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Higher-order semantic processing in formal thought disorder in schizophrenia



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ABSTRACT

Higher-order semantic impairments and lack of sensitivity to linguistic context have both been implicated in formal thought disorder (FTD) in schizophrenia. Most investigations have focused on comprehension. We investigated the processing of higher-order semantic relations and the role of emotional arousal in FTD patients' linguistic comprehension and production. We compared FTD schizophrenia patients ($n=14$) with non-FTD schizophrenia patients ($n=18$) and healthy controls ($n=15$) on sense-judgment and repetition tasks, in emotionally negative and neutral conditions. We predicted that the FTD group would display poor sensitivity compared to the other two groups in comprehension and production, and that this would be exacerbated by sentence complexity and negative emotional arousal. The emotional manipulation was not robustly successful, and did not affect task performance in the patient groups. FTD patients made significantly more errors on sense-judgments and repetition than the other two groups. Complexity affected all groups to a similar extent in sense-judgments, but affected FTD patients disproportionately in the repetition task. These results support the view that a lack of sensitivity to context underlies FTD in comprehension and production stages of processing. Patients fail to utilise linguistic context to integrate lexical forms into a global whole and guide their access to lexical targets.

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1. Introduction

1.1. Semantic processing and formal thought disorder

Formal thought disorder (FTD) is a cardinal symptom of schizophrenia observed in approximately 16% of patients (Andreasen, 1979). It is characterised by disorganised and often incomprehensible speech, and can fluctuate in severity with emotional arousal.

There is considerable evidence that a purely linguistic abnormality contributes to the speech pattern seen in FTD (see Covington

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et al., 2005 for a review). Impaired performance on semantic processing tasks distinguishes FTD patients from non-FTD patients, in the presence of preserved syntactic functioning in both groups (Rodriguez-Ferrera et al., 2001; Oh et al., 2002). However, not all aspects of semantics are compromised. FTD patients do not necessarily have difficulty with the meaning of single isolated words but are impaired in processing higher-order semantic relations (Barrera et al., 2005). FTD patients also lack sensitivity to contextualised words (Spitzer et al., 1994), to semantic, syntactic and pragmatic anomalies (Kuperberg et al., 1998, 2000, 2006a) and to semantic relations (Besche et al., 1997).

The ability to process higher-order semantic relations is partially dependent on monitoring of linguistic context. Yet it has been proposed that, "a degradation in the ability to construct and maintain internal representations of context" is a primary cognitive deficit underlying schizophrenia (Cohen and Servan-Schreiber,

1992). Within the domain of language processing, a growing body of research reporting impairment in the processing of linguistic context in schizophrenia, and FTD specifically (see Kuperberg et al., 2010 for a review), has led to the proposal that FTD patients are impaired at using linguistic context to encode meaning required for the integration of information in single words in sentence construction, and that this inability underlies disorganised speech characterising FTD (Kuperberg et al., 1998).

Event related potential (ERP) studies in schizophrenia using the N400 paradigm have also demonstrated that, as a group, individuals with a diagnosis of schizophrenia show abnormalities in processing linguistic context. In healthy individuals, words preceded by a semantically incongruous context (words or sentences) elicit N400s of larger amplitude than words preceded by a semantically congruous context (Kutas and Federmeier, 2011). Findings from studies investigating the N400 effect in schizophrenia are mixed. However, in a recent meta-analysis, Wang et al. (2011) concluded that patients with schizophrenia show an abnormally large N400 amplitude for contextually congruous material while they are not different to healthy controls when encountering contextually incongruous material. In other words, patients' language processes seem to be less constrained by semantic context in that it does not facilitate the generation of expectancies, while inhibition of contextually incongruent information seems to be relatively preserved.

ERP studies in schizophrenia have also found abnormalities of modulation of the P600, a late positivity thought to reflect a later attempt to integrate semantic and syntactic information in order to interpret the overall message. Kuperberg et al. (2006b) found that the amplitude of the P600 in patients relative to controls was significantly reduced in morphosyntactic violations (e.g. For breakfast the boys would only eats....) and in animacy–semantic violations (e.g. For breakfast the eggs would only eat...). These findings seem to suggest that in schizophrenia an abnormality in combining semantic and syntactic information online to build up propositional meaning leaves sentence processing to be primarily driven by semantic relationships between individual words.

Together these findings have led to the proposal of an imbalance in schizophrenia between locally based semantic analysis and the extraction of syntactic, pragmatic and other cues, resulting in sentence level processing anomalies (Kuperberg et al., 2010). This proposal of an imbalance in processing streams biasing semantic association analysis provides an account of a pattern of language abnormalities which seems to neatly capture the main characteristic of FTD, namely a preoccupation with the relationship between individual words. Indeed many electrophysiological studies have found correlations between reduced N400 and FTD (e.g. Andrews et al., 1993; Debrulle, 2007; Kuperberg et al., 2006b; Ditman and Kuperberg, 2007; Kostova et al., 2005; Kreher et al., 2008; Sitnikova et al., 2009), which seems to suggest a specific link between FTD and the inefficient use of linguistic context.

It has alternatively been proposed that impaired contextual processing is not specific to FTD, but characteristic of schizophrenia as a whole, and that FTD only manifests when integration processes break down completely, a proposal yet to be rigorously tested. Moreover, contextual processing studies have primarily assessed patients' performance on comprehension-based tasks, assuming the same failure of mechanisms to be involved in the processing context in speech. There are good theoretical reasons for expecting the same factors to influence patients' speech production. Comprehension and production processes are interwoven (Pickering and Garrod, 2007, 2013): production is understood as a mapping of information from higher to lower linguistic levels while comprehension operates in reverse. Production relies on internal self-monitoring (of the utterance under construction) and external self-monitoring (of the output), both using comprehension processes that convert sound to

meaning (Levelt, 1989). Furthermore, comprehension and production processes demonstrate the recruitment of overlapping neural circuits (Scott and Johnsruide, 2003). Thus, the combining of semantic and syntactic information from context to create higher-order semantic connections serves both speech input and output systems (Levelt, 1989; Monsell, 1987). A disruption to these connections would thus manifest in both comprehension and production. However, the crucial experiments comparing comprehension and production have not been conducted.

1.2. Emotional arousal and formal thought disorder

FTD can vary over time and severity may fluctuate. It has been widely observed that, in a clinical setting, patients show more thought disorder when they are emotionally aroused, for example, when discussing their symptoms. FTD in schizophrenia has been shown to increase in interviews with emotionally salient material (Haddock et al., 1995), and similar results have been found in thought disordered manic patients (Tai et al., 2004). Furthermore, certain types of communication disturbances in schizophrenia have been found to be more reactive to affect, namely poor reference performance (Docherty et al., 1994a, 1994b), vague references, confused references and ambiguous word meanings (Docherty and Hebert, 1997). While there is considerable evidence that affect modulates language processing in schizophrenia, this has not been examined specifically in relation to the emerging evidence that an abnormality of contextual processing underlies FTD.

1.3. Aims

The first aim of the present study was to extend the findings of Kuperberg et al. (1998, 2000) by investigating FTD patients' sensitivity to semantic context in both comprehension and production in an off-line task using the same linguistic material for both modalities, in comparison to non-FTD patients and matched healthy controls. A verbatim sentence repetition task was used for the production task since this type of immediate recall is believed to employ the same mechanisms as those used in normal speech production (Potter and Lombardi, 1992), in that recall is believed to be reconstructed by drawing on activated conceptual and lexical-semantic information (e.g. Levelt, 1989). This allows investigation of participants' ability to construct the global whole within a visible context. The second aim of this study was to examine whether emotional arousal would have a detrimental impact specifically on FTD patients' ability to integrate contextual information in sentence comprehension and production.

It was predicted that the FTD group would produce more errors in both comprehension and production than non-FTD patients and healthy controls. While the rate of errors made by all groups was expected to increase with sentence complexity due to the increased working memory demand, FTD patients were predicted to be more affected by increasing complexity. Similarly, it was predicted that negative emotional arousal would result in poorer performance in all groups, but that the greatest decrement would be observed in the FTD patients.

2. Method

2.1. Participants

All patients met Diagnostic and Statistical Manual of Mental Disorders (4th ed., DSM-IV, American Psychiatric Association, 1994) criteria for schizophrenia, were aged 18–65, and were native British speakers of English. All patients had ongoing chronic symptoms despite having been relatively stable on neuroleptic medication between 4 months and 5 years (average length of treatment, 3.9 years). They were

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