented to them to follow along with, reducing the working memory demand. After each story, participants were asked if anyone said something they shouldn't have said or something awkward, for the purposes of FP detection. If a FP was identified, the participants were then asked: 'Who said something they shouldn't have said or something awkward?', 'Why shouldn't he/she have said it or why was it awkward?', 'Why do you think he/she said it?', a question pertaining to whether the individual that committed the FP had done so intentionally, and how the person negatively affected by the FP felt. They were then asked two control questions to assess story comprehension. Alternatively, if a FP was not detected, participants were only asked the two control questions. An example of a faux pas story and control story are included in the Appendix. The Faux Pas Test includes both cognitive and affective components, as it requires an understanding that the FP was unintentionally committed by one individual and that it would be hurtful to another individual present.

For each FP story, one point was awarded for each question answered correctly, and for each control story, two points were awarded if the lack of a FP was correctly identified and one point was allotted for each of the control questions. Separate composite scores were calculated for FP detection and ToM questions (/45), including the first five questions asked, emotional understanding (/9), referring to the question about how someone felt, FP story control questions (/18), no FP detection (/18), referring to correctly identifying the lack of a FP, and control story control questions (/18).

Judgment of Preference task. The Judgment of Preference task (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Snowden et al., 2003) is a ToM task which includes both cognitive and affective aspects, and requires the participant to make mental state judgments based on eye-gaze and verbal indications. The current version was created by Dina van der Hulst based on a version developed by Shamay-Tsoory and Aharon-Peretz (2007) using stimuli from Girardi et al. (2011). Participants were presented with four pictures of objects from the same semantic category (e.g., vegetables or animals) positioned in the four corners of the computer screen. There were three different conditions, beginning with the pre-experimental condition (12 trials). Next came the experimental condition (96 trials; see Figure 1), which required mental inference and included first-order and second-

order ToM blocks. The control condition (84 trials; see Figure 2) came last, which involved making a choice based on physical attributes and also included first-order and second-order blocks.

Pre- and experimental conditions. Firstly, in the pre-experimental condition, participants were asked to indicate which picture was their favourite by touching it on the screen. The experimental condition followed. It began with the first-order ToM block, in which a cartoon face named 'Dina' appeared in the centre of the computer screen along with the four objects. The participant was either prompted with 'Which picture does Dina love?' (affective; 24 trials) or 'Which picture is Dina thinking of?' (cognitive; 24 trials) at the top of the screen. They were expected to respond based on the direction of Dina's eye-gaze and facial expression. The second half of both the affective trials and cognitive trials included a distractor, in the form of an arrow pointing to one of the incorrect objects. Following this, in the second-order ToM block, Dina remained in the centre, with the four pictures present in the screen corners, but four smaller cartoon faces were situated in between the pictures. The participant was either asked to indicate which smaller face loves the same picture that Dina loves (affective; 24 trials) or is thinking of the same picture that Dina is thinking of (cognitive; 24 trials). They were expected to respond based on the eye-gaze and facial expression of both Dina and the smaller faces. Again, the second half of both the cognitive and affective trials included a distractor. There were four versions of the task, such that the affective and cognitive sections were presented in different orders, and these were cross-balanced across the patient and control groups.

Control condition. In the first-order block of the control condition, four objects were located in the screen corners with Dina in the centre again, but participants were prompted with 'Which picture is Dina looking at?' at the top of the screen (24 trials). The second half of the trials contained a distractor pointing at an incorrect object. In the next section Dina was no longer in the centre of the screen, and participants had to indicate which of the four pictures Dina was close to (12 trials). The second-order block followed, with the four objects present in the screen corners, and the four smaller faces situated in between the pictures. Participants were asked to indicate which of the smaller faces was looking at the same picture Dina was looking at (24 trials). The second half of these trials included a distractor. Dina was then situated in the centre of the screen with a picture to her left that matched one of those present in one of the four corners. Participants were prompted to touch the smaller face that

had the same picture that Dina had (12 trials). In the final section a blank yellow circle was present in the centre, and there were also four blank yellow circles in the screen corners. A face appeared in one of the corner circles and participants had to touch that circle (12 trials). Control trials were included to determine whether or not participants were able to respond appropriately to eye-gaze, whether they were responding merely to eye-gaze direction without reading the sentence at the top of the screen, and to control for reaction time/motor problems in the absence of having to make a decision.

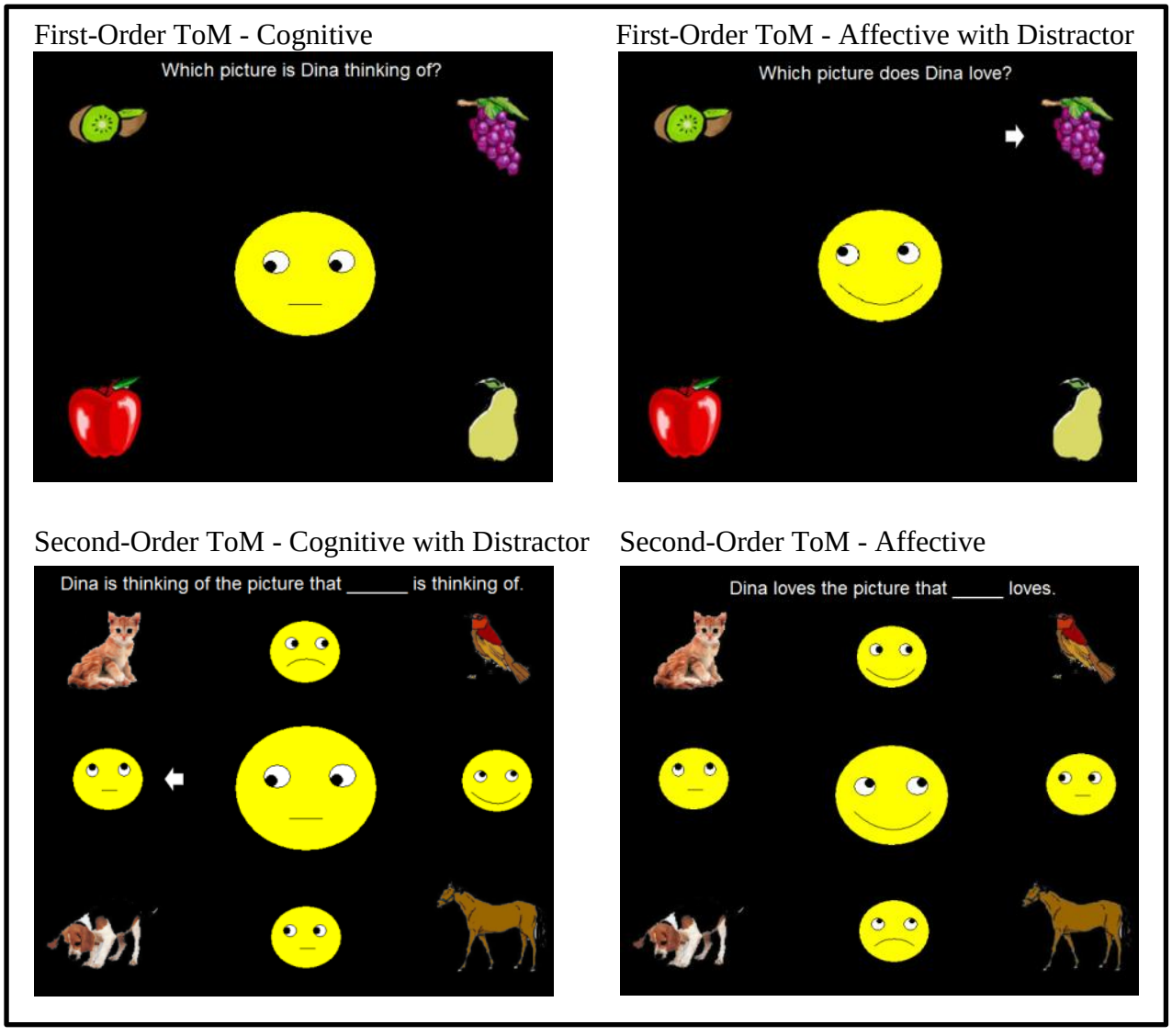
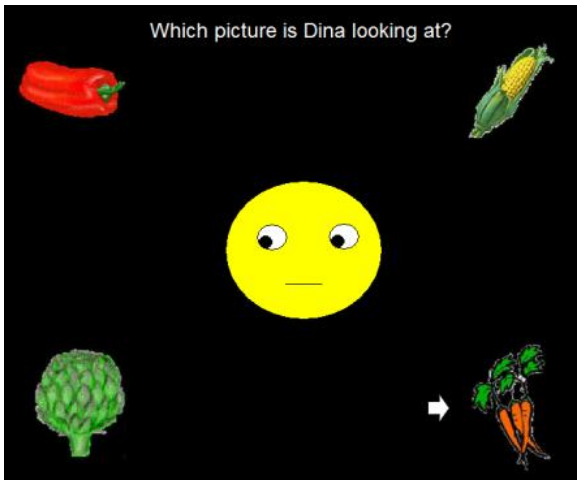
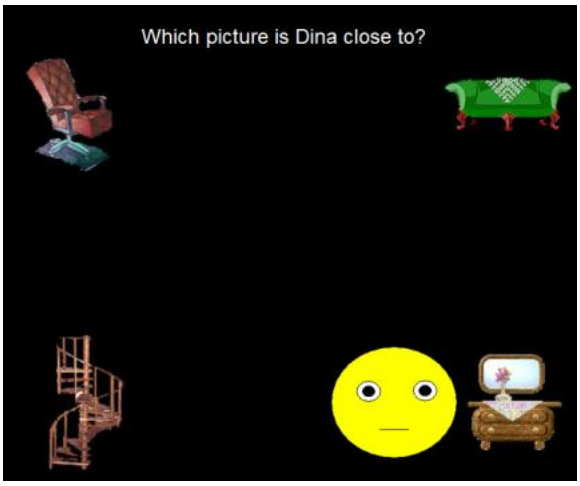


Figure 1. The experimental condition of the Judgment of Preference task. This figure depicts a sample of trials from the experimental condition.

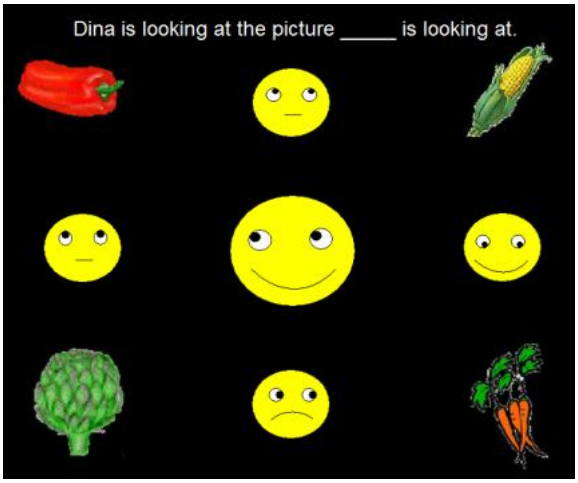
First-Order with Distractor



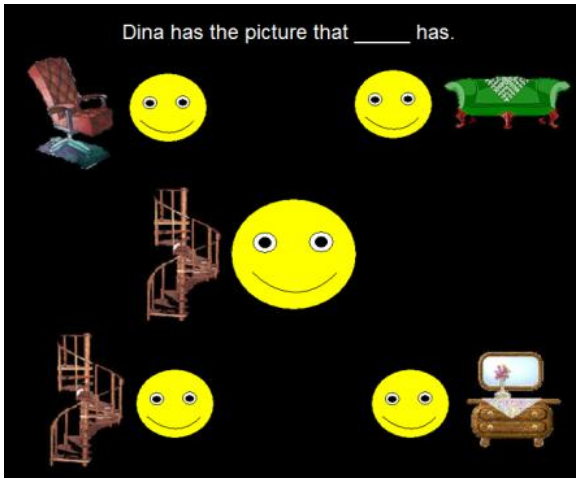
Close To



Second-Order



Same Picture



Face Touch

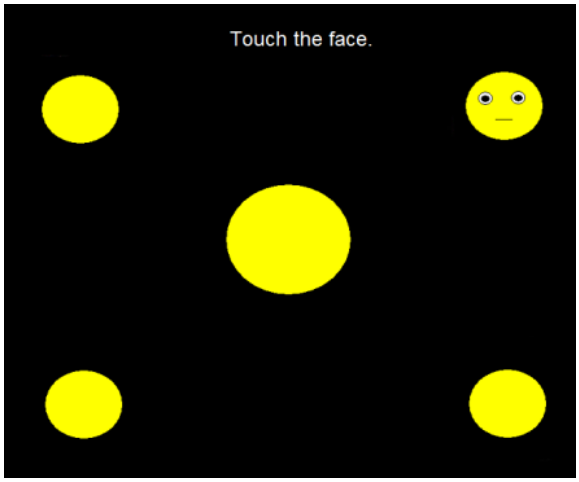


Figure 2. The control condition of the Judgment of Preference task. This figure depicts a sample of trials from the control condition.

Participants were scored based on the number of errors made overall, as well as the number of each type of error made. Task errors were classified as either 'favourite', if they chose their favourite picture based on their pre-experimental condition responses, 'arrow', if participants chose the object that the distractor arrow pointed to, 'arrow + favourite', if they chose a picture that was both indicated by the distractor arrow and their favourite, or 'other', if they chose a picture that did not fall into another error category.

Facial Expressions of Emotion Test. Participants were administered the Ekman 60 item subtest from the Facial Expressions of Emotion: Stimuli and Tests (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002), which is a test of emotional facial expression recognition. Black and white photographs of faces were presented in the centre of the computer screen and participants chose the adjective they felt best described the emotion being portrayed. The six options were shown below the photograph each time (see Figure 3 for example stimuli). The photograph disappeared after a delay, but the next one only appeared once the participant responded, either via pressing the screen or a corresponding key. For patients with limited mobility, they responded aloud and the corresponding emotion was pressed for them. The participants were administered a practice test including one trial for each emotion, and then the actual test, which consisted of 60 trials, including ten stimuli for each emotion. Participants were awarded one point for each correct response, and raw scores for each emotion were calculated, as well as a total score.

Reading the Mind in the Eyes. Using the stimuli from Baron-Cohen, Wheelwright, Hill, Raste, & Plumb (2001), a version of the task was created in Microsoft Office Powerpoint (Microsoft Corporation, 2010). It is a test of complex emotion and mental state recognition based purely on the eyes. Participants were presented with a display cross in the centre of the computer screen with four adjectives describing complex mental states below it. They were asked whether they knew the meaning of each of the words and if they did not a glossary was available that contained all the definitions. If they were familiar with the words, they pressed the spacebar to proceed, at which point a picture of the eye region of a face replaced the fixation cross above the same four words (see Figure 4). They were then prompted to voice aloud which of the four words they felt best described how the person was thinking or feeling. They pressed the spacebar to proceed to the next trial, of which there were 36 in total. The experimental trials were preceded by one practice trial. A gender control version of the test was also administered with the same stimuli. Participants merely had to

voice aloud whether they felt the face was male or female for each one. For both versions of the task, each correct response was allotted one point, giving a maximum score of 36.

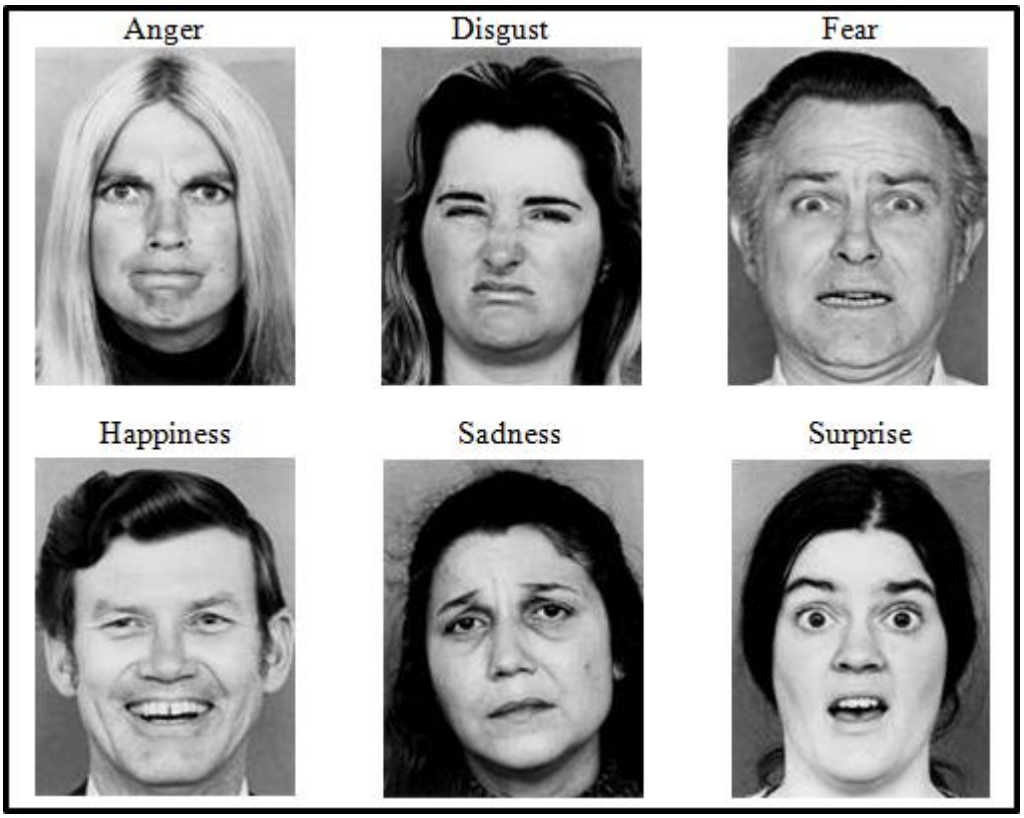


Figure 3. The Facial Expressions of Emotion Test. This figure presents sample stimuli for the six emotions from the Ekman 60 item subtest.

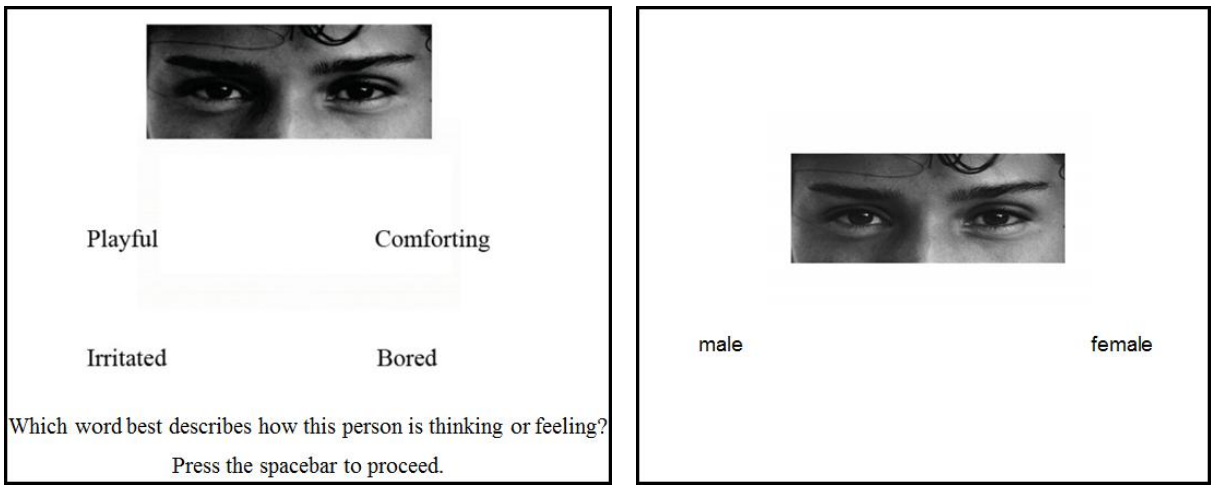
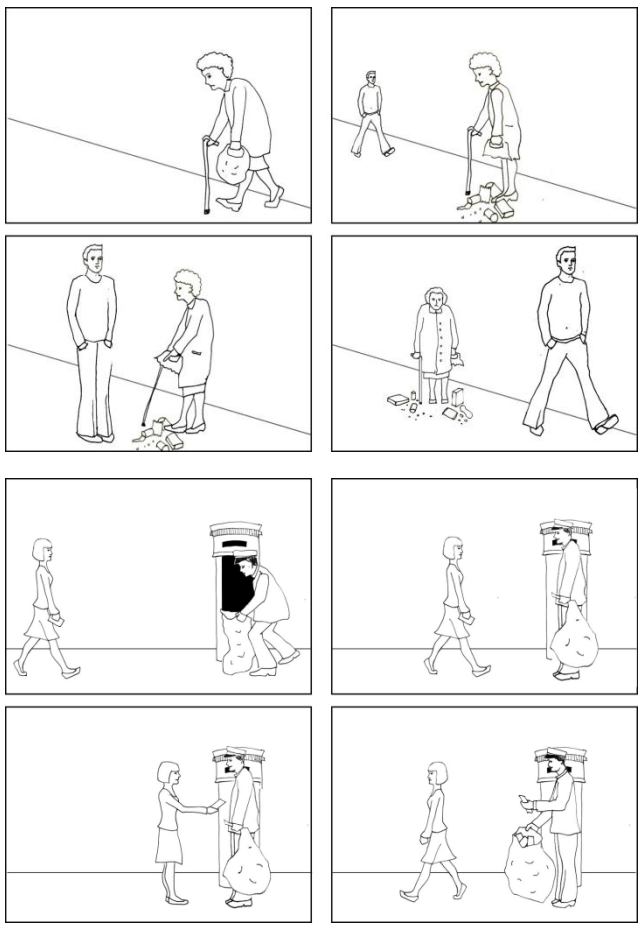


Figure 4. Reading the Mind in the Eyes. This figure illustrates sample trials from Reading the Mind in the Eyes test (left) and control (right) versions.

Experimental tests.

Social Rule Break Cartoons. This task was developed by MacPherson and Abrahams to investigate ToM, emotional understanding, and social rules, all within the same task (Karwig, MacPherson, & Abrahams, 2009). Participants were presented with ten sets of four pictures that tell a story on the computer screen, five of which contained a social rule violation and five of which did not. For each group of four pictures, participants were asked a general story comprehension question, a ToM question concerning what one character in the story thought another person wanted, an emotional understanding question regarding how someone felt at the end of the story, and a social rule knowledge question as to whether someone in the cartoon behaved as other people should behave (see Figure 5 for examples). For each question, participants responded verbally and were given no more than one prompt. They were allotted one point for a partial response or implicit reference and two points for a complete and explicit explanation. Composite scores were calculated by summing the raw scores for general comprehension, ToM, emotional understanding, and social rule knowledge.



Social Rule Violation Story

General: Can you tell me what's happening in this story, starting with the first picture and finishing with the last picture?
ToM: What does the man think that the woman wants?
Emotional understanding: How does the woman feel at the end of the story?
Social rule knowledge: Did the man in the cartoon behave as other people should behave?

Control Story

General: Can you tell me what's happening in this story, starting with the first picture and finishing with the last picture?
ToM: What did the man think that the woman wanted?
Emotional understanding: How does the woman feel at the end of the story?
Social rule knowledge: Did the man in the cartoon behave as other people should behave?

Figure 5. The Social Rule Break Cartoons task. This figure includes sample social rule violation and control stories, and the corresponding questions.

Implicit Association Tests (IATs). The IAT assesses implicit social cognition and was developed by Greenwald et al. (1998). Its efficacy depends on the assumption that it is easier for people to sort words when categories that are highly associated are placed together as compared to when paired categories are not associated. Based on this, two IATs were created from a template provided by Greenwald (2007) to measure the differential association of exercise and smoking, and sweets or alcohol and healthy food (target concept dimensions), with pleasant or unpleasant (attribute dimensions) words. The exercise and smoking stimuli were taken from Swanson, Rudman, and Greenwald (2001). The sweets or alcohol stimuli were generated by Wiers, van Woerden, Smulders, and de Jong (2002) and Swanson et al. (2001), and the healthy food stimuli were taken from Maison, Greenwald, and Bruin (2001) and Roefs and Jansen (2002). The pleasant and unpleasant attributes were selected from Greenwald et al. (1998). A list of the stimuli used in both tasks is included in the Appendix.

Participants were presented with stimulus words in the centre of the computer screen and required to sort them one at a time, as quickly and as accurately as possible, based on categories in the upper left and upper right corners of the screen, using the ‘d’ and ‘k’ keys respectively. If the participant responded correctly, the next stimulus word appeared, and if they responded incorrectly a red ‘X’ appeared and the correct key had to be pressed to proceed. The categories were either concept or attribute dimensions (e.g., exercise/smoking or pleasant/unpleasant), or a combination of the two where they were compatible (e.g., exercise+pleasant) or incompatible (e.g., smoking+unpleasant).

The tasks both consisted of seven blocks of trials (see Figure 6). The first block was for practice and involved categorising words based on the two target concepts (e.g., exercise and smoking). The second block was also for practice, but involved categorising words based on the attribute dimensions ‘pleasant’ and ‘unpleasant’. The third block was a practice run for combined categorisation, meaning that the words were sorted based on a concept plus an attribute dimension (e.g., exercise+pleasant/smoking+unpleasant). The fourth block was a critical block identical to the previous one. The fifth block was another practice round involving categorisation based on the concept dimensions, but with the response keys reversed from the first block assignments. The sixth block was a practice mixed categorisation round again, but the concept and attribute dimension pairings were swapped from the third and fourth blocks (e.g., exercise+unpleasant/smoking+pleasant). The last block

was identical to the sixth block, but consisted of the crucial trials for this combined categorisation. The order in which the combined categorisation blocks were presented to participants, referring to blocks 3 and 4, and 6 and 7, was counterbalanced.

Error rates and response latencies were recorded. A difference score, *D*, was calculated for each participant based on suggested guidelines from Grafman, Nosek, and Banaji (2003), who have shown that this measure is psychometrically sound. Trials with latencies greater than 10 000 ms were deleted. Essentially, mean latencies were calculated for each of blocks 3, 4, 6, and 7, and pooled standard deviations were calculated for blocks 3 and 6, and 4 and 7. The difference between mean latencies for incompatible and compatible combined practice blocks (3 and 6) and test blocks (4 and 7) were calculated. These differences were divided by the associated pooled standard deviation and then averaged to produce *D*. A greater *D* value suggests a stronger association between the compatible concept and attribute.

EXERCISE-SMOKING IAT					
Block	**1**	**2**	**3/4**	**5**	**6/7**
Task Description	Initial Target Concept Discrimination	Attribute Dimension Discrimination	Initial Combined Categorisation	Reversed Target Concept Discrimination	Reversed Combined Categorisation
Categories	• EXERCISE SMOKING •	• pleasant unpleasant •	• EXERCISE + pleasant SMOKING + unpleasant •	EXERCISE • • SMOKING	EXERCISE + unpleasant • • SMOKING + pleasant
Sample Stimuli	• JOGGING • SPORTS CIGARETTES • ASHTRAY •	• caress • love abuse • crash •	• SWIMMING • honour NICOTINE • filth •	WORKOUT • BIKING • • TOBACCO • CIGARS	AEROBICS • hatred • • LIGHTER • sunrise

SWEETS OR ALCOHOL-HEALTHY FOOD IAT					
Block	**1**	**2**	**3/4**	**5**	**6/7**
Task Description	Initial Target Concept Discrimination	Attribute Dimension Discrimination	Initial Combined Categorisation	Reversed Target Concept Discrimination	Reversed Combined Categorisation
Categories	• SWEETS OR ALCOHOL HEALTHY FOOD •	• pleasant unpleasant •	• SWEETS OR ALCOHOL + pleasant HEALTHY FOOD + unpleasant •	SWEETS OR ALCOHOL • • HEALTHY FOOD	SWEETS OR ALCOHOL + unpleasant • • HEALTHY FOOD + pleasant
Sample Stimuli	• CANDY • BEER LETTUCE • STRAWBERRIES •	• peace • cheer grief • tragedy •	• COKE • miracle FRUITS • pollute •	COOKIES • WHISKY • • YOGURT • RICE	CHOCOLATE • agony • • CHICKEN • pleasure

Figure 6. The Implicit Association Tests. This figure is a schematic representation of the IATs. The key response assigned to each category is indicated by the black dots in the 'Categories' row, where left corresponds to the 'd' key and right corresponds to the 'k' key. The dots in the 'Sample Stimuli' row denote the correct key response for each stimulus word.

Explicit Measures. Upon completion of both the IATs, participants were asked to fill out two paper and pencil questionnaires pertaining to the four target concepts in the tasks. Copies of both are included in the Appendix. The first was a Healthy Attitudes and Habits

Questionnaire developed for this investigation. It included feeling thermometers based on those used by Greenwald et al. (1998), for each of exercise, smoking, healthy food and sweets/alcohol. Participants had to indicate their level of warmth or coolness towards the given target concept from 0 to 100 by putting a mark in the appropriate place on a thermometer illustration. The thermometers were labeled every 10 degrees, and 0, 50, and 100 were denoted by the words 'cold or unfavourable', 'neutral', and 'warm or favourable', respectively. Difference scores were attained by subtracting the thermometer score for smoking from the exercise score, and the score for sweets/alcohol from the healthy food score. Higher scores indicated more positive attitudes toward exercise and healthy food (compared to smoking and sweets/alcohol).

For each of the target concepts, participants also filled in five semantic differential items. These were five-point scales anchored at either end by adjectives that were polar opposites, taken from Greenwald et al. (1998) and Swanson et al. (2001). Each item was rated on a scale from -2 (negative) to 2 (positive), and target concepts were scored by averaging the scores from the five items for each one. A difference score was calculated by subtracting the smoking score from the exercise score, and the sweets/alcohol score from the healthy food score, as per Greenwald et al. (1998). More positive attitudes toward exercise and healthy food are reflected by higher difference scores. Two groups of several statements adapted from Roefs and Jansen (2002), separated based on their pertinence to exercise and smoking or healthy food and sweets/alcohol, were also included in the questionnaire. Participants had to indicate the degree to which they agreed or disagreed with these statements on a scale of 1 (*totally agree*) to 7 (*totally disagree*).

The participants also filled out a questionnaire composed of select questions from the 2007 Health Survey for England (Craig & Shelton, 2009). This included queries about smoking, alcohol consumption, and eating habits from which qualitative information could be gained.

Statistical Analysis

R was used to perform the statistical analyses. The data were analysed in terms of group scores as well as individually. Group comparisons were made using nonparametric Kruskall-Wallis tests for three or more groups, and Mann-Whitney tests for two groups. If a significant difference was found using a Kruskall-Wallis test, *post hoc* pairwise comparisons

were done using a Mann-Whitney test with Bonferroni correction for multiple comparisons to determine which groups differed from one another. Correlational analyses were performed using Spearman's rank correlation coefficients. The scores from each patient were compared to the control means using single-case analysis software from Crawford & Garthwaite (2002), which performs a significance test for abnormality of an individual's score compared to the mean of the control sample on a given test. As well, Wilcoxon signed rank tests were used to compare group questionnaire scores from two different time-points.

Results

Background Neuropsychological Tests and Questionnaires

The means and standard deviations for the background neuropsychological test performance of the FTD, MND, and control groups are presented in Table 1. The AD group was excluded from group analyses due to insufficient recruitment. Individual patient data is presented in Table 2. Notably, some patients were unable to complete every task due to complexity and/or time, speech, or movement limitations.

There were no significant differences in Mini-Mental State Examination scores between the FTD, MND, and control groups. Single-case analysis was not possible due to the standard deviation of the control sample being zero, though two patients scored below 24, which is the standard cut-off score suggestive of cognitive dysfunction (Tombaugh & McIntyre, 1992). Three patients fell below the ACE-R cut-off score for dementia of 88, and two scored below the cut-score of 82 (Mioshi et al., 2006). There was also a main effect of group on WTAR scores, with the MND but not FTD patients performing significantly worse than controls. Single-case analyses revealed that all but two patient scores were significantly worse than control scores on this task. No significant difference was found between the groups in Verbal IQ, according to WASI scores, though one FTD patient and one MND patient scored significantly lower than the control group. The same pattern was seen in naming ability on the GNT, but the impaired FTD and MND patients differed. A significant group difference was found on the Brixton Spatial Anticipation Test, with the MND but not FTD patients performing significantly worse than controls. Only one FTD and two MND patients did not score significantly lower than the control sample on this test. The groups did not perform significantly differently on the VOSP Number Location and Cubes subtests,

though one FTD patient scored significantly lower than controls on both, and another on just Number Location. Lastly, there was no significant difference between the groups on written VF, though one AD patient performed significantly worse than controls. For spoken VF, there was a main effect of group on scores, with significant differences between the FTD and control groups, as well as the MND and control groups. All patients, aside from one FTD and one MND patient, had scores that differed significantly from the control sample.

Table 1

Comparison of frontal variant Frontotemporal Dementia (fvFTD), Motor Neurone Disease (MND), and Control Group Performance on Background Neuropsychological Tests

Domain	Test	fvFTD, Mean (SD)	MND, Mean (SD)	Controls, Mean (SD)	Kruskal-Wallis Chi-Squared	*p* and *Post Hoc* Comparisons
General Cognition	MMSE (/30)	25.3 (8.1)	29.8 (0.50)	30.0 (0.0)	2.95	0.23
	ACE-R (total score /100)	74.3 (18.7)	92.5 (3.7)	98.8 (0.97)	12.13	< 0.01 †§
Intellectual Functioning	WTAR (standard score)	99.3 (29.0)	103.2 (8.1)	119.33 (3.2)	9.57	< 0.01 §
	WASI Verbal IQ	118 (15.6)	110.7 (4.5)	118.11 (5.5)	2.75	0.25
Language	GNT (/30)	21 (7.9)	25 (5.1)	26.9 (2.5)	2.18	0.34
Visuospatial Skills	Brixton (scaled score /10)	2.67 (2.9)	3.60 (2.2)	7.25 (1.4)	9.23	< 0.01 §
	VOSP - Number Location (/10)	5.33 (4.5)	9.50 (1.0)	9.11 (1.1)	2.53	0.28
	VOSP - Cubes (/10)	6.67 (5.8)	9.75 (0.50)	9.56 (0.73)	0.287	0.87
Executive Functioning	written VF Index (z-score)	0.745 (1.7)	1.03 (0.33)	0.0033 (1.0)	2.64	0.27
	spoken VF Index (z-score)	7.01 (5.4)	2.95 (1.0)	0.0022 (1.0)	11.67	< 0.01 †§

Note. SD = standard deviation; MMSE = Mini-Mental State Examination; ACE-R = Addenbrooke's Cognitive Examination-Revised; WTAR = Wechsler Test of Adult Reading; WASI = Wechsler Abbreviated Scale of Intelligence; GNT = Graded Naming Test; Brixton = Brixton Spatial Anticipation Test; VOSP = Visual Object and Space Perception Battery; VF = Verbal Fluency. $p < 0.05$ is significant; § MND significantly different from controls; †§ FTD and MND significantly different from controls.

Table 2

Demographic Data and Comparison of Individual Patient Performance on Background Neuropsychological Tests

Patient	Age (years)	Years of Education	MMSE (/30)	ACE-R (/100)	WTAR	WASI Verbal IQ	GNT (/30)	Brixton (/10)	VOSP - Number Location (/10)	VOSP - Cubes (/10)	written VF Index	spoken VF Index
F001	64	11	16 ≠	53 ▪▫	66 ***	NA	12 ***	1 **	1 ***	0 ***	NA	12.61 ***
F002	59	11	30	82 ▪	113 *	107 *	24	6	10	10	1.92	6.57 ***
F016	67	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F017	61	18	30	88	119	129	27	1 **	5 **	10	-0.43	1.85
M008	54	12	30	95	115	106 *	28	6	10	10	1.26	2.4 *
M009	62	12	30	96	101 ***	NA	27	2 **	8	9	NA	1.58
M010	66	10	30	91	106 **	115	26	2 **	10	10	NA	2.83 *
M011	62	11	NA	NA	93 ***	NA	16 **	2 **	NA	NA	0.79	4.03 **
M012	72	10	29	88	101 ***	111	28	6	10	10	NA	3.9 **
A023	65	18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A025	67	11	21 ≠	51 ▪▫	NA	NA	NA	NA	NA	NA	10.35 ***	11.1 ***

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; MMSE = Mini-Mental State Examination; ACE-R = Addenbrooke's Cognitive Examination-Revised; WTAR = Wechsler Test of Adult Reading; WASI = Wechsler Abbreviated Scale of Intelligence; GNT = Graded Naming Test; Brixton = Brixton Spatial Anticipation Test; VOSP = Visual Object and Space Perception Battery; VF = Verbal Fluency; NA = data not available. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ≠ score < 24 (cognitive dysfunction cut-score); ▪ score < 88 (dementia cut-score - 94% sensitivity, 89% specificity); ▫ score < 82 (dementia cut-score - 84% sensitivity, 100% specificity).

FrSBe results were analysed based on total scores as well as the apathy, disinhibition, and executive dysfunction subscales. Comparisons of current self-ratings between the FTD, MND, and control groups revealed no significant differences in total or subscale scores. However, current family-rating total scores were found to be significantly higher in the FTD group compared to the MND group ($W = 12$, $p < 0.05$). As well, group tended towards having a significant effect on current family-ratings of both disinhibition ($W = 12$, $p = 0.057$) and executive dysfunction ($W = 12$, $p = 0.057$), with the FTD patients scoring higher than the MND patients on both subscales. No significant differences were found between premorbid and current self-ratings within each group, or premorbid and current family-ratings. Similarly, within-group premorbid self- and family-ratings were not found to differ significantly, nor were current self- and family-ratings. On an individual basis, standardised scores above 65 were interpreted as indicative of impairment on that scale, and scores between 60 and 64 were suggestive of borderline impairment (Grace & Malloy, 2001). Individual standardised self-rated and family-rated scores are presented in Tables 3 and 4,

respectively. Current self-ratings implied that one FTD and one MND patient were impaired on all subscales as well as overall, and two other MND patients had clinically abnormal apathy scores. Current family-ratings suggested that three FTD patients and one AD patient were impaired on all subscales as well as overall. Family scores also implied that three MND patients had clinically abnormal apathy levels. There were also some discrepancies between premorbid self- and family-ratings, providing patient insight information.

Table 3

Self-Rated Individual Patient Scores (Standardised) on the Frontal Systems Behavior Scale

	Premorbid				Current			
Participant	Apathy	Disinhibition	ED	Total	Apathy	Disinhibition	ED	Total
F001	NA	NA	NA	NA	NA	NA	NA	NA
F002	77	**68**	**86**	**86**	**93**	**78**	**100**	**99**
F016	NA	NA	NA	NA	NA	NA	NA	NA
F017	43	48	48	45	61 •	40	55	55
M008	53	42	47	47	**69**	47	47	54
M009	45	59	44	48	**75**	52	50	60 •
M010	37	50	40	40	43	39	39	38
M012	60 •	**65**	**65**	**66**	**76**	**70**	**65**	**74**
A025	NA	NA	NA	NA	NA	NA	NA	NA

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; ED = executive dysfunction; NA = data not available. Clinically abnormal scores (> 65) are in bold; • Borderline impairment.

Similarly, total scores, as well as scores for perspective taking, fantasy, empathic concern, and personal distress were calculated for the IRIs. No significant differences were found in current self-ratings between the FTD, MND, and control groups. Comparing current family-ratings for the FTD and MND groups did not yield a significant group effect either. As well, there were no significant differences between current and premorbid family-ratings within the FTD and MND groups, or within-group current self- and family-ratings. Individual standardised self- and family-rated scores are presented in Table 5. Comparisons of current patient self-rated scores with the control sample using single-case analyses demonstrated that one MND patient scored significantly higher on personal distress, and one MND patient had significantly lower self-reported total, perspective taking, and empathic concern scores. Individual comparisons using current family-ratings implied that all three FTD patients, as well as two other patients had significantly lower perspective taking abilities than controls.

As well, one FTD patient and one AD patient scored significantly lower on empathic concern, and three patients had significantly higher personal distress scores than the control sample. Lastly, individual comparisons using premorbid family-ratings revealed no significant differences from the control sample on any scales.

Table 4

Family-Rated Individual Patient Scores (Standardised) on the Frontal Systems Behavior Scale

	Premorbid				Current			
Participant	Apathy	Disinhibition	ED	Total	Apathy	Disinhibition	ED	Total
F001	60 •	**65**	57	61 •	**117**	**122**	**115**	**125**
F002	50	48	47	48	**105**	**92**	**107**	**108**
F016	61 •	43	62 •	58	**95**	**75**	**102**	**99**
F017	NA	NA	NA	NA	NA	NA	NA	NA
M008	58	36	46	46	**98**	38	57	64 •
M009	53	39	51	49	**83**	52	54	64 •
M010	48	42	50	47	48	42	50	47
M012	42	42	44	42	**66**	50	53	56
A025	56	46	49	50	**80**	**65**	**86**	**83**

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; ED = executive dysfunction; NA = data not available. Clinically abnormal scores (> 65) are in bold; • Borderline impairment.

Table 5

Self- and Family-Rated Individual Patient Scores on the Interpersonal Reactivity Index

	Current Self-Rating					Premorbid Family-Rating				Current Family Rating				
Participant	PT	FS	EC	PD	Total	FS	EC	PD	Total	PT	FS	EC	PD	Total
F001	NA	NA	NA	NA	NA	4	21	2	40	8 *	10	21	22 *	61
F002	15	11	20	14	60	12	22	6	53	8 *	14	2 ***	24 **	48
F016	NA	NA	NA	NA	NA	13	16	10	44	5 **	13	19	12	49
F017	23	14	25	15	77	NA	NA	NA	NA	NA	NA	NA	NA	NA
M008	18	16	27	19 *	80	9	21	13	59	19	10	24	16	69
M009	NA	NA	NA	NA	NA	16	19	12	56	7 **	17	20	20 *	64
M010	4 **	4	13 *	0	21 *	10	26	4	61	17	14	18	8	57
M012	21	14	24	15	74	NA	NA	NA	NA	NA	NA	NA	NA	NA
A025	NA	NA	NA	NA	NA	6	35 **	15	68	3 **	9	10 *	18 *	40

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; PT = perspective taking; FS = fantasy; EC = empathic concern; PD = personal distress; NA = data not available. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Social Cognition Tests

Faux Pas Test. Table 6 shows the proportion of correct responses for faux pas (FP) detection and ToM questions, FP emotional understanding questions, FP story control questions, identification of a lack of FP, and control story (C) control questions. Individual patient performance can be seen in Table 7. In cases where participants answered both comprehension questions incorrectly for a given story, this was included in their score but the rest of their answers were not, and their overall score was adjusted accordingly. The proportion of correct responses for FP detection and ToM questions was found to differ significantly between groups. A subsequent Mann-Whitney test revealed no significant differences. However, the R function 'kruskalmc', which is a multiple comparison test designed for use after the Kruskal-Wallis test showed a significant difference between the FTD but not the MND group and controls ($p < 0.05$). There was no significant group effect on the proportion of FP emotional understanding questions, FP control questions, correct FP rejection questions, or C comprehension questions answered correctly.

On an individual basis, five patients (2 FTD, 1 MND, 2 AD) scored significantly worse than controls on FP detection and ToM questions, and these same patients, aside from one AD patient, also had significantly lower scores on the emotional understanding questions. Five patients (2 FTD, 2 MND, 1 AD) answered significantly fewer FP control questions correctly than the control sample as well. Due to the controls performing at ceiling on the C control questions, single-case analyses could not be performed on these patient scores.

Table 6

Comparison of frontal variant Frontotemporal Dementia (fvFTD), Motor Neurone Disease (MND), and Control Group Performance on Social Cognition Tests

Test	fvFTD, Mean (SD)	MND, Mean (SD)[a]	AD, Mean (SD)	Controls, Mean (SD)	Kruskal-Wallis Chi-Squared	p and *Post Hoc* Comparisons
Faux Pas Test						
FP - Detection and ToM questions	0.49 (0.31)	0.72 (0.22)	0.49 (0.05)	0.84 (0.13)	6.45	< 0.05 †
FP - Emotional understanding	0.48 (0.22)	0.62 (0.24)	0.53 (0.14)	0.79 (0.16)	4.95	0.084
FP - Control questions	0.88 (0.16)	0.98 (0.03)	0.88 (0.18)	0.99 (0.02)	3.17	0.21
C - No FP detection	0.86 (0.14)	0.82 (0.17)	0.94 (0.09)	0.84 (0.11)	0.212	0.90
C - Control questions	0.93 (0.08)	0.94 (0.07)	0.86 (0.11)	1.0 (0.0)	6.35	0.072
Facial Expressions of Emotion Test						
Total (/60)	34.00 (15.6)	42.25 (4.6)	39.00	48.11 (5.5)	4.45	0.11
Anger (/10)	5.67 (4.2)	4.50 (3.0)	2.00	7.11 (1.5)	1.89	0.39
Disgust (/10)	5.33 (3.8)	9.00 (1.4)	8.00	7.89 (1.4)	3.64	0.16
Fear (/10)	2.67 (3.1)	3.75 (0.96)	4.00	6.89 (3.2)	4.97	0.082
Happiness (/10)	8.67 (2.3)	9.75 (0.50)	10.00	9.89 (0.33)	1.08	0.58
Sadness (/10)	7.00 (2.8)	6.75 (2.1)	7.00	7.78 (2.2)	1.11	0.57
Surprise (/10)	9.50 (0.71)	8.50 (1.3)	8.00	8.56 (0.88)	1.78	0.41
Reading the Mind in the Eyes						
Test (/36)	24.3 (8.3)	25.0 (5.4)	18.0	27.9 (5.3)	1.50	0.47
Control (/36)	34.7 (1.5)	35.5 (0.58)	34.0	35.1 (0.60)	1.24	0.54
Social Rule Break Cartoons						
General	0.65 (0.3)	0.90 (0.05)	0.60	0.93 (0.10)	4.98	0.083
ToM	0.90 (0.05)	0.97 (0.06)	0.70	0.98 (0.04)	4.56	0.10
Emotional understanding	0.77 (0.3)	0.93 (0.1)	0.85	0.95 (0.08)	1.93	0.38
Social rule knowledge	0.63 (0.2)	0.87 (0.2)	0.65	0.91 (0.07)	5.57	0.062

Note. SD = standard deviation; FP = faux pas; ToM = theory of mind; C = control. [a] Values without a SD in this column had only one entry. $p < 0.05$ is significant; † FTD significantly different from controls (according to 'kruskalmc' function, but not pairwise Mann-Whitney test with Bonferroni correction).

Table 7

Individual Patient Performance on Social Cognition Tests

	Faux Pas Test (proportion correct)					Facial Expressions of Emotion Test							RME	
Patient	FP - Detection and ToM	FP - Emo	FP - Control questions	C - No FP detection	C - Control questions[a]	Total (/60)	Anger (/10)	Disgust (/10)	Fear (/10)	Happiness (/10)	Sadness (/10)	Surprise (/10)	Test (/36)	Control (/36)
F001	0.40 **	0.38 *	0.67 ***	0.89	0.89	23 **	1 **	1 **	0 *	6 ***	5	10	15 *	33 **
F002	0.73	0.67	1.00	1.00	1.00	45	7	8	2	10	9	9	31	36
F016	0.09 ***	0.22 **	0.83 ***	0.67	0.83	NA	NA	NA	NA	NA	NA	NA	NA	NA
F017	0.73	0.67	1.00	0.89	1.00	NA	9	7	6	10	NA	NA	27	35
M008	0.89	0.67	1.00	0.89	1.00	49	8	7	5	10	9	10	31	36
M009	0.76	0.67	1.00	0.78	0.94	40	2 **	9	4	10	7	8	25	36
M010	0.78	0.89	1.00	0.89	1.00	39	2 **	10	3	10	7	7	26	35
M011	0.33 **	0.22 **	0.94 *	0.56 *	0.83	NA	NA	NA	NA	NA	NA	NA	NA	NA
M012	0.82	0.67	0.94 *	1.00	0.94	41	6	10	3	9	4	9	18	35
A023	0.53 *	0.63	1.00	0.88	0.94	NA	NA	NA	NA	NA	NA	NA	NA	NA
A025	0.46 *	0.43 *	0.75 ***	1.00	0.78	39	2 **	8	4	10	7	8	18	34

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; FP = faux pas; ToM = theory of mind; C = control; NA = data not available. [a] Single-case analyses could not be done for this column due to a control sample SD of 0. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Judgment of Preference task. Firstly, patients F001 and F017 were not included in group analyses for the experimental condition because they both scored significantly lower than controls on the first-order block of the control condition ('Which picture is Dina looking at?'; F001: $t = -94.9$, $p < 0.001$; F017: $t = -104.4$, $p < 0.001$), indicating that they were unable either to comprehend the task or discern the direction of 'Dina's' eye-gaze. Being that this is the basis of the experimental trials, their data from the experimental condition was untenable. Thus, group analyses for the experimental condition only included the MND and control groups.

Group had no significant effect on the number of correct responses throughout all blocks of both the experimental and control conditions, with and without distractors (see Table 8). The controls performed at ceiling on all trial types except for the first-order affective with distractor (Aff1 D) trials and the second-order affective without distractor (Aff2) trials, such that individual analyses were only possible on these. Individual patient scores for each of the different trial blocks can be seen in Table 9. Four patients had significantly fewer correct responses than the control sample on the Aff1 D trials, two of whom were the patients with significantly lower response accuracies than the controls for the Aff2 trials.

Table 8

Comparison of Motor Neurone Disease (MND) and Control Group Scores (Total Correct) on Different Trials of the Judgment of Preference Task

Trials	MND, Mean (SD)	Controls, Mean (SD)	Mann-Whitney *W*	*p*
Aff1	9.75 (4.5)	12.0 (0.0)	13.5	0.18
Aff1 D	9.50 (5.0)	11.9 (0.33)	15	0.54
Cog1	12.0 (0.0)	12.0 (0.0)	18	NA
Cog1 D	12.0 (0.0)	12.0 (0.0)	18	NA
Aff2	10.5 (3.0)	11.8 (0.44)	16.5	0.83
Aff2 D	10.8 (2.5)	12.0 (0.0)	16.5	0.18
Cog2	11.0 (2.0)	12.0 (0.0)	13.5	0.18
Cog2 D	10.3 (3.5)	12.0 (0.0)	13.5	0.18
Look	12.0 (0.0)	12.0 (0.0)	18	NA
Look1 D	12.0 (0.0)	12.0 (0.0)	18	NA
Look2	10.5 (3.0)	12.0 (0.0)	13.5	0.18
Look2 D	11.3 (1.5)	12.0 (0.0)	13.5	0.18

Note. SD = standard deviation; Aff = affective; Cog = cognitive; 1 = first-order; 2 = second-order; D = with distractor; NA = data incalculable due to both groups performing at ceiling. $p < 0.05$ is significant.

Table 9

Individual Patient Scores (Total Correct) on Different Trials of the Judgment of Preference Task

Patient	Aff1	Aff1 D	Cog1	Cog1 D	Aff2	Aff2 D	Cog2	Cog2 D	Look1	Look1 D	Look2	Look2 D
F001	1	1 ***	3	2	NA	NA	NA	NA	2	NA	NA	NA
F002	12	12	12	12	12	12	12	11	12	12	12	12
F017	4	4 ***	4	1	3 ***	6	3	0	1	0	3	0
M008	12	12	12	12	12	12	12	12	12	12	12	12
M009	12	12	12	12	12	12	12	12	12	12	12	12
M010	3	2 ***	12	12	6 ***	7	8	5	12	12	6	9
M012	12	12	12	12	12	12	12	12	12	12	12	12
A025	12	10 ***	10	10	NA	NA	NA	NA	12	12	NA	NA

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; Aff = affective; Cog = cognitive; 1 = first-order; 2 = second-order; D = with distractor; NA = data not available. *** $p < 0.001$.

Due to the fact that almost every participant performed at ceiling aside from patient M010 and A025, and the two FTD patients that seemed unable to grasp the task, group analyses of the types of errors made were forgone. However, Kruskal-Wallis tests for within-

patient differences in the number of favourite, arrow, and other errors made were performed for patients M010, A025, F001, and F016. They revealed no significant effect of type on the number of errors made. Similarly, no within-patient significant differences in response accuracy were detected as a result of trial type, referring to affective, cognitive, and physical/control.

Facial Expressions of Emotion Test. The mean accuracy scores for each emotion and total test scores for each group are presented in Table 6 and individual performance data can be seen in Table 7. No significant differences were found on any scores across groups. One FTD patient performed significantly worse than controls overall, and on every emotion aside from sadness and happiness. Two MND patients and one AD patient also scored significantly lower than controls on angry expressions.

Reading the Mind in the Eyes. Group mean accuracy scores for the test and control task and individual scores are presented in Tables 6 and 7, respectively. There was no significant difference in the number of correct responses on either task between the FTD, MND, and control groups. One FTD patient performed significantly worse than the control sample on the RME test, but they did so on the control version as well.

Experimental Tests

Social Rule Break Cartoons. The mean proportion of accurate responses for the general, ToM, emotional understanding, and social rule knowledge questions for each group are presented in Table 6 and individual patient performance is presented in Table 10. In cases where participants did not exhibit comprehension of a given story in their general question response, their subsequent answers were not assessed and their overall score was adjusted accordingly. There was no significant difference in scores on any of the aspects across the groups. However, the effect of group tended towards significance for correct responses to social rule knowledge questions, with the FTD patients attaining lower scores than the control group. One FTD patient and one MND patient scored significantly worse than the controls on general questions, and four patients performed significantly worse on ToM questions. As well, one FTD patient did significantly worse than the control sample on emotional understanding questions, and four patients scored significantly lower on social rule knowledge questions.

Table 10

Individual Patient Performance on Social Rule Break Cartoons

	SRB Cartoons (proportion correct)			
Patient	General	ToM	Emo	Social Knowledge
F001	0.25 *	0.90 ***	0.50 ***	0.40 ***
F002	0.85	0.95	1.00	0.70 *
F016	NA	NA	NA	NA
F017	0.85	0.85 **	0.80	0.80
M008	0.95	1.00	1.00	0.95
M009	NA	NA	NA	NA
M010	0.85	1.00	1.00	1.00
M011	NA	NA	NA	NA
M012	0.90	0.90 ***	0.80	0.65 **
A023	NA	NA	NA	NA
A025	0.60 **	0.70 ***	0.85	0.65 **

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; FP = faux pas; ToM = theory of mind; C = control; Emo = emotional understanding; NA = data not available. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

IATs and explicit measures. Only five patients completed the IATs, including two FTD and three MND patients. Individual mean response latencies for compatible and incompatible test blocks, *D* values, and explicit measure difference scores are presented in Table 11 for the exercise-smoking IAT and Table 12 for the sweets or alcohol-healthy food IAT. As expected based on research done by Greenwald et al. (1998), error rates remained low (< 6% for both patients and controls) regardless of concept-attribute compatibility in combined categorisation test blocks.

Exercise-Smoking. Comparisons of raw mean latency values from the compatible and incompatible combined categorisation test blocks (4 and 7) for each participant were done using Mann-Whitney tests. The difference in latencies was significant for every patient and control participant, except C105. Participants generally showed a response bias for more typically compatible concept and attribute pairs, meaning 'exercise+pleasant' and 'smoking+unpleasant'. *D* values were used to compare performance between the FTD, MND, and control groups, revealing no significant differences. Similarly, *D* values for each patient did not differ significantly from the control sample. On explicit measures, participants tended to report very negative views of smoking and mixed but more positive views of exercise. The MND patients had particularly positive opinions of exercise. Accordingly, there was a significant effect of group on feeling thermometer difference scores ($\chi^2 = 6.43$, $p < 0.05$). A

subsequent pairwise Mann-Whitney test did not show any significant differences between the groups, though the 'kruskalmc' function reported significantly higher scores for the MND but not the FTD patients than controls ($p < 0.05$). Semantic differential difference scores were not found to differ significantly between groups. Correlational analyses did not reveal a significant association between *D* values and feeling thermometer difference scores ($\rho = 0.21$, $p > 0.05$), or *D* values and semantic differential difference scores ($\rho = 0.33$, $p > 0.05$) for exercise and smoking across participants. However, feeling thermometer and semantic differential difference scores were significantly positively associated ($\rho = 0.61$, $p < 0.05$).

Table 11

Individual Patient Performance on the Exercise-Smoking Implicit Association Test and Corresponding Explicit Measures

Participant	Inompatible Test Block Latency (ms), Mean (SD)[a]		Compatible Test Block Latency (ms), Mean (SD)	*D*	Feeling Thermometer Difference Score	Semantic Differential Difference Score
F002	1982.0 (656)	***	1187.7 (684)	1.260	80	2.6
F017	2725.5 (820)	***	1387.0 (816)	1.228	70	4.0
M008	1230.9 (337)	***	908.7 (229)	0.839	100	3.0
M009	2208.4 (1294)	***	1479.2 (865)	0.834	100	4.0
M011	1488.3 (737)	***	918.6 (530)	0.757	100	3.2
C100	1112.3 (412)	***	753.0 (257)	0.600	30	2.4
C101	841.0 (243)	**	724.4 (153)	0.734	100	3.8
C102	790.1 (182)	*	737.2 (191)	0.465	75	2.2
C103	1242.6 (416)	***	1083.6 (709)	0.534	20	0.4
C104	1082.3 (353)	***	789.5 (382)	0.768	70	2.6
C105	1087.9 (419)		1126.7 (350)	-0.044	60	3.2
C106	1072.4 (315)	***	691.6 (73)	0.735	55	1.4
C107	888.9 (224)	***	706.6 (148)	0.872	70	3.8
C108	688.3 (103)	***	541.1 (60)	1.364	50	2.4

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; SD = standard deviation. [a] Significant differences between incompatible and compatible latencies are denoted in this column. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Sweets or alcohol-Healthy food. Individual comparisons of mean latencies for blocks 4 and 7 showed significant differences for three patients, and six healthy controls. Thus, a response bias was not observed for 'sweets or alcohol+unpleasant' and 'healthy food+pleasant' for one FTD patient, one MND patient, and three controls. However, there

was no significant difference in *D* values as a result of group, and individual patient *D* scores did not differ significantly from controls. Explicitly, participants tended to feel fairly positively about healthy food and many felt similarly towards sweets and alcohol, despite recognising that they were not the best for you. There was no significant difference between groups in feeling thermometer difference scores or semantic differential difference scores. Feeling thermometer and semantic differential difference scores for sweets/alcohol and healthy food were found to correlate significantly with each other ($\rho = 0.89$, $p < 0.001$), though neither did with participant *D* scores (feeling thermometer: $\rho = 0.45$, $p > 0.05$; semantic differential: $\rho = 0.35$, $p > 0.05$).

Table 12

Individual Patient Performance on the Sweets or Alcohol-Healthy Food Implicit Association Test and Corresponding Explicit Measures

Participant	Incompatible Test Block Latency (ms), Mean (SD)[a]	Compatible Test Block Latency (ms), Mean (SD)	*D*	Feeling Thermometer Difference Score	Semantic Differential Difference Score
F002	1952.9 (429)	1970.9 (375)	0.217	20	1.0
F017	2343.9 (1364) ***	1166.1 (529)	0.786	70	4.0
M008	1138.9 (368)	1152.1 (362)	0.294	15	1.8
M009	2383.4 (1046) ***	1009.5 (362)	1.111	70	2.4
M011	1911.6 (884) ***	944.1 (363)	0.990	50	1.6
C100	1012.0 (193)	955.2 (273)	0.114	65	2.2
C101	1022.3 (189) ***	595.1 (111)	1.515	40	1.2
C102	620.8 (65)	657.3 (109)	-0.349	-10	0.2
C103	1103.0 (273) *	1159.8 (793)	0.320	20	1.0
C104	982.9 (331) ***	835.8 (548)	0.209	0	0.6
C105	1110.8 (223)	1124.6 (390)	-0.101	0	-0.2
C106	1016.9 (263) ***	790.3 (147)	0.861	-5	-0.2
C107	1152.5 (414) ***	702.6 (169)	1.372	30	1.4
C108	637.9 (265) ***	651.8 (78)	0.589	-20	0

Note. F = frontotemporal dementia patient; M = motor neurone disease patient; A = Alzheimer's disease patient; SD = standard deviation. [a] Significant differences between incompatible and compatible latencies are denoted in this column. * $p < 0.05$; *** $p < 0.001$.

Discussion

This study represents the first time such an extensive social cognition battery, including the recently developed SRB Cartoons task, has been administered to three different patient groups for the purpose of one investigation. As well, the IAT has never before been utilised with FTD, MND, or AD patients. Overall, the limited number of participants included in each patient group made it difficult to find consistent and significant group differences on the social cognition tasks administered. However, SRB Cartoons and Faux Pas Test performance pointed towards a social cognition deficit in the fvFTD group, possibly seated in social knowledge impairments. Individual patient performance fell in line with what is known about disease progression in these conditions. As well, the unique aspect of examining several patient groups with the same extensive test battery allowed for evaluation of which tests are more suitable for different patients.

Despite a lack of significant differences in group scores on SRB Cartoons, the FTD patient group nearly did significantly worse on social rule knowledge questions compared to the controls. This is of interest, as the inability to access social knowledge has been suggested as a possible mechanism underlying the impaired social behaviour seen in VMPFC lesion patients (Mah et al., 2005). Investigations with contradictory evidence have similarly included single-case analysis or small samples (Saver & Damasio, 1991). The FTD patients also scored significantly lower than the control sample on FP detection and ToM questions on the Faux Pas Test (according to one of two *post hoc* pairwise comparisons). Behavioural abnormalities identified in the FTD patients may be related to these observed deficits. For example, all of the FTD patients who had family-rated IRIs completed scored significantly lower on current perspective taking compared to the controls. This is indicative of deficient cognitive empathy (Davis, 1990), which also relates to ToM in terms of recognising another individual's perspective. The FTD patient group was also found to have significantly greater family-rated total scores on the FrSBe, with disinhibition and executive dysfunction scores nearing significance, compared to the MND group. It seems likely that social rule knowledge plays an important role in inhibition of socially inappropriate behaviour, such that a deficit in this domain may contribute to increased disinhibition. Together, these findings suggest that the FTD patient group may exhibit a deficit in social cognition seated in inaccessibility to, or deficient, social knowledge, resulting in altered behaviour. It could be argued that the FP detection and ToM questions evaluate cognitive ToM as well as social rule knowledge, as

participants are required to infer what someone in the story was thinking as well as judge whether their actions were appropriate according to social rules. This provides a good link to the IAT in the detection of implicit associations, such as stereotypes and attitudes, as these are representations of social knowledge thought to underlie interpersonal behaviour. Along with SRB Cartoons, the IAT may be useful in further investigating whether impaired social knowledge is responsible for some of the social cognition deficits seen in FTD patients, as well as provide insight into the nature of the problem in terms of accessibility or loss of information.

Of the four patients that exhibited significantly worse performance on social rule knowledge than the control sample, two were FTD patients. Patient F001 scored significantly worse than the control group on all social cognition tests. On both the Faux Pas Test, SRB Cartoons task, and RME she also struggled with control questions, and her performance on the background neuropsychological tests are suggestive of global impairment. She performed significantly worse than the control sample on tests tapping intellect, language, visuospatial skills, and executive functioning. Family-rated FrSBe scores indicated impairments overall, as well as on each subscale, and significantly decreased perspective taking and increased personal distress in response to distress in others were reported through family-rated IRI scores. With deficits apparent in so many domains, determining what is responsible for her deficient performance on a given task is impossible within the confines of this investigation. This likely contributes to her classification of ‘FTD Query’.

Alternatively, patient F002 performed significantly worse than the controls on social rule knowledge questions in SRB Cartoons, but exhibited no other impairments on the social cognition tests. His ACE-R score was indicative of dementia, and family-rated questionnaire results suggest that his behaviour has changed drastically in the domains of apathy, disinhibition, and executive functioning, each of which was rated as normal beforehand and abnormal after disease onset. Deficits in executive functioning were corroborated by a significantly lower score than the controls on spoken VF. However, he rated himself as being impaired on these aspects both before and after the onset of his illness, perhaps suggestive of a lack of insight, which is frequently seen early on in FTD (Neary et al., 1998).

Patient F016 performed as anticipated for an FTD patient, in that she had significantly lower scores than the control group on both FP detection and ToM, and emotional

understanding questions, even with the exclusion of miscomprehended stories. She was also family-rated as having significantly lower perspective taking scores than the controls, and being impaired on all aspects of the FrSBe. Unfortunately, she did not wish to complete any other tests, so whether or not these findings would be replicated using SRB Cartoons or whether there might be a deficit outside the realm of social cognition responsible, remains unknown.

Patient F017 appeared to be relatively unimpaired in the realm of social cognition, though he did perform significantly worse on ToM questions in SRB Cartoons as compared to the controls. He also performed poorly on the Judgment of Preference task, but his significantly lower scores on visuospatial background measures as compared to controls, combined with the fact that he could not correctly identify the direction of 'Dina's' eye-gaze seem to suggest that he may have a vision problem. He did report an increase in apathy, though this only bordered on impaired, and unfortunately no significant other was present to provide a second opinion on behavioural changes. These results fit nicely with his 'FTD Query' status.

The MND patients all performed at the level of the controls on SRB Cartoons, except for patient M012, who scored significantly lower on ToM and social rule knowledge questions. These deficits were not replicated on the Faux Pas Test, though. This could provide support for the notion that nonverbal tasks may be more sensitive to deficits in social cognition (Mah et al., 2005), based on evidence suggesting that the right VMPFC has a predominant role in social cognition (Hornak et al., 1996; Tranel, Bechara, & Denburg, 2002). In fact, any patient that exhibited deficits on the Faux Pas Test also demonstrated an impairment on the same aspect, or more aspects, on SRB Cartoons, when patients completed both tasks. In the case of patients F017 and M012, deficits were apparent on SRB Cartoons, but not the Faux Pas Test. Further, though his score was not significantly lower than the control sample, patient M012 only chose the correct descriptive word for half of the eyes presented in the RME test, which is also a nonverbal ToM task. If FTD/MND and pure MND are indeed part of a spectrum, it seems patient M012 may be closer to the FTD/MND end.

Executive functioning is often impaired in MND patients (Abrahams et al., 2000, 2005a), and this was the case for all but patient M009, who also exhibited no deficits in social cognition, aside from angry expression recognition. It would seem that her condition is one

with almost purely motor symptoms. Patient M010 scored significantly lower than the controls on recognising expressions of anger as well. However, he also attained low scores on the first-order affective blocks of the experimental condition in the Judgment of Preference task, despite performing perfectly on the first-order cognitive block of the experimental condition and the first-order block of the control condition. He also had lower scores on all of the second-order blocks. This implies a possible deficit in affective ToM with intact cognitive ToM. Unfortunately, single-case analyses could not be performed to determine whether these scores were significantly different from the control sample though, and the other test scores provide no corroborative data.

The final MND patient, patient M011, scored significantly lower than the controls on all aspects of the Faux Pas Test. This was the only social cognition test he completed, though, and the background neuropsychological tests he finished were indicative of widespread deficits. The global nature of his impairments makes it very difficult to determine whether a deficit in social cognition or some other domain was underlying his poor Faux Pas Test performance. The only prominent behavioural change in MND patients as indicated by the questionnaires were in apathy levels. All but patient M010 had clinically abnormal apathy levels according to family-ratings. However, the FrSBe apathy items relate to mobility, which was limited to some degree in all of the MND patients involved. Thus, these results should be interpreted with caution.

The one AD patient that completed SRB Cartoons was found to score significantly lower than controls on general, ToM, and social rule knowledge questions. As well, though her score was not significantly lower than the control sample, she only answered correctly for half of the sets of eyes in the RME test. She performed significantly worse on FP detection and ToM and FP emotional understanding too. As expected, she scored significantly lower on FP control questions as well. Though some of the Faux Pas Test impairments are replicated in her SRB Cartoons scores, it should be noted that the patient voiced that her vision was impaired such that she could not easily read the stories herself. As such, her poor performance may be at least partially due to memory problems, which were quite obvious and severe based on observations and her ACE-R performance. Along with these cognitive issues, questionnaire results were also suggestive of VMPFC dysfunction and thereby heightened disease severity. Specifically, family-ratings were indicative of abnormal levels of apathy and disinhibition, and impaired perspective taking, empathic concern, and personal

distress. She also demonstrated visuospatial issues on the ACE-R, and executive difficulties via written and spoken VF and family-rated FrSBe scores, which are both fairly common in AD (Gregory & Hodges, 1996).

The only other AD patient involved in the study completed the Faux Pas Test and nothing else. He performed significantly worse than the controls on the FP detection and ToM questions, but did not demonstrate problems with control questions, surprisingly. Without more information, it is difficult to interpret these results, aside from the possibility of a ToM deficit. As mentioned, studies have reported ToM deficits in some AD patients on second-order false belief tasks, but this is often linked to executive dysfunction (Cuerva et al., 2001; Youmans & Bourgeois, 2010).

Notably, two control participants, C103 and C106, stood out as performing worse than the majority of their peers. They both had lower scores on FP detection and ToM questions on the Faux Pas Test, had difficulty with fear recognition, and performed worse on the RME test than all other controls and all but three patients. These two cases often largely influenced control sample means, such that group results and individual case analyses may have produced different results with a larger sample. The choice not to omit them from analyses was made based on how small the control sample was in the first place, as well as the fact that generally their scores were still not greater than two standard deviations below the control mean.

An implicit association between ‘exercise’ and ‘pleasant’, and ‘smoking’ and ‘unpleasant’ was observed in all participants aside from C105. This does not necessarily contend with our predictions, because only in patients that smoke could the hypothesis that an inability to access negative implicit associations regarding smoking might underlie this behaviour be investigated. Because none of the patients who completed the task smoked, the demonstration of an automatic association between these stereotypically compatible concepts and attributes is not shocking. Notably, the individual that did not show a similar response bias was the only one who completed the IAT that did not rate smoking at 0 on the feeling thermometer, and one of four participants that indicated they did not mind other people smoking near them. Every other participant reported entirely negative views of smoking. Thus, explicit measures seem to account for this lack of response bias. In future, this version of the IAT should only be included in studies that are certain to include some patients that

smoke. Unfortunately, this information was unknown at the time of recruitment, and the only FTD patient that smoked was unable to complete this task.

Alternatively, about one-third of the participants that completed the IATs did not demonstrate a response bias for stereotypically compatible categorisation on the sweets or alcohol-healthy food IAT. This is not terribly surprising, as the explicit measures along with participant remarks indicated that the relationship between pleasantness and healthy food items, and unpleasantness and sweets or alcoholic beverages was not always obvious. Several participants blatantly disagreed with stimuli characterised as sweets versus healthy food, such as coke in one instance. Specifically, two patients failed to show a greater association between compatible attributes and concepts. Both patient F002 and M008 rated sweets/alcohol highly on the feeling thermometer and indicated that they enjoyed sweets and ate quite a few despite realising that they are not that good for you. Patient F002 indicated outright that they did not enjoy healthy food, and expressed a preference for sweet foods, which is typical of FTD patients. Similarly, the three control participants that did not demonstrate the expected response bias felt sweets tasted better than healthy foods. These highly positive feelings towards sweets and alcohol suggest that this target concept may inherently be associated with pleasantness rather than unpleasantness for these participants. Thus, in each case of a lack of implicit association, the explicit measures seem to provide an explanation for the findings. Too few patients completed the task to determine whether FTD patients or a subset of MND patients more often exhibit decreased implicit associations between typically compatible attributes and concepts that may underlie behavioural changes characteristic of these patients. However, patient F002 did score significantly lower than the control sample on social rule knowledge questions in SRB Cartoons, providing some support for the possibility of a loss of response bias underlying sweet food preference. In future, tailoring the explicit measures to gain insight into whether changes in appetite and the types of foods being consumed have occurred could provide more insight into whether the implicit associations of interest are merely inaccessible or were never apparent in a given participant.

Overall, the deficits observed were not necessarily as expected across each patient group. All the FTD patients did not demonstrate great impairments across most facets of social cognition, and the MND and AD patients were not devoid of them aside from a MND subgroup. However, each FTD patient did exhibit a deficit in at least one aspect of social cognition of at least one test as compared to the control sample. Further, the findings did not

contradict with previous research. Particularly, though not a lot of insight can be gained into the locality of degeneration in these patients based on our results, FTD patients that did exhibit impaired executive functioning, via spoken VF, also showed a deficit in at least one aspect of social cognition. Further, the one FTD patient that did not perform significantly worse than the controls on spoken VF still had a significantly lower score on the ToM questions of the SRB Cartoons task. The FTD group also has significantly higher FrSBe total scores than the MND group, influenced by disinhibition and executive dysfuntion. They individually exhibited deficits in perspective taking as well. This corresponds with the belief that the VMPFC is affected initially and primarily in fvFTD, with the DLPFC often being affected later on (Gregory et al., 1999; Perry et al., 2006).

Similarly, all but one MND patient exhibited executive dysfunction and mostly intact social cognition, with apathy being the main behavioural change. The absence of a clear subgroup with social cognition deficits is not surprising considering the MND sample size. As for the AD patient with enough data to analyse, deficits in social cognition were accompanied by impaired memory and visuospatial skills, as well as executive dysfunction, as demonstrated on both written and spoken VF tests. This is consistent with the suggested progression of degeneration in AD outward from the medial temporal region both frontally and occipitally (Thompson et al., 2003).

This points to the important fact that regions of degeneration and the resultant manifestations in a given disease are not as clear-cut as some reports make them seem. Larger patient groups can provide a better picture of the average experience, and insight into common impairments and corresponding probable neural correlates. However, it is critical to remember that individual cases can vary tremendously. Finding a balance between patients that are affected to a degree that will give an appropriate picture of the deficits characteristic of a given disease, and patients that are still able to complete the tasks designed to investigate and identify these impairments, is a real challenge. For example, patients F016, M011, and A023 all demonstrated informative impairments on the tasks they completed, but did not wish to partake in the rest of the battery. In the case of patients F016 and A023, they became highly frustrated with the IATs and were unable to complete them. Their distress was maintained throughout the Faux Pas Test, after which they expressed that they had no desire to participate in any further testing.

In future, it may be beneficial to use a subset of the Faux Pas Test stories in the case of highly impaired participants. As well, creating a touch-screen version of the IAT may be helpful in reducing the number of instructions participants have to remember in order to perform the task, as well as reducing the need for intact fine motor skills. One of the SRB Cartoons stories was also frequently misinterpreted among both patients and control participants, suggesting that the cartoon itself might be ambiguous and could be altered for clarification. Beyond limitations presented by the tests themselves, the reliability and representativeness of these findings was most limited by the lack of patients recruited for each group, due to time restrictions. Further, executive problems were apparent in most of the patients that were involved, and the degree to which this may have influenced their performance in other domains was not evaluated, which is a possible confound.

Though the size of the patient groups did not allow for patterns of deficits within different aspects of the SRB Cartoons task to emerge, future studies with more participants may reveal the ability of this test to dissociate these and see whether certain aspects are affected to a greater degree, or earlier than others, in given conditions. The possibility that the SRB Cartoons task may not only be more specific, in terms of deficit identification within the realm of social cognition, but more sensitive to impairments, warrants further investigation. The exercise-smoking IAT was unable to provide insight into a possible lack of implicit associations underlying smoking behaviour in FTD patients, owing to the fact that none of the patients that completed it were smokers. As well, performance on the sweets or alcohol-healthy food IAT was varied, though individuals that showed a lack of response bias for the compatible categorisations had explicit opinions that coincided well with these findings. The small number of patients that completed the task did not allow for patterns to emerge between patient groups. Despite a general lack of group effects due to limited participants, individual findings were broadly consistent with what is known about these diseases in terms of neural substrates and disease progression. SRB Cartoons and Faux Pas Test performance pointed towards the possibility of a social knowledge impairment underlying a social cognition deficit in the fvFTD group. With more time and participants, perhaps SRB Cartoons and the IAT can be used in conjunction in the future to investigate this possibility.

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Appendix

Faux Pas Test Excerpt

Faux pas story. Vicky was at a party at her friend Oliver's house. She was talking to Oliver when another woman came up to them. She was one of Oliver's neighbours. The woman said, "Hello," then turned to Vicky and said, "I don't think we've met. I'm Maria, what's your name?" "I'm Vicky." "Would anyone like something to drink?" Oliver asked.

Faux pas detection question:
Did anyone say something they shouldn't have said or something awkward?

ToM questions:
Who said something they shouldn't have said or something awkward?

Why shouldn't he/she have said it or why was it awkward?

Why do you think he/she said it?

Did Oliver know that Vicky and Maria did not know each other?

Emotional understanding question:
How do you think Vicky felt?

Control questions:
In the story, where was Vicky?

Did Vicky and Maria know each other?

Control story. Helen's husband was throwing a surprise party for her birthday. He invited Sarah, a friend of Helen's, and said, "Don't tell anyone, especially Helen." The day before the party, Helen was over at Sarah's and Sarah spilled some coffee on a new dress that was hanging over her chair. "Oh!" said Sarah, "I was going to wear this to your party!" "What party?" said Helen. "Come on," said Sarah, "Let's go see if we can get the stain out."

Faux pas detection question:
Did anyone say something they shouldn't have said or something awkward?

ToM questions:
Who said something they shouldn't have said or something awkward?

Why shouldn't he/she have said it or why was it awkward?

Why do you think he/she said it?

Did Sarah remember that the party was a surprise party?

Emotional understanding question:

How do you think Helen felt?

Control questions:

In the story, who was the surprise party for?

What got spilled on the dress?

IAT Stimuli

Exercise-Smoking IAT.

Exercise	Smoking	Pleasant	Unpleasant
jogging	cigarettes	caress	abuse
sports	ashtray	love	crash
swimming	nicotine	honour	filth
workout	tobacco	sunrise	hatred
ing	cigars	happy	death
aerobics	lighter	paradise	poverty

Sweets or Alcohol-Healthy Food IAT.

Healthy Food	Sweets or Alcohol	Pleasant	Unpleasant
fruits	candy	peace	grief
lettuce	cookies	cheer	tragedy
yogurt	chocolate	pleasure	agony
rice	coke	laughter	pollute
strawberries	beer	miracle	sickness
chicken	whisky	freedom	evil

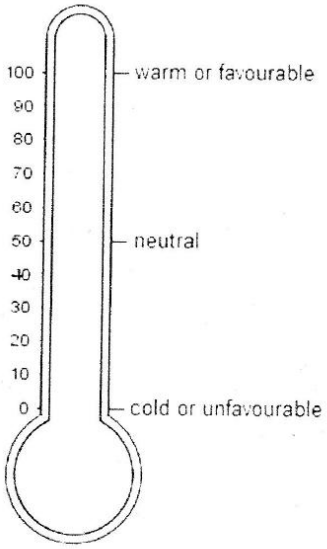
Questionnaires

Healthy Attitudes and Habits Questionnaire.

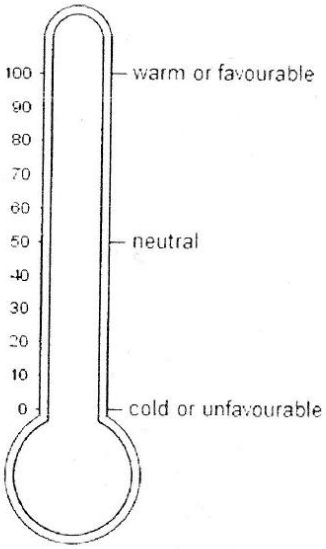
Healthy Attitudes and Habits Questionnaire

Please describe your general level of warmth or coolness towards _____ by making a mark at the appropriate position on the thermometer.

EXERCISE



SMOKING



Please indicate using a check mark the degree to which you feel a given adjective describes the target concept. Check the middle of the range if you consider both adjectives to be irrelevant to the concept.

EXERCISE

	very	quite	neither/nor	quite	very	
good	[ ]	[ ]	[ ]	[ ]	[ ]	bad
unpleasant	[ ]	[ ]	[ ]	[ ]	[ ]	pleasant
harmless	[ ]	[ ]	[ ]	[ ]	[ ]	harmful
ugly	[ ]	[ ]	[ ]	[ ]	[ ]	glamorous
nice	[ ]	[ ]	[ ]	[ ]	[ ]	awful

SMOKING

	very	quite	neither/nor	quite	very	
good	[ ]	[ ]	[ ]	[ ]	[ ]	bad
unpleasant	[ ]	[ ]	[ ]	[ ]	[ ]	pleasant
harmless	[ ]	[ ]	[ ]	[ ]	[ ]	harmful
ugly	[ ]	[ ]	[ ]	[ ]	[ ]	glamorous
nice	[ ]	[ ]	[ ]	[ ]	[ ]	awful

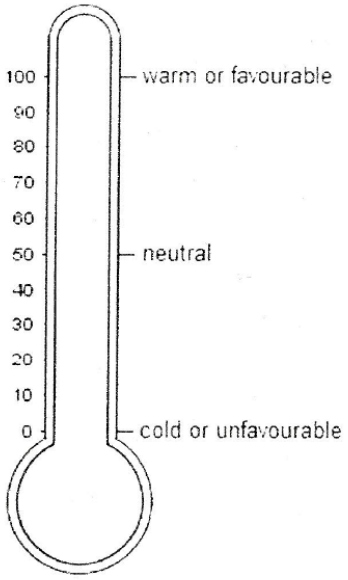
1

Please indicate the level to which you agree or disagree with the statements below by circling the corresponding number.

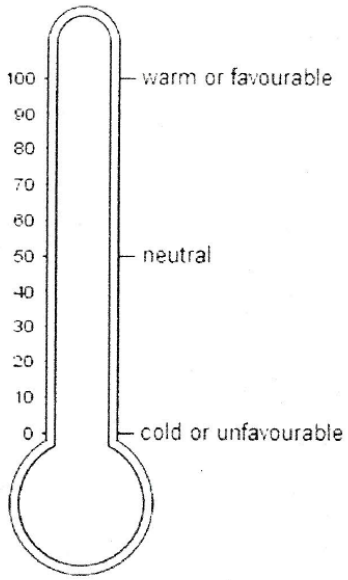
	Totally Agree	Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Disagree	Totally Disagree
1. Exercise is healthy	1	2	3	4	5	6	7
2. Smoking is healthy	1	2	3	4	5	6	7
3. I exercise a lot	1	2	3	4	5	6	7
4. I smoke a lot	1	2	3	4	5	6	7
5. Exercise is not important	1	2	3	4	5	6	7
6. I should not smoke	1	2	3	4	5	6	7

Please describe your general level of warmth or coolness towards _____ by making a mark at the appropriate position on the thermometer.

HEALTHY FOOD



SWEETS/ALCOHOL



Please indicate using a check mark the degree to which you feel a given adjective describes the target concept. Check the middle of the range if you consider both adjectives to be irrelevant to the concept.

HEALTHY FOOD

	very	quite	neither/nor	quite	very	
good	[ ]	[ ]	[ ]	[ ]	[ ]	bad
unpleasant	[ ]	[ ]	[ ]	[ ]	[ ]	pleasant
harmless	[ ]	[ ]	[ ]	[ ]	[ ]	harmful
ugly	[ ]	[ ]	[ ]	[ ]	[ ]	glamorous
nice	[ ]	[ ]	[ ]	[ ]	[ ]	awful

SWEETS/ALCOHOL

	very	quite	neither/nor	quite	very	
good	[ ]	[ ]	[ ]	[ ]	[ ]	bad
unpleasant	[ ]	[ ]	[ ]	[ ]	[ ]	pleasant
harmless	[ ]	[ ]	[ ]	[ ]	[ ]	harmful
ugly	[ ]	[ ]	[ ]	[ ]	[ ]	glamorous
nice	[ ]	[ ]	[ ]	[ ]	[ ]	awful

Please indicate the level to which you agree or disagree with the statements below by circling the corresponding number.

	Totally Agree	Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Disagree	Totally Disagree
1. Sweet foods taste good	1	2	3	4	5	6	7
2. Healthy foods taste good	1	2	3	4	5	6	7
3. I should not drink alcohol	1	2	3	4	5	6	7
4. I should eat sweets	1	2	3	4	5	6	7
5. I should eat healthy food	1	2	3	4	5	6	7
6. I drink a lot of alcohol	1	2	3	4	5	6	7
7. I do not eat a lot of sweets	1	2	3	4	5	6	7

Questions Taken from the 2007 Health Survey for England.

Q1 In general, do you mind if other people smoke near you?

Spare 21-153

154

- Yes [1]
- No [2]
- It depends [3]

Q2 How much, if at all, do you think breathing in other people's smoke affects the health of **adults** who are exposed to it?

155

- A great deal [1]
- A fair amount [2]
- Just a little [3]
- Not at all [4] → **Go to Q4**
- I don't know [8] → **Go to Q4**

Q3 In what ways would you say breathing in other people's smoke affects the health of **adults**?

Tick ALL that apply

156-173

- Causes breathlessness [01]
- Causes coughing [02]
- Causes wheezing [03]
- Causes people to get asthma or makes asthma worse [04]
- Makes people more prone to chest infections or bronchitis [05]
- Makes people less fit than they used to be [06]
- Makes people more likely to suffer from cancer [07]
- Makes people more likely to suffer from another serious illness (such as heart disease or stroke) [08]
- Something else [09]
- I don't know [98]

Q25 Here are some statements about drinking.

Please indicate how strongly you agree or disagree with the statements.

Please tick ONE box for each row

		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Can't choose
a)	Getting drunk is a perfectly acceptable thing for people to do	1	2	3	4	5	8 227
b)	Drinking is a major part of the British way of life	1	2	3	4	5	8 228
c)	It's easier to enjoy a social event if you've had a drink	1	2	3	4	5	8 229
d)	There is nothing wrong with people getting drunk regularly	1	2	3	4	5	8 230
e)	Most people with serious drinking problems can never fully recover	1	2	3	4	5	8 231
f)	People in some other parts of Europe tend to drink alcohol more sensibly than people in Britain	1	2	3	4	5	8 232
g)	The government should tax alcohol more heavily to encourage people to drink less	1	2	3	4	5	8 233
h)	Most people with serious drinking problems have only themselves to blame	1	2	3	4	5	8 234

Q26 Would you like to drink less than, more than or about the same amount of alcohol as you do at the moment?

Tick ONE box 235

Less 1

More 2

About the same 3

Q32 Here are some statements about eating.

Please indicate how strongly you agree or disagree with the statements.

Please tick ONE box per row

		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Can't choose	
a)	The tastiest foods are the ones that are bad for you	1	2	3	4	5	8	274
b)	Healthy foods are enjoyable	1	2	3	4	5	8	275
c)	I get confused over what's supposed to be healthy and what isn't	1	2	3	4	5	8	276
d)	I really care about what I eat	1	2	3	4	5	8	277
e)	Healthy eating is just another fad	1	2	3	4	5	8	278
f)	If you do enough exercise you can eat whatever you like	1	2	3	4	5	8	279

Q33 Overall, would you say that what you usually eat is…

280

- Very healthy 1
- Quite healthy 2
- Not very healthy 3
- Very unhealthy 4

Q34 Would you like to eat more healthily than you do at the moment?

281

- Yes 1
- No 2
- Don't know 8