



Behavioural Neurology

Frontotemporal lobar degeneration and social behaviour: Dissociation between the knowledge of its consequences and its conceptual meaning

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ABSTRACT

Inappropriate social behaviour is an early symptom of frontotemporal lobar degeneration (FTLD) in both behavioural variant frontotemporal dementia (bvFTD) and semantic dementia (SD) subtypes. Knowledge of social behaviour is essential for appropriate social conduct. The superior anterior temporal lobe (ATL) has been identified as one key neural component for the *conceptual knowledge* of social behaviour, but it is unknown whether this is dissociable from knowledge of the *consequences* of social behaviour. Here, we used a newly-developed test of knowledge about long-term and short-term consequences of social behaviour to investigate its impairment in patients with FTLD relative to a previously-developed test of social conceptual knowledge. We included 19 healthy elderly control participants and 19 consecutive patients with features of bvFTD or SD and defined dissociations as performance differences between tasks for each patient (Bonferroni-corrected $p < .05$). Knowledge of long-term consequences was selectively impaired relative to short-term consequences in five patients and the reverse dissociation occurred in one patient. Six patients showed a selective impairment of social concepts relative to long-term consequences with the reverse dissociation occurring in one patient. These results corroborate the hypothesis that knowledge of long-term consequences of social behaviour is

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dissociable from knowledge of short-term consequences, as well as of social conceptual knowledge. Confirming our hypothesis, we found that patients with more marked grey matter (GM) volume loss in frontopolar relative to right superior ATL regions of interest exhibited poorer knowledge of the long-term consequences of social behaviour relative to the knowledge of its conceptual meaning and vice versa ($n = 15$). These findings support the hypothesis that frontopolar and ATL regions represent distinct aspects of social knowledge. This suggests that rather than being unable to suppress urges to behave inappropriately, FTLD patients often lose the knowledge of what appropriate social behaviour is and can therefore not be expected to behave accordingly.

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1. Introduction

Social knowledge has been defined as knowledge of one's own and other people's minds (Adolphs, 2009). Because “mind” or “mental states” are hard to break down neuropsychologically, we prefer defining social knowledge as denoting non-episodic (i.e., semantic) knowledge of social sensory properties and social behaviour [i.e., functions (Zahn, de Oliveira-Souza, & Moll, 2015)]. Socially appropriate behaviour requires knowledge of adequate social actions within a given short-term sequential context [e.g., “to appropriately touch a romantic partner after a romantic date” but not “the waiter/waitress after dinner in a restaurant” (Wood & Grafman, 2003)]. Socially appropriate behaviour also requires anticipating possible long-term consequences (e.g., “being unemployed with a criminal record for sexual harassment” as a consequence of e.g., “inappropriate touching”), but also knowledge of the abstract conceptual quality of a given social action within a given context [e.g., enabling us to flexibly interpret “not being greeted by a colleague who is passing by in a corridor at work” as a sign of “disrespect”, “impoliteness”, “shyness” or “absent-mindedness” (Zahn, Moll, Iyengar et al., 2009)].

Using fMRI and transcranial magnetic stimulation (TMS) methods, we have demonstrated that this abstract conceptual social knowledge, which is independent of the context of actions (Zahn, Moll, Paiva et al., 2009) and emotions (Zahn et al., 2007; Zahn, Moll, Paiva et al., 2009), is represented in the superior anterior temporal lobe [ATL: (Pobric, Lambon Ralph, & Zahn, 2016)]. fMRI studies have shown that the ATLs, especially within their superior sectors (Skipper, Ross, & Olson, 2011; Zahn et al., 2007), are selectively more activated when considering social concepts than they are for non-social concepts (Ross & Olson, 2010; Simmons, Reddish, Bellgowan, & Martin, 2009; Skipper et al., 2011; Zahn et al., 2007), whereas the ventral ATL is equally engaged for social and non-social concepts (Binney, Hoffman, & Lambon Ralph, 2016). Furthermore, right superior ATL activation increased with the richness of detail with which social concepts describe social behaviour (Zahn et al., 2007). This is in keeping with the role of the ATLs in representing coherent conceptual knowledge (Lambon Ralph & Patterson, 2008; Patterson, Nestor, & Rogers, 2007). Frontotemporal lobar degeneration (FTLD) patients with hypometabolism of the right ATL showed selective impairments on social relative to

non-social concepts (Zahn, Moll, Iyengar et al., 2009). Furthermore, two rare cases with selective right and left ATL atrophy respectively showed selective impairments on social versus non-social concepts in the right ATL and an impairment of both types of concepts in the left ATL case (Pobric et al., 2016). These results were in keeping with repetitive TMS of the right and left superior ATL, showing a selective slowing of social relative to non-social concepts in the right superior ATL, as well as a slowing of social and non-social conceptual task responses relative to a non-semantic control condition in the left superior ATL (Pobric et al., 2016). These findings were in keeping with a larger body of evidence on graded hemispheric and regional specialisation within the ATLs for different conceptual content (Rice, Hoffman, & Lambon Ralph, 2015; Rice, Lambon Ralph, & Hoffman, 2015).

Less is known about the representation of sequential social knowledge. Non-social sequential knowledge was associated with lateral frontal neurodegeneration by showing impairments in the hierarchical organisation of non-social scripts as measured by event ordering tasks (Farag et al., 2010). The structured event complex theory (Wood & Grafman, 2003) posited that the prefrontal cortex is a long-term memory store for event/action sequences (also referred to as “scripts”) with the frontopolar cortex (BA10) representing the most sequentially complex information (Moll, Zahn, de Oliveira-Souza, Krueger, & Grafman, 2005). The specific association of the medial frontopolar cortex with complex sequential representations has been corroborated in fMRI studies in healthy control participants by directly modelling the number of events (Krueger et al., 2009) entailed in daily life activities (e.g., going shopping) and their frequency of occurrence (Krueger, Moll, Zahn, Heinecke, & Grafman, 2007), as well as participants' sequential rule knowledge (Wood, Knutson, & Grafman, 2005). Patients with frontal lesions or neurodegeneration which included the frontopolar cortex were shown to perform poorly on tasks that require sequencing daily life activities [i.e., ordering component events into a sequential order (Krueger, Rostami, Huey, Snyder, & Grafman, 2007; Sirigu et al., 1996)] and structuring events for real-world planning (Goel, Grafman, Tajik, Gana, & Danto, 1997), whilst performing normally on making superordinate-subordinate judgements about daily life event themes and component events once executive demands were controlled for (Wood, Tierney,

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