The relationship between atypical semantic activation and odd speech in schizotypy across emotionally evocative conditions

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A B S T R A C T

Introduction: Odd speech is prevalent in individuals with schizotypy compared to controls and this odd speech is particularly pronounced under stress-induced conditions. Despite a number of research studies that have examined odd speech, the mechanisms underlying this phenomenon remain unclear. There is reason to suspect that the increase in odd speech observed in schizotypy may reflect atypical semantic activation patterns, defined in terms of increased activation of weakly associated words within the semantic network.

Methods: In this study, we compared atypical semantic activation in individuals with a broad set of cognitive-perceptual, interpersonal and disorganization schizotypal traits (n = 83) and controls (n = 23). Odd speech was measured using a behavior-based analysis of natural speech procured from a laboratory speech-task involving separate experimentally manipulated stressful, pleasant, and neutral conditions.

Results: The schizotypy and control groups did not differ in semantic activation, but atypical semantic activation was more pronounced in individuals with disorganization traits and attenuated in those with interpersonal traits. Interestingly, the relationship between semantic activation and odd speech was observed for the stressful, but not pleasant or neutral conditions in the schizotypy group.

Conclusions: These findings suggest that individuals with schizotypy may be able to inhibit atypical associations in nonstressful situations. However, their ability to prevent atypical semantic activation from affecting speech may be disrupted under stress, thus resulting in more odd speech. This study also highlights the dramatic differences in semantic activation across the various manifestations of schizotypy.

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1. Introduction

Odd speech is a cardinal symptom of schizophrenia that was first described during early conceptualizations of the disorder (Bleuler, 1911; Kraepelin, 1919). This symptom is often characterized by ambiguous references, loss of goal-directed thought, and loose associations between phrases (Docherty et al., 1996; McKenna and Oh, 2005). Despite receiving increasing empirical attention over the last few decades, the mechanism underlying odd speech in schizophrenia is poorly understood. One explanation for the higher frequency of odd speech in schizophrenia is an increase in atypical associations within semantic memory. Support for this explanation has been marshaled from studies of schizophrenia employing verbal fluency tasks, where researchers have observed that patients produce more atypical exemplars that are less likely to be semantically related to the exemplars preceding or following them when compared to healthy controls (Aloia et al., 1996; Paulsen et al., 1996; Sumiyoshi et al., 2005; Tamlyn et al., 1992).

There is also some evidence to suggest that odd speech is elevated in individuals who demonstrate subclinical traits of
schizophrenia (Minor and Cohen, 2010), a condition commonly referred to as schizotypy (Chapman et al., 1978; Horan et al., 2004; Meehl, 1962; Rado, 1953). Understanding the underlying mechanisms of odd speech in individuals with schizotypy may provide a more complete picture of schizophrenia, as schizotypal traits are multidimensional and resemble diminished forms of schizophrenia symptoms (Chapman et al., 1978; Horan et al., 2004; Raine, 1991). To our knowledge, only one study has investigated atypical semantic associations in schizotypy. Kiang and Kutas (2006) observed that individuals scoring high on a questionnaire measuring schizotypal traits demonstrated atypical activation patterns in semantic memory that are similar to semantic activation exhibited in schizophrenia, albeit to a lesser extent. The authors proposed that atypical semantic activation might be related to odd speech; however, odd speech was only measured using participants’ self-report. In the current project, we extended these findings by examining whether atypical semantic activation was related to odd speech in both schizotypy and control groups using a behavior-based, process measure to analyze natural speech. We also examined whether the two groups differed in terms of semantic activation. These were the primary goals of the present study.

One factor that appears to exacerbate odd speech in individuals with schizophrenia is stress, as patients demonstrate an increase in this symptom when they are asked to discuss aversive events (Docherty et al., 1994; Docherty and Hebert, 1997). There is some evidence that stress may also exacerbate odd speech in certain individuals with schizotypy (Kerns and Becker, 2008; Minor and Cohen, 2010). Conducting emotion induction studies could potentially differentiate stress responses in individuals with schizotypy compared to controls. This line of research is essential, as evidence suggests that stress may play an important role in the progression to schizophrenia (Myin-Germeys et al., 2001, 2002, 2005; Norman and Malla, 1993; Ventura et al., 1989). At present, the link between atypical semantic activation and odd speech has not been examined in schizotypy using laboratory controlled procedures. We addressed this issue by examining odd speech across a range of stressful, neutral, and pleasant evocative conditions.

An additional goal was to investigate how semantic activation differs across schizotypal traits. Heterogeneity is a hurdle in understanding schizophrenia and schizotypy, as there is no metabolic, genetic, neuroanatomical, neuropsychological symptom or trait that is present in all, or even most, individuals (Cohen and Docherty, 2005; Menezes et al., 2006). Thus, it seems unreasonable to expect that an isomorphic abnormality in semantic association occurs for all schizotypic individuals. Supporting this notion, some schizotypic traits (i.e., disorganization traits) have been associated with increased odd speech while other traits have been associated with reduced odd speech (i.e., interpersonal/negative traits; Minor and Cohen, 2010). Only one previous study has investigated the relationship between semantic activation and schizotypal traits (Kiang and Kutas, 2006). In that study, the authors defined schizotypy as a dimensional construct and administered a psychometric questionnaire to 60 individuals who were not chosen based on schizotypal traits. Here, we administered the same questionnaire and selected participants based on their scores on three scales measuring schizotypic traits. This conceptualization is consistent with many landmark studies, in which schizotypy is defined as a discrete category (see Chapman et al., 1994; Kwapil, 1998; Gooding et al., 2005). To our knowledge, our study is the first to examine the relationship between schizotypal traits and semantic activation using a categorical conceptualization of schizotypy.

In the current study, we had four major aims. First, we compared semantic activation in schizotypy and control groups with the expectation that semantic activation would be more atypical in schizotypy. Second, we examined the degree to which atypicality of semantic association networks was related to odd speech separately for both groups. Our expectation was that a significant relationship between odd speech and atypical activation would be observed in the schizotypy, but not control, group. Third, we attempted to clarify whether atypical semantic activation would exacerbate as a function of stress. We believed that atypical semantic activation would be highly correlated with odd speech in the schizotypy, but not control, group when stress was induced. Finally, the relationship between semantic activation and cognitive–perceptual, interpersonal, and disorganization schizotypal traits was examined in order to better understand heterogeneity within schizotypy. Here, we hypothesized that disorganized schizotypy would be related to more atypical semantic activation, and interpersonal traits would be inversely associated with atypical semantic activation.

2. Method

2.1. Participants

Participants were adults recruited from a university in the Southeastern United States and data from this sample has previously been presented in Minor and Cohen (2010). A measure of schizotypal traits was administered to 1775 adults. Follow-up testing was conducted in our laboratory and participants who scored at the 95th percentile on at least one of three symptom subscales were recruited for the schizotypy group. Individuals who scored below the mean on each subscale were recruited for the control group. In total, data for 23 control participants and 83 individuals with schizotypy were examined here.

2.2. Measures

A modified version of the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) was utilized to assess schizotypal traits. The SPQ consists of 74 items across nine subscales (Ideas of Reference, Social Anxiety, Magical Ideation, Unusual Perceptions, Eccentric Behavior, No Close Friends, Odd Speech, Constricted Affect, and Suspiciousness). These subscales comprise a three-factor structure consisting of cognitive–perceptual, interpersonal, and disorganization traits (Chen et al., 1997; Fossati et al., 2003; Raine et al., 1994). In this study, we used the criteria outlined by Raine (2010), with one exception. For the interpersonal scale, we only used the No Close Friends, Constricted Affect subscales and omitted Social Anxiety and Suspiciousness. The modified version of the SPQ utilized in this study used a five-point Likert-style response format (see Wuthrich and Bates, 2005; Cohen et al., 2010, for validity data). Total SPQ and factor scores were calculated by summing the z-transformed scores (computed from the screening sample separately by sex and ethnicity) of corresponding subscales.
The Typicality Index (TI; Kiang and Kutas, 2006) was employed here and is a quantitative method of measuring semantic associations using responses from a category fluency (CF) test. Results using TI from a Fruit CF test show promise for differentiating between individuals with schizotypy and healthy controls, as high scorers on a psychometric schizotypy measure demonstrated significant increases in TI compared to low scorers in a population of 60 healthy adults (Kiang and Kutas, 2006). The CF subtest in this study was utilized from the Repeatable Battery for the Assessment of Neuropsychological Status Form A (RBANS-A; Randolph, 1998). On this test, participants had one minute to name as many fruits and vegetables as they could. Each participant’s set of responses was compared to RBANS-A normative data to form their TI score (Kiang and Kutas, 2006; for norms, see Minor et al., submitted for publication), with higher TI reflecting more atypical semantic activation (i.e., ‘satsuma’ is rated as a less typical response for fruit than ‘apple’, therefore it has a higher TI score). The order of each response from participants served as the value $i$ (i.e., the fruit or vegetable said first was given an $i$ value of 1, the second response an $i$ value of 2, etc.). Where each given response is ranked in the norms served as the value $j$. For example, if ‘apple’ was the first response given, it has an $i$ value of ‘1’ and an $j$ value of ‘1’, as it is the most likely first response according to our normative data. In contrast, if ‘satsuma’ is the tenth response given, it has an $i$ value of ‘10’ and an $j$ value of ‘43’, as it had the 43rd highest odds ratio according normative data from our laboratory (for full protocol, see Kiang and Kutas, 2006).

Participants completed a narrative task and speech samples were recorded across three emotionally-valenced conditions (pleasant, neutral, and stressful). In each condition, participants viewed photographs from the International Affective Picture Systems (IAPS), a library of approximately 1000 pictures designed to elicit a wide range of reactions. Each condition consisted of ten photographs displayed for 40 s each at a total time of 6 min. Speech samples were later transcribed in our laboratory and Communication Disturbances Index (CDI) ratings were made using these narratives (for more information, see Minor and Cohen, 2010).

The CDI (Docherty, 1996) was used to assess odd speech in this study. The CDI is a behavior-based measure that employs a frequency count of communication failures from natural speech. Six different types of communication failures are included (vague references, confused references, missing information references, ambiguous word meanings, wrong word references, and structural unclarity) and these scores are summed to compute a total score. Using the CDI, odd speech is calculated as number of errors per 100 words to control for differences in the amount of speech generated by participants. The CDI has been used to differentiate the speech of healthy controls from both patients with schizophrenia (Docherty et al., 1996, 1998, 2003) and individuals with schizotypy (Minor and Cohen, 2010). For this study, the first author and an undergraduate student rated all transcripts and were blind to participant group, but not condition. High interrater reliability (0.91) was observed on thirty transcripts rated by both. Data concerning odd speech from this study. The CDI is a behavior-based measure that employs (for full summary, see Minor et al., submitted for publication). Second, we examined whether there were differences on demographic variables between the schizotypy and control groups. Independent t-tests were used to determine whether groups differed in age or gender and an ANOVA was conducted to examine whether groups differed according to ethnicity. Third, independent t-tests were employed to compare fluency and atypical semantic activation in the schizotypy and control groups. The relationship between fluency and atypical semantic activation was examined using correlations. Finally, we examined the relationship between atypical semantic activation and schizotypy traits within the schizotypy group. We also investigated how atypical semantic activation was related to odd speech in the schizotypy and control groups using correlations and Fisher r-to-z transformations. These analyses were conducted to examine whether the correlation between odd speech and atypical activation was stronger in the schizotypy group when stress was induced. An alpha level of 0.05 was used to determine significance for all analyses.

### 3. Results

#### 3.1. Demographic factors

No group differences were observed between the schizotypy and control groups when demographic variables were compared (Table 1).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive data for the schizotypy and control groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Control TI ($n = 23$)</td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
</tr>
<tr>
<td>Female</td>
<td>13</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>18</td>
</tr>
<tr>
<td>African American</td>
<td>4</td>
</tr>
<tr>
<td>Asian American</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic American</td>
<td>0</td>
</tr>
<tr>
<td>Other ethnicity</td>
<td>1</td>
</tr>
<tr>
<td>Age</td>
<td>Mean (SD) 19.91 (3.50)</td>
</tr>
</tbody>
</table>

Raw scores for overall CDI in the control group were: stressful, $M = 2.04$, $SD = 1.12$; neutral, $M = 1.65$, $SD = 0.81$; pleasant, $M = 1.66$, $SD = 0.79$.
was examined, no significant relationship between atypical semantic activation and SD groups’ fluency was significant associations with odd speech for any of the three speech conditions. In the schizotypy group, atypical semantic activation was related to odd speech in the stressful condition and atypical semantic activation was significantly higher in the stressful compared to neutral condition (Table 3). No other significant associations were found.

### 3.2. Atypical semantic activation: Schizotypy versus controls

The results of an independent t-test indicated no significant differences in atypical semantic activation between schizotypy (M = 2.82, SD = 0.94) and control groups (M = 2.72, SD = 0.75). There were also no significant differences when groups’ fluency scores were compared (schizotypy: M = 19.47, SD = 4.08; control: M = 19.57, SD = 3.74). When the relationship between atypical semantic activation and fluency scores was examined, no significant correlations were observed in either the schizotypy, r (83) = −0.05, p > 0.65, or control groups, r (23) = −0.04, p > 0.85.

### 3.3. Atypical semantic activation: Odd speech in schizotypy and control groups

In the control group, atypical activation was not significantly associated with odd speech for any of the three speech conditions. In the schizotypy group, atypical semantic activation was significantly associated with increased odd speech in the stressful condition, but not in the neutral or pleasant conditions (Table 2).

When correlations between groups were compared, we observed that the correlation was significantly stronger in the schizotypy versus control group during the stressful condition. Correlations between the two groups in the pleasant and neutral condition did not reach the level of significance. Correlations between speech conditions were also compared within each group. In the schizotypy group, we observed that the relationship between odd speech and atypical activation was significantly higher in the stressful compared to neutral condition (Table 3). No other significant associations were found.

### 3.4. Atypical semantic activation: Heterogeneity within 2schizotypy

A significant relationship was observed between atypical activation and disorganized schizotypy, and an inverse correlation between atypical activation and interpersonal schizotypy was found (Table 4). Cognitive–perceptual traits were not significantly related to atypical semantic activation.

### 4. Discussion

Our primary goal in this project was to examine whether atypical semantic activation was related to odd speech in individuals with schizotypy and controls across a range of emotionally evocative conditions. Researchers have observed that patients with schizophrenia demonstrate more atypical semantic associations than healthy controls (Aloia et al., 1996; Paulsen et al., 1996; Sumiyoshi et al., 2005; Tamlyn et al., 1992) and we were interested in investigating whether individuals with schizotypy exhibit similar semantic activation patterns compared to patients. We found that atypical semantic activation was related to significantly elevated odd speech in the schizotypy group when stress was induced. It was not related to odd speech in the control group, nor was it related to odd speech in the schizotypy group across pleasant or neutral conditions. In addition, the correlation between odd speech in the stressful condition and atypical semantic activation was significantly stronger in individuals with schizotypy compared to controls.

One potential explanation for these findings is that individuals with schizotypy who exhibit atypical semantic activation patterns may be able to inhibit these unique associations when not under stress. However, the resources required for inhibiting atypical semantic processing from affecting speech may be tapped due to an additional cognitive load from an increase in stress, thus resulting in more odd speech. In line with this explanation, researchers have observed an increase in odd speech in stressful compared to pleasant conditions when individuals with schizophrenia (Docherty et al., 1994; Docherty and Hebert, 1997) and schizotypy (Kerns and Becker, 2008) are compared to controls.

Our findings in regard to atypical semantic activation may suggest the presence of spreading activation in schizotypy. According to the spreading activation model (Spitzer, 1997), loose associations in schizophrenia-spectrum disorders are, in part, a result of the broad spread of activation to both strongly and weakly associated items within the semantic network. In contrast, healthy adults produce comparatively

### Table 2

Correlations between atypical semantic activation with odd speech in the schizotypy and control groups.

<table>
<thead>
<tr>
<th>Odd speech</th>
<th>Control TI (n = 23)</th>
<th>Schizotypy TI (n = 83)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stressful</td>
<td>−0.23</td>
<td>0.26*</td>
</tr>
<tr>
<td>Neutral</td>
<td>0.17</td>
<td>−0.06</td>
</tr>
<tr>
<td>Pleasant</td>
<td>−0.08</td>
<td>0.13</td>
</tr>
</tbody>
</table>

* p < 0.05.

### Table 3

Between and within group comparisons of correlations examining the relationship between atypical semantic activation and odd speech using Fisher’s transformation.

<table>
<thead>
<tr>
<th>Between group</th>
<th>Schizotypy to control (z)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stressful</td>
<td>2.03*</td>
</tr>
<tr>
<td>Neutral</td>
<td>−0.89</td>
</tr>
<tr>
<td>Pleasant</td>
<td>0.82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Within group</th>
<th>Control z (n = 23)</th>
<th>Schizotypy z (n = 83)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stressful to neutral</td>
<td>−1.62</td>
<td>2.41*</td>
</tr>
<tr>
<td>Stressful to pleasant</td>
<td>−0.69</td>
<td>1.19</td>
</tr>
<tr>
<td>Pleasant to neutral</td>
<td>−0.77</td>
<td>1.20</td>
</tr>
</tbody>
</table>

* p < 0.05.

### Table 4

Correlations between atypical semantic activation with schizotypal traits within the schizotypy group.

<table>
<thead>
<tr>
<th>Schizotypal traits</th>
<th>Atypical semantic activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive–perceptual</td>
<td>0.08</td>
</tr>
<tr>
<td>Disorganized</td>
<td>0.25*</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>−0.42***</td>
</tr>
</tbody>
</table>

* p < 0.05.

*** p < 0.001.
more typical associations due to the spread of activation to strongly, but not weakly, associated items within their semantic networks. Thus, more weakly related items enter the information-processing stream in schizophrenia, manifesting in odd speech. The presence of more atypical semantic associations in the stressful condition may be due to an increase in spreading activation in those with schizotypy, which would suggest that these individuals demonstrate similarities in semantic processing with patients with schizophrenia. However, it could also be the case that atypical semantic associations reflect other issues, such as low attentional vigilance or unusual semantic networks, as opposed to spreading activation. Future studies should examine this issue further by employing a measure of indirect priming.

Surprisingly, significant differences were not observed in overall semantic activation when the schizotypy and control groups were compared. This is in contrast with a previous study (Kiang and Kutas, 2006), where the authors found that semantic activation was more atypical on a Fruit CF task in high compared to low scorers on the SQP. In the present study, the heterogeneity within the schizotypy group is one potential explanation why differences in semantic activation were not found, as atypical semantic activation varied as a function of disorganization or interpersonal schizotypal trait severity. Individuals with schizotypy who exhibited primarily disorganization features produced significantly increased atypical semantic activation patterns, whereas those with predominantly interpersonal traits demonstrated attenuated atypical activation. It is possible that significant differences between groups might have been observed if a more homogeneous schizotypy sample consisting of individuals with predominantly disorganization traits had been recruited.

Tying in with our earlier explanation, it could be the case that patterns of atypical semantic activation only become apparent once individuals with schizotypy become stressed, whereas they appear to be more pervasive in schizophrenia (Aloia et al., 1996; Paulsen et al., 1996; Sumiyoshi et al., 2005; Tamlyn et al., 1992). Evidence supporting the presence of atypical semantic activation in schizotypy can be found in the creativity literature, where researchers have observed that individuals with schizotypy tend to display a more over-inclusive thinking style (Dykes and McRae, 1976; Eysenck, 1995; Rawlings and Toogood, 1997). For example, when asked to name as many different uses as they can for a common household object, individuals with schizotypy are able to produce a higher number of unique responses than controls, which suggests access to unique semantic associations (Andreasen and Powers, 1975; Folley and Park, 2005; Green and Williams, 1999). To clarify this issue, future research should examine whether odd speech and creativity are related in individuals with schizotypy and, if so, whether atypical semantic activation mediates this relationship.

A few limitations of this study should be mentioned. One limitation concerns the use of an undergraduate sample. The use of undergraduates is common in schizotypy studies such as this one (Chapman et al., 1978, 1994; Gooding et al., 2005; Kerns, 2007; Kwapil, 1998; Kwapil et al., 1997); however, this strategy does raise potential generalizability concerns. For instance, individuals with schizotypy who are able to success-fully maintain enrollment in a university setting likely represent the high end of functioning in schizotypy and may not be representative of lower functioning individuals with schizotypy. A second limitation is that we did not include handedness data or a measure of verbal intelligence in this study. Both omissions may raise potential problems with speech analyses. For instance, it is possible that higher TI scores may reflect an increased vocabulary in some individuals, rather than atypical semantic activation. A measure of verbal intelligence would be able to determine if this were the case and, if so, allow us to control for this variable. In regard to handedness, researchers have observed that individuals with schizotypy tend to have a higher propensity for left-handedness and mixed-handedness than controls (Chapman and Chapman, 1987; Barnett and Corballis, 2002). This finding is relevant in that significantly more left-handed than right-handed individuals exhibit right hemisphere dominance for speech processing (Wada and Rasmussen, 1960). As speech production is predominantly controlled in the left hemisphere, right hemispheric dominance could account for some speech deficits, including the production of more atypical responses on a semantic fluency task. Both verbal intelligence and handedness data will be included in future studies.

In conclusion, atypical semantic activation appears to be related to odd speech in individuals with schizotypy when stress is induced, but not when pleasant or neutral topics are broached. The results from this study also highlight the dramatic differences in semantic activation across the various manifestations of schizotypy. Future research should expand on the role of stress in regard to semantic activation and clarify the neurocognitive and neuropathological underpinnings of atypical semantic activation patterns across the schizophrenia spectrum. Future studies should also examine whether atypical semantic activation exhibited in schizotypy is related to spreading activation and, if so, whether this model has important implications for explaining how atypical semantic activation is related to stress reactions in individuals with schizotypy.

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Contributors
Kyle S. Minor conducted the literature search, performed data analyses, and wrote or co-wrote all drafts of the manuscript. In addition, he assisted in the design of the study, collected and coded all data. Dr. Alex S. Cohen was the mentor for this project. He designed the narrative task used within, and was a co-author on all drafts of the manuscript. Christopher R. Weber contributed to data analysis and co-author the final draft of the manuscript. Laura A. Brown was a co-author on all drafts of the manuscript and helped with data coding. All authors contributed to and have approved the final manuscript.

Conflict of interest
All authors declare no conflicts of interest in the current study.

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