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Schizophrenia Research 84 (2006) 272–280

SCHIZOPHRENIA RESEARCH

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Evidence of semantic disorganisation using semantic priming in individuals with high schizotypy

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Received 8 September 2005; received in revised form 24 January 2006; accepted 27 January 2006
Available online 29 March 2006

Abstract

Semantic processing deficits are present in schizophrenia and are particularly evident on semantic priming tasks. Using high schizotypes (psychosis-prone individuals) can overcome some confounds involved in studying actively symptomatic schizophrenics. In the current study, 26 high and 32 low scorers on the O-LIFE schizotypy scale (from a sample of 251 students) were selected for testing. All subjects were administered a lexical-decision semantic priming task where half the stimuli had a short 200 ms stimulus onset asynchrony (SOA, length of time from onset of prime to onset of target) and half the stimuli had a long 750 ms SOA. In addition, half the words were of high frequency and half of a low frequency. There were no group differences in priming for words of different frequencies. Low schizotypes showed greater priming at the 200 ms SOA than at the 750 ms SOA, whilst individuals with high schizotypy showed the opposite pattern. The pattern shown by the low schizotypes replicates earlier work by the authors using other normal control samples; establishing that there is greater priming under conditions of automatic spreading of activation. Furthermore, the data shows there is not an increase in automatic spreading of activation in individuals with high schizotypy. There has been controversy in the schizophrenia literature over whether there is increased priming under automatic conditions. The current study suggests that, when confounds are controlled for, schizophrenia-like symptoms are not related to an increase in automatic spreading of activation.

Keywords: Semantic priming; Schizotypy; Schizophrenia; Semantic disorganisation

1. Introduction

It has long been suggested that schizophrenic symptoms arise from a disturbance in the organisation of knowledge (e.g. Bleuler, 1911). In terms of symptomatology, this is perhaps best demonstrated in patients with thought disorder where an individual's

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0920-9964/$ - see front matter
doi:10.1016/j.schres.2006.01.020

speech will often be very difficult to follow as statements seem unrelated to the person's own previous discourse. More recently, delusions have been conceptualised as a manifestation of semantic deficits and there is some evidence to support this notion (e.g. Rossell et al., 1999). As such, semantic processing deficits are considered by some researchers to be central to cognitive abnormalities in schizophrenia, and are present on a wide range of tasks (Brebion et al., 2004; Rossell et al., 1998; Rossell et al., 2000).

Semantic priming is one of the most commonly used methods used to assess semantic deficits in schizophrenia. This technique examines the nature of the relationship between the mental representations of words. Semantic priming refers to the facilitation of responding to a word (e.g. table), when it is preceded by a semantically *related* word (e.g. chair) as compared with an *unrelated* word (e.g. sheep) (Neely, 1977; Meyer and Schvaneveldt, 1971; Fischler, 1977). This facilitation is proposed to occur as semantic knowledge is organized in networks of interconnected concepts or 'nodes'. Activating a node in this semantic network is thought to result in a spread of activation to nearby concepts in a network, resulting in a lower threshold of activation for these nodes. Research examining semantic priming in schizophrenia has yielded equivocal results: some studies report increased priming in schizophrenic patients (Moritz et al., 2001; Spitzer et al., 1993); several describe decreased priming (Condray et al., 1999; Rossell et al., 2000); and some found no difference between schizophrenic and control subjects (Passerieux et al., 1995; Vinogradov et al., 1992). Several variables have been identified as potentially accounting for these discrepancies in the schizophrenia literature including medication, attentional dysfunction and reaction time confounds.

Within the 'normal' population, many individuals will experience something akin to a schizophrenic experience at some point in their lifetime (Launay and Slade, 1981). Some have argued that, rather than a discrete, diagnostic category, the concept of schizophrenia should be redefined as symptoms occurring on a *continuum* (Chadwick et al., 1996; Claridge, 1987). This notion of a continuum of schizophrenic symptoms has been termed schizotypy: at one end are individuals who experience full-blown psychotic symptoms and further along the continuum to 'normal' are healthy individuals who have personality traits that mark a proneness to psychosis, for instance believing in telepathy or magic. The concept of schizotypy has been shown to have validity in that healthy volunteers with high scores on schizotypy scales demonstrate poorer performance on tasks upon which schizophrenic patients themselves exhibit deficits (Claridge, 1997; Peters et al., 1994). In addition, individuals with high schizotypy scores are at a greater risk of developing a schizophrenic illness (Chapman et al., 1994). Hence, this population has been used to examine cognitive processes that are impaired schizophrenia in an attempt to circumvent some of the confounding variables in schizophrenia research, such as those discussed above in reference to semantic priming.

Despite a wealth of research examining the cognitive profile of schizotypal individuals, there have been few studies to date that have investigated semantic priming in this population. Studies with high schizotypes have found both increased (Moritz et al., 1999) and unaffected semantic priming (Fisher and Weinman, 1989; Pizzagalli et al., 2001). However, the interpretation of the above findings has been complicated by the use of either small numbers of subjects or little validated measures of schizotypy. In addition, all but one of these studies examined priming at following a brief duration between the onset of the target and prime (stimulus onset asynchrony – SOA).

Research with schizophrenic patients has manipulated the SOA to attempt to tease apart the relative contributions of automatic and controlled processing. Considerable debate has raged as to whether schizophrenia is a disturbance in controlled or automatic processing. Automatic cognitive processes occur quickly and make slim demands on attentional processes, however controlled processing occurs more slowly and relies heavily on attentional processes. It has been suggested that cognitive impairments in schizophrenia are a function of a deficit in controlled and not automatic processes (Nuechterlein and Dawson, 1984). There is some evidence from the semantic priming in schizophrenia literature however that both controlled and, less consistently, automatic semantic processing deficits are present (Minzenberg et al., 2002). This is suggestive of a disruption in the storage of, or access to semantic information and not a secondary effect of the well-documented attentional disturbances associated with the disorder. In semantic priming research, the length of the SOA is varied in an attempt to provoke relatively more automatic or controlled processing. Up to an SOA of approximately 250 ms, it is thought that it is largely the automatic spread of activation that is responsible for the priming effect. However, after an SOA of approximately 700 ms, it is thought that controlled processes begin to operate. These controlled processes are proposed to include expectancy effects and semantic matching (Neely and Keefe, 1989). Expectancy is the pre-lexical mechanism whereby a set of potential targets is generated from a prime. It is thought that the processing of words outside the expectancy-generated set is inhibited, leading to increased reaction times (RTs) for unrelated words. Semantic matching refers to the matching post-lexically of the primes and targets for semantic similarity. The presence or absence of a semantic relationship provides information about the lexical status of a word (Chwilla et al., 1998). Moritz et al. (1999) found that semantic priming in people who score highly on a language disturbance scale was enhanced both at a short and long SOA. However, it is not clear how this scale might relate to the notion of schizotypy. To our knowledge, no previous study has examined the impact of schizotypy on semantic priming at different SOAs.

Other parameters may also be manipulated in semantic priming tasks to yield valuable insights into the nature of semantic memory impairments. In semantic dementia, patients who exhibit a progressive degradation of the semantic memory store ‘lose’ low-frequency words first (Warrington, 1975; Warrington and Cipolotti, 1996). However, certain aphasic patients have impaired access to semantic memory, and find low and high frequency words equally difficult to name (Warrington and Shallice, 1979). Thus, using high and low frequency words in a semantic priming paradigm could theoretically differentiate between impairments in access to, or storage of, semantic knowledge (Rossell and David, 2006). No previous research has examined the effect of frequency on semantic priming in high and low schizotypy subjects.

Research utilising high schizotypes (psychosis-prone individuals) could overcome some of the confounds involved in studying actively symptomatic schizophrenics – since the former are non-psychotic, unmedicated and unhospitalised – as well as providing important information on the possible cognitive underpinnings of psychotic symptoms. Therefore, the aim of this project was to investigate semantic priming in individuals who rate highly on a self-report measure of schizotypy. If the highly psychosis-prone individuals have deficits in automatic semantic processing (i.e. it is slower), a lower rate of priming should be evident in this group at the short SOA. However, if they possess impaired or slower controlled and not automatic processing, a lower rate of priming should be evident in the high schizotypes at the long SOA. In terms of the frequency manipulation, a lower level of priming for low frequency words alone may indicate a problem with storage of semantic information, whereas lower priming for both high and low frequency words would be suggestive of an impairment in access to the semantic store. In addition, by using a comprehensive measure of schizotypy, we aimed to examine the relationship between different schizotypal factors and any semantic priming deficits.

2. Methods

2.1. Participants

251 native English-speaking students completed the Oxford-Liverpool Inventory of Feelings and the Experiences (O-LIFE; Mason et al., 1995) questionnaire initially. The O-LIFE is a 159-item questionnaire based on the Combined Schizotypal Traits Questionnaire (CSTQ; Bentall et al., 1989), and yields four factors: unusual experiences, cognitive disorganisation, introvertive anhedonia, and impulsive non-conformity.

Unusual Experiences relates to unusual perceptual events, hallucinatory experiences, and magical thinking. This is the most consistent factor emerging in analyses of schizotypal scales (Bentall et al., 1989; Nunn and Peters, 2001) and is represented by such questions as: ‘I have felt that I have special, almost magical powers’ and ‘Does your sense of smell sometimes become unusually strong?’.

The factor of Cognitive Disorganisation represents difficulties in sustaining attention and concentration, as well as moodiness and social anxiety, this is scored by questions such as: ‘No matter how hard you try to concentrate, do unrelated thoughts always creep into your mind?’ and ‘Do you frequently have difficulty starting to do things?’.

Introvertive Anhedonia is conceptualised as difficulties in gaining enjoyment from social, or other sources, a lack of enjoyment of physical and emotional intimacy, and a preference for spending time alone. These items are thought to relate particularly to the ‘negative symptoms’ of schizophrenia and are identified by such items as: ‘There are just not many things that I have ever really enjoyed’ and ‘Are people better off if they stay aloof from emotional involvement with people?’.

The factor of Impulsive Non-conformity taps into asocial behaviours, impulsivity and non-conformity. Items on this factor include: ‘Do you ever have the urge to break or smash things?’ and ‘Do you often feel like doing the opposite of what people suggest, even though you know they are right?’.

In addition to providing separate scores for each of the four factors, analysis of the O-LIFE also generates a composite ‘schizotypy’ score (STA score). The questionnaire also generates an Extraversion score, these questions were included in the O-LIFE as ‘filler items’ and the data from these were not analysed.

Participants for the experimental stage were selected based on their scores on the STA sub-scale of the O-LIFE. The O-LIFE scores were trichotomised based on pilot work into groups corresponding to, for the low scorers the bottom 10th percentile, and the high scorers the top 90th percentile. The high schizotypy group was comprised of 26 (13 males) students who scored between 24 and 36 and the low schizotypy group were 32 (12 males) students who scored between 0 and 10.

2.2. Design and procedure

An independent groups design was used to compared the high and low schizotypy groups. All participants gave written, informed, witnessed consent and were paid for participation. Subjects in the experimental stage were tested on semantic priming and premorbid verbal IQ was estimated by the National Adult Reading Test (NART; Nelson, 1982).

2.3. Semantic priming task

Semantically related, unrelated and word–pseudo prime–target pairs were presented with a frequency and SOA manipulation. The stimuli were 560 concrete nouns and 120 pseudo-words. They were arranged into 240 prime–target pairs; 120 word–word pairs which were semantically related and 120 words followed by pseudo-words. Semantically related pairs were related by virtue of being co-exemplars of a given category (e.g. lemon–*pear*) rather than associative relationships (e.g. key–*lock*). These semantically related pairs were formed using category norms from Battig and Montague (1969). All words had 3–8 letters. 230 of the word stimuli had a frequency of 1–30 words per million (low frequency), the other 230 word stimuli had a frequency of >30 words per million (high frequency) (MRC Psycholinguistic database). Both words in the word–word pairs had the same frequency rating, i.e. either both high or both low. The word–pseudo-word pairs had 120 words with a high frequency and 120 with a low frequency. Pseudo-words were pronounceable and legally spelled letter strings (e.g., pont), and were selected from the ARC non-word database.

The semantically related stimuli were further divided into two shorter lists (A and B). In version A, 60 word–word pairs maintained their semantic relationship (related), while the pairing of the remaining 60 was re-arranged so that they now formed unrelated word pairs (unrelated). In version B, these relationships were counterbalanced, so that related pairs were now randomly re-assigned to create unrelated pairs, and the unrelated pairs were correctly assigned to their related word pairing. Each final list therefore contained three types: *related*, *unrelated* and *pseudo*, with 50% of the word stimuli having a low frequency and 50% a high frequency. The experiment was run at a short SOA, 200 ms (i.e. length of time between prime–target presentation) and a long SOA, 750 ms. Primes were presented for 200 ms, there was a 0 ms or a 550 ms blank screen and then the target followed for 200 ms. There was a blank screen between trials of 2500 ms and the subjects are able to respond for 2000 ms after the target presentation. All letters were in lower case Times New Roman with a 44-point font. Stimuli were presented in the centre of a computer screen and the subjects used a two-button press to indicate whether the target was a real or a pseudo-word. Reaction times and accuracy were recorded. An analysis of the accuracy data revealed no main effect of group or interactions with group, thus suggesting that accuracy was well matched between the two groups.

2.4. Statistical analysis

Demographic data were analysed with independent groups *t*-tests, where data were non-parametric with a Mann–Whitney *U* test and frequency data with χ^2. For the semantic priming task, subjects making more than 20% errors were excluded however none met these criteria. In addition, reaction times (RTs) more than 2.5 standard deviations (S.D.) from the overall mean for each subject were excluded, and RTs faster than 250 ms and slower than 1500 ms were discarded. Subjects were also excluded if more than 20% of their data had been discarded due to overly short or long RTs; however, again none met these criteria. Reaction time and accuracy data for the semantic priming task were subjected to a $2\times2\times2\times2$ repeated measures ANOVA with a between subjects factor of Groups (high or low schizotypy), and 2 within subjects factors of Relatedness (related or unrelated word pairs), Frequency (high or low) and SOA (short or long). When significant interactions emerged involving the relatedness factor, the level of priming effect was computed (unrelated − related) and used in subsequent analysis. Post-hoc tests were then conducted and Bonferroni corrected for multiple comparisons ($\alpha=0.025$). Where significant group differences in priming emerged, Bonferroni corrected correlations were performed between priming scores in the high schizotypy group and the factors of the O-LIFE.

Table 1
Demographics

	High, $N=26$	Low, $N=32$
Male/Female	12/14	13/19
Age (years)	21.2 (1.7)	21.1 (2.7)
No. of years education	15.5 (1.33)	15.3 (2.2)
NART IQ	112.7 (6.81)	113.0 (5.3)
NART Verbal IQ	112.34 (7.57)	112.7 (5.9)

Table 2
Mean scores across groups on the factors of the O-LIFE

Scores out of 36	High	Low	*F*	p
Unusual experiences	20.2 (4.3)	4.1 (2.9)	288.4	0.001
Cognitive disorganisation	18.0 (3.2)	6.9 (4.9)	96.9	0.001
Introvertive anhedonia	6.2 (4.6)	3.6 (3.4)	5.9	0.01
Impulsive non-conformity	13.9 (2.7)	7.3 (3.5)	61.9	0.001
STA	26.6 (2.7)	7.0 (2.6)	796.9	0.001

3. Results

3.1. Subjects

All participants were between the ages of 18 and 31 years, with estimated IQ scores ranging between 103 and 122 points (as scored by NART). There was no significant difference in age, gender, education, handedness or IQ between the two subject groups (Table 1).

A general propensity to delusional thinking was assessed using the PDI (Peters' Delusional Inventory; Peters et al., 1999), revealing that the high schizotypy group showed a greater degree of delusional thinking than the low schizotypy group (scores out of 21: high = 11.2 (S.D. = 7.5) and low = 3.8 (S.D. = 2.5); $F(1,57)=27.9$, $p<0.001$). There were additionally significant differences between the groups on all

Table 3
Semantic priming reaction time data

SOA	Variable	High	Low
Short	High related	691.9 (102.3)	670.4 (109.7)
	Low related	723.4 (117.1)	701.9 (122.6)
	High unrelated	701.6 (92.9)	706.9 (120.3)
	Low unrelated	737.9 (90.3)	739.5 (141.7)
	High pseudo	776.7 (82.8)	797.0 (126.9)
	Low pseudo	777.9 (98.8)	777.6 (118.8)
Long	High related	666.9 (91.1)	669.8 (122.1)
	Low related	706.7 (102.2)	707.6 (108.2)
	High unrelated	701.9 (88.6)	688.8 (121.0)
	Low unrelated	756.3 (113.2)	726.9 (130.1)
	High pseudo	766.8 (90.5)	776.0 (125.2)
	Low pseudo	761.8 (103.1)	774.6 (128.7)

factors of the schizotypy scale, as well as overall schizotypy scores (see Table 2).

3.2. Semantic priming task

3.2.1. Reaction time data

A $2\times2\times2\times2$ repeated measures ANOVA with 2 subject groups (high and low), 2 types of relatedness (related and unrelated pairs), 2 types of frequency (high and low) and 2 different SOAs (short and long) was performed using the reaction time data (Table 3). There was no main effect of group indicating that high and low schizotypes were well matched on their mean overall reaction times. Main effects were found for relatedness and frequency. The relatedness main effect [$F(1,54)=37.8$, $p<0.001$] indicated that reaction times were faster for related word pairs (692.3 ms) than unrelated word pairs (719.9 ms), indicating that priming has occurred. The frequency main effect [$F(1,54)=75.7$, $p<0.001$] indicated that reaction times were faster to high frequency (687.3 ms) than low frequency word pairs (725.0 ms). Frequency did not interact with any of the other test variables. There was a three-way interaction between group, relatedness, and SOA [$F(1,54)=5.7$, $p<0.05$] (see Fig. 1 where priming effect = unrelated RT − related RT).

The low schizotypy group had lower priming scores at the long SOA (related = 688.7 ms and unrelated = 707.9 ms) compared to the short SOA (related = 686.1 ms and unrelated = 723.2 ms). In comparison, the high schizotypy group had greater priming at the long SOA (related = 686.8 ms and unrelated = 729.1 ms) compared to the short SOA (related = 707.6 ms and unrelated = 719.7 ms). Post-hoc tests revealed trends in the high schizotypy group both for lower priming at the short SOA ($p=0.076$) and greater priming effect at the long SOA ($p=0.077$) than in the low schizotypy group.

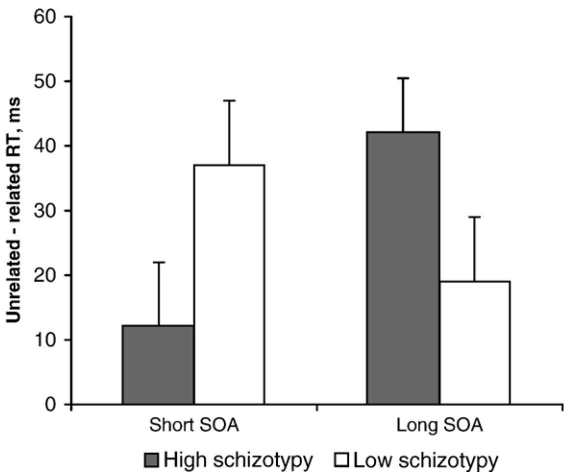

Fig. 1. Priming effect across the long and short SOAs in the high and low schizotypy groups.

3.2.2. Accuracy data

A $2\times2\times2\times2$ RMANOVA, with a between subjects factor of Group and within subjects factors of Relatedness, SOA and Frequency was conducted. There was a main effect of Frequency [$F(1,56)=39.9$, $p<0.001$], reflecting greater errors to low (5.3%) compared to high (1.8%) frequency word pairs. In addition there was a main effect of Relatedness [$F(1,56)=18.9$, $p<0.001$] with more errors to unrelated (4.9%) than related word pairs (2.2%). There was also a significant Frequency x Relatedness interaction [$F(1,56)=7.4$, $p<0.009$]. Error rates across the different types of word pairs were: high frequency related (1.2%), high frequency unrelated (2.4%), low frequency related (3.3%), low frequency unrelated (7.5%). There were no main effects of Group or interactions with Group.

3.3. Correlations

In the high schizotypy group there were trends, after Bonferroni correction, for a correlation between the increased priming observed at the long SOA and the unusual experiences subscale of the O-LIFE ($r=0.43$, $p=0.032$), along with the overall STA score ($r=0.45$, $p=0.024$).

4. Discussion

This study set out to examine semantic processing in high and low schizotypy groups using a semantic priming task. The main findings were an indication of lower priming in high scorers on a schizotypy scale at the short SOA compared to the low schizotypy group. The reverse pattern was observed at the long SOA with greater priming in low compared to high schizotypes. The increased priming at the long SOA was correlated with overall schizotypy score and the score on the subfactor of unusual experiences. There were no group differences in priming for words of high and low frequency.

The priming effect at the short SOA in the low schizotypes is evidence of the automatic spread of semantic activation. The priming effect at this SOA was much smaller in the high schizotypy group. This reduction in priming at the short SOA in the high schizotypes may reflect slower automatic spreading of activation in the semantic network in these individuals. Compared to the short SOA, at the long SOA, a reduction in priming was observed in the low schizotypes. Lower priming at the long SOA compared to the short SOA in the low schizotypy group is consistent with that observed in and other healthy control groups (Rossell et al., 2003; Morgan et al., 2006) and has been hypothesised to be due to controlled processes delaying priming at this time interval (Rossell et al., 2003). At the long SOA, the increased priming observed in the high schizotypy group may reflect one of two processes. In the high schizotypes, it may be that controlled semantic processes, such as semantic matching and expectancy, are enhanced. This could possibly indicate a mechanism to compensate for impaired automatic spreading of activation. Conversely, however, it may be that controlled processes are impaired and hence the putative delay in priming as a result of the operation of these controlled processes, observed in this study in the low schizotypy group, is absent. Whilst these data cannot speak to this issue, further work manipulating expectancy and semantic matching may help to elucidate these underlying processes.

The priming effects in the high schizotypes were correlated with the subfactor of unusual perceptual experiences, however only at the long SOA. It has been suggested that semantic priming deficits underlie thought disorder in schizophrenia (Moritz et al., 2003). This was not reflected in this population, as schizophrenic thought disorder is most similar to the schizotypy subfactor of cognitive disorganisation (Mason et al., 1995). Unusual perceptual experiences comprise of delusions (see also Rossell et al., 2000). Speculatively, abnormal semantic processing may lead to aberrant links between nodes in the semantic network which may be reflected in delusion ideation. However, the relationship between the priming and unusual perceptual experiences was only observed at the long SOA which perhaps suggests that altered controlled semantic processing may be more related to these traits than disrupted automatic semantic activation.

The results of the current study contradict those of recent work examining priming and schizotypy where it has been suggested that increased spreading of activation occurs in high schizotypes (Moritz et al., 1999; Pizzagalli et al., 2001). However, key methodological differences between may explain these discrepancies. Pizzagalli et al. (2001) used a small number of all female subjects. Moritz et al. (2001), who found enhanced semantic priming at both a short and long SOA, performed a median split of subjects based upon a scale of language comprehension. As language is clearly intimately linked with semantic functioning, they may have simply divided subjects into groups based on a subjective measure of semantic functioning. Thus, these results are hard to interpret in the context of schizotypy and are particularly difficult to relate to those of this study as they did not report the schizotypy scores of their participants.

There were no group differences in priming at the two different word frequencies in the current study. As the groups were well matched on this variable, it suggests that the high schizotypy group showed neither problems with access to, nor storage of, semantic information. In contrast, patients with schizophrenia (Rossell and David, 2006) and ketamine abusers (Morgan et al., 2006) have been shown to have priming deficits to low frequency word pairs, implicating an abnormality with storage of semantic information. The absence of group differences in accuracy is also important to note, as this implies that differences in priming were not a product of any general performance decrements, as has been the case in the schizophrenia literature. This also demonstrates the utility of using this population to circumvent some of the methodological problems associated with research in schizophrenia.

Within schizophrenia research, some researchers have suggested that automatic spreading of activation is enhanced (e.g. Spitzer et al., 1993), whereas some have suggested a reduced spreading of activation (Barch et al., 1996) and still others have proposed that it is a deficit in controlled processing that is responsible for semantic priming differences (Callaway and Nagdhi, 1982). Assuming similar cognitive processes underpin deficits in schizotypy and schizophrenia, the current findings with high schizotypes do not support the former hypothesis. Spreading of activation was in fact reduced. Unfortunately, these data cannot speak to whether controlled processing deficits are evident in this group, and this issue should be addressed in future research.

In summary, there were no differences in priming of words of different frequencies, suggesting an intact semantic store and no problems with access to information. However idiosyncratic semantic processing was observed in the high schizotypy group at the two different SOAs. Our findings suggest that spreading of activation is impaired, or delayed, in high schizotypes as was evident in reduced priming at a short SOA. There was additionally some evidence of potential compensatory controlled processing at a long SOA which was related to the degree of unusual perceptual experiences reported in these individuals. This research has demonstrated semantic disorganisation in healthy subjects who report elevated schizotypal symptoms, and hence reinforced the validity of this approach in addressing confounds in patient studies.

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