Speech Production and Disorganization in Schizotypy: Investigating the Role of Cognitive and Affective Systems.

Matthew P. Marggraf[1], Beshaun J. Davis[1], Kat L. Hardin[1], Samuel J. Abplanalp[1], Jennifer A. Haller[1], Paula DeCrescenzo[1], Kyle S. Minor[1]

[1]Department of Psychology, Indiana University-Purdue University Indianapolis, Indianapolis, IN, United States

[*]Corresponding Author: Matthew P. Marggraf; IUPUI School of Science, Department of Psychology, LD 124, 402 N. Blackford St., Indianapolis, IN, 46202; Phone: (763) 242 -2447; Fax: (317) 274-6756; email: mpmarggr@iupui.edu

This is the author's manuscript of the article published in final edited form as:

Marggraf, M. P., Davis, B. J., Hardin, K. L., Abplanalp, S. J., Haller, J. A., DeCrescenzo, P., & Minor, K. S. (2019). Speech production and disorganization in schizotypy: Investigating the role of cognitive and affective systems. Journal of Psychiatric Research. https://doi.org/10.1016/j.jpsychires.2019.03.023

Abstract

Diminished productivity and elevated disorganization have been detected in the speech of individuals with schizotypy. However, the underlying mechanisms for these disruptions are not well understood. Separate lines of research suggest potential contributions from cognitive and affective systems. In this study, disorganized speech and speech production were examined in speech samples generated by schizotypy (n = 47) and non-schizotypy (n = 51) groups by assessing "reactivity" (i.e., a change in experimental compared with baseline conditions) across baseline, affective, and dual-task (i.e., cognitive) conditions. Relationships with social functioning were also examined within each group. Three key findings emerged: 1) compared to the non-schizotypy group, those with schizotypy exhibited diminished speech production in the affective condition and affective reactivity was observed; 2) the schizotypy group displayed greater levels of disorganized speech in dual-task conditions and cognitive reactivity was observed; and 3) affective reactivity for disorganized speech was linked to worse social functioning within the schizotypy group. This study provides evidence that cognitive and affective systems are uniquely involved in separate characteristics of speech in schizotypy. At this stage, cognitive systems appear to have a specific role in the organization of speech, whereas affective systems are more heavily involved in speech production. Regarding the association between affective reactivity and social functioning, previous research has demonstrated individuals highly reactive to emotional stimuli carry additional risk for conversion to psychosis. Future research identifying a subset with schizotypy who demonstrate affective reactivity could lead to a better understanding of links between schizotypy and future psychosis symptoms.

Keywords: schizotypy, disorganized speech, speech production, negative affect, dual task, social functioning

Introduction

Disorganized speech and diminished speech production are cardinal features of schizophrenia-spectrum disorders (Andreasen, 1979; Docherty, 2012); both have been linked to poor functional outcomes including reduced social functioning (Bowie et al., 2011). Although the vast majority of research on disorganized and diminished speech has examined chronic psychosis, these constructs extend across the schizophrenia-spectrum, including individuals with early psychosis (Minor et al., 2016), unaffected first-degree relatives (Docherty and Gordinier, 1999; Docherty et al., 1998) and clinical high-risk samples (Bedi et al., 2015). Elevations in disorganized and diminished speech have also been observed in individuals with schizotypy – a group characterized by attenuated, schizophrenia-like traits who are at heightened risk for future development of psychotic and other psychiatric disorders (Chapman et al., 1994; Gooding et al., 2005; Meehl, 1962). Given schizotypy reflects subclinical manifestations of schizophrenia-like traits, examining disorganized speech and diminished speech production holds the potential to identifying intermediate phenotypes at one of the earliest points on the schizophrenia-spectrum.

To date, the evidence for speech disruptions in schizotypy has been mixed (Cohen et al., 2012; Cohen et al., 2014, Kerns and Becker, 2008; Minor and Cohen, 2010, 2012; Minor et al., 2018; Weinstein et al., 2008). A major obstacle is that many traditional instruments lack the sensitivity to detect the attenuated forms of disorganized speech and diminished speech production potentially present in schizotypy. Typically, speech is assessed using Likert-style rating measures (e.g., Thought, Language, and Communication scale, Positive and Negative Syndrome Scale) designed to capture overt forms of disorganized speech. To measure attenuated speech disruptions it is more appropriate to implement behaviorally-based instruments (e.g., Thought Disorder Index, Communication Disturbances Index), which feature sophisticated

scoring systems, count instances of disorganization, and can produce ratio-levels of disorganized speech. These instruments have increased sensitivity and can detect low levels of speech disruptions even in healthy controls (Docherty et al., 2003). Studies employing behaviorally-based instruments have reported significantly greater speech disruptions in schizotypy compared to non-schizotypy (Minor and Cohen, 2010; Kerns and Becker, 2008; Minor et al., 2018). However, attempted replication of these findings has yielded mixed support both across- and within-schizotypy studies (Cohen et al., 2012; Cohen et al., 2014; Minor et al., 2011; Minor and Cohen, 2012), and indicate that disorganized and diminished speech are more likely to be observed when certain underlying mechanisms are activated.

One line of research has examined affective systems as a potential mechanism contributing to speech disruptions. Specifically, negative affect is one condition that exhibited influence on disorganized and diminished speech across the schizophrenia-spectrum. Affective reactivity – measured as a greater change from baseline to negative valence conditions – has been observed in both chronic (Burbridge and Barch, 2002; Docherty and Hebert, 1997; Rubino et al., 2009) and early-stage psychosis (Minor et al., 2016). In schizotypy, three studies have examined affective reactivity in regard to disorganized speech. Kerns and Becker (2008) observed that those with disorganized schizotypy exhibited affective reactivity compared to a non-schizotypy group, demonstrating greater disorganized speech in a negative valence, but not positive valence condition. Minor and Cohen (2010) observed that those with schizotypy exhibited elevated disorganized speech compared to the non-schizotypy group across negative and positive valence conditions—but no increase in affective reactivity. In a separate study, Minor and Cohen (2012) failed to observe increased affective reactivity. The influence of affect on speech production has been examined in two studies in schizotypy, both of which reported no

group differences in either positive or negative affect conditions (Kerns and Becker, 2008; Najolia et al., 2011). On the other hand, Minor and colleagues (2018) observed an inverse relationship between negative affect and speech production in daily, conversational speech, and specifically, that schizotypy group status moderated the relationship such that the relationship between negative affect and speech production was stronger in those with elevated schizotypy compared to those with lower levels of schizotypy – indicating a specific role of affective systems in schizotypy speech production. Given these inconsistent findings, we examined whether increased negative affect would lead to greater levels of disorganized speech *and* diminished speech production in schizotypy.

A second mechanism that may influence disorganized and diminished speech is cognitive load. Previous research has demonstrated that individuals with schizophrenia-spectrum disorders have greater difficulty with dual-task information processing than other psychiatric populations and healthy controls, which suggests unique cognitive resource limitations within this population (e.g., Granholm et al 1996). Furthermore, research using dual-task paradigms (i.e., auditory distraction during conversation) has demonstrated increases in communication failures in individuals with schizophrenia spectrum disorders (Hotchkiss and Harvey, 1990; Moskowitz et al., 1991), suggesting that speech processes may particularly be vulnerable to increases in cognitive demands. Although cognitive load's effect on disorganized speech has not been examined in schizotypy, Kerns and Becker (2008) found that working memory performance predicted disorganized speech after accounting for schizotypy status. Further, a meta-analysis examining neurocognitive performance revealed that the largest deficits schizotypy were in the working memory domain (Chun et al., 2013). Taken together, these findings suggest that working memory deficits may contribute to the greater disorganized speech observed in

schizotypy (Kerns and Becker, 2008; Minor and Cohen, 2010). In regard to speech production in schizotypy, only two studies have compared speech produced in baseline to dual-task conditions, and no significant group differences were observed (Cohen et al., 2012; Cohen et al., 2014). Given that working memory deficits have been demonstrated in this population (Chun et al., 2013; Kerns and Becker, 2008) and contribute to speech disruptions in psychosis (Kerns and Berenbaum, 2002; Melinder and Barch, 2003), we examined whether increased cognitive load (via a dual-task condition) would result in greater disorganized speech and less speech production in schizotypy.

The current study had three aims. First, we determined whether those with schizotypy exhibited more disorganized speech and less speech production than controls across three speech conditions (baseline, affective, dual-task). Second, we assessed whether affective or cognitive systems played a role in disorganized speech or speech production by testing if affective or cognitive reactivity was greater in schizotypy. Third, given that both disorganization and diminished speech production have been linked to poor social functioning (Bowie et al., 2011), we examined if affective- and cognitive-reactivity for both constructs were linked to lower social functioning in the schizotypy group.

Method

Participants

Participants were undergraduate students from a large Midwestern university who completed an online schizotypy survey (n = 904). On the survey, participants had to have z-score > 1.65 on one of three factor scales (positive, negative, or disorganized) to meet criteria for the schizotypy group or a z-score < mean on the overall scale to meet criteria for the control group.

Gender- and ethnicity-derived means were used to compute *z*-scores. Additional eligibility criteria included being age 18 - 30 (*n* = 9 excluded); fluent in English (*n* = 1 excluded); not being intoxicated during lab procedures (*n* =1 excluded); no previous diagnosis of a schizophrenia-spectrum disorder (*n* = 1 excluded); and completed transcripts for all three speech conditions (*n* = 3 excluded). Participants were compensated with course credit and/or $10 per hour. The final sample consisted of 47 individuals in the schizotypy group and 51 individuals in the non-schizotypy group. All study procedures were approved by the university's institutional review board. All participants gave written informed consent prior to participation.

Measures

Schizotypy

Schizotypy traits were assessed using the Schizotypal Personality Questionnaire (SPQ; Raine, 1991), a 74-item self-report measure with strong psychometric properties (Raine, 1991). The SPQ has nine subscales and previous research has demonstrated that the measure is composed of a three factor structure consisting of positive (i.e. ideas of reference, odd beliefs/magical thinking, suspiciousness, unusual perceptual experiences), disorganized (i.e. odd speech, odd/eccentric behavior), and negative traits (i.e. no close friends, constricted affect) (Wuthrich and Bates, 2006). We excluded the social anxiety score to assess for negative schizotypy traits that are consistent with those found in schizophrenia, while excluding traits that might be secondary to affective conditions. To increase the sensitivity of detecting schizotypy traits, we modified the SPQ from a dichotomous choice format to a 5-point Likert-style response format (1 = Strongly Disagree, 5 = Strongly Agree). The modified version has a high degree of convergence with the original version (Wuthrich and Bates, 2005).

Speech Paradigm

Participants spoke into a head-mounted microphone for two minutes about negatively- (affective condition) and neutrally-valenced (baseline, dual-task conditions) topics. The order of speech conditions was counterbalanced across participants. In the affective condition, participants were instructed to discuss unpleasant experiences. Prompts were provided on the screen (e.g. "Tell us some stories about times when you were really disappointed with something") though participants could discuss any unpleasant experiences they wished. In the neutrally-valenced conditions, participants were instructed to discuss neutral topics (i.e. daily routine, place of residence), which were counterbalanced across baseline and dual-task conditions. Participants looked at the computer prompts when speaking and research assistants were instructed not to speak during the recording. The recorded speech samples were transcribed by trained research assistants.

In the dual-task condition, participants completed the speech task while simultaneously performing a one-back visual working memory task (35 trials). Symbols (e.g., '*', '@') were presented consecutively on a computer screen and participants were instructed to indicate whether the current symbol was identical to the previous symbol by pressing the "v" key or different than the previous symbol by pressing the "7" key. The maximum duration of each symbol presentation was 2000ms and they were presented at 1500ms intervals. Participants were given 13-15 practice trials to ensure task understanding. The practice trials served as a baseline (single-task) cognitive performance condition. Accuracy was calculated as a percentage of correct responses. Groups did not differ on cognitive performance in single-task, $t(96) = -0.11$, $p = 0.917$, or dual-task conditions, $t(96) = -0.14$, $p = 0.888$ (see Table 1).

Speech Disruptions

Disorganized speech was measured using the Communication Disturbances Index (CDI; Docherty, 1996). The CDI is a well-validated, behaviorally-based instrument used to detect mild forms of disorganized speech (Docherty et al., 1996). Instances are counted when speech lacks clarity or contains references that may be unclear to listeners. Disorganized speech scores were calculated for each transcript by dividing the number of instances by the total number of words generated and multiplying this value by 100. Increasing CDI scores reflect greater disorganized speech. Previous research has demonstrated that the CDI has sensitivity to differentiate the speech of schizotypy and controls (Minor and Cohen, 2010, 2012). In this study, the first author rated all transcripts using the CDI; two trained undergraduate research assistants, blind to group, also rated transcripts. Inter-rater reliability was established between the first author and each undergraduate research assistant (inter-rater reliability on 90 randomly selected transcripts prior to consensus review, *ICC's = .81, .66*). Discrepancies between ratings were resolved during weekly consensus meetings. To calculate speech production for each transcript, the total number of words generated was divided by the length of the recording; thus, producing a value indicating the number of words generated per second. Lower values indicated less speech production.

Social Functioning

During the laboratory portion, participants responded to a series of open-ended questions, administered on the computer, inquiring about the quality of their social interactions and relationships. Using the information in these responses, social functioning was measured using anchors from the Global Functioning Scale-Social (GFS-Social; Auther et al., 2006). The GFS-Social is a measure of age-appropriate social contact and relationships. It uses a 10-point scale; with higher scores reflecting better social functioning. All ratings were made by a trained graduate research assistant.

Statistical Analyses

Analyses were conducted in three parts. First, two multivariate repeated measures of analysis of variance (MANOVA) were conducted to investigate the role of affective and cognitive systems in disorganized speech and speech production. Group (schizotypy, control) was the between-subjects independent variable (IV), speech condition (baseline, affective [first], cognitive [second]) was the within-subjects IV, and disorganized speech and speech production were the dependent variables (DV). Independent t-tests were employed to investigate main effects. Second, affective and cognitive reactivity were calculated by regressing CDI percentage and speech production scores in experimental conditions from baseline conditions. Finally, correlations were calculated to examine relationships between social functioning and affective and cognitive reactivity for disorganized speech and speech production. All analyses were two-tailed and outliers were reduced to within 3 standard deviations of the mean.

Results

Groups did not differ in age (schizotypy, $M = 20.21$, $SD = 2.15$; non-schizotypy, $M = 19.85$, $SD = 1.76$, $t\ (99) = -.92$, $p = .36$), sex (schizotypy, 54% female; non-schizotypy, 55% female, $\chi^2\ (1) = 0.00$, $p = 0.96$), or race (schizotypy, 73% Caucasian; non-schizotypy, 85% Caucasian, $\chi^2\ (5) = 6.69$, $p = .25$). Accordingly, no demographic factors were controlled in subsequent analyses.

Speech Disruptions Across Affective Conditions

Group comparisons for all analyses involving disorganized speech and speech production can be found in Table 1. The results of the repeated measures MANOVA indicated that the main effect of condition was significant, $F(2,95) = 3.92$, $p = 0.023$. Regarding condition, significant

individual main effects were found for disorganized speech, $F(1,96) = 7.88$, $p = 0.006$, but not speech production, $F(1,96) = 1.51$, $p = 0.698$. This suggests that, across both groups, higher levels of disorganized speech were present in the affective condition compared to the baseline condition; speech production did not vary across conditions.

A significant overall main effect was not observed for group, $F(2,95) = 0.54$, $p = 0.587$. Regarding group, no significant main effects were found for disorganized speech, $F(1,96) = 0.01$, $p = 0.945$, or speech production $F(1,96) = 1.07$, $p = 0.303$. This suggests that across conditions, groups did not differ in severity of disorganized speech and speech production. Follow-up *t*-tests revealed one significant finding. Compared to the non-schizotypy group, those with schizotypy produced less speech in the affective condition $t(96) = 2.01$, $p = 0.047$. No significant differences were observed for disorganized speech in the affective condition, $t(96) = -0.29$, $p = 0.774$. In the baseline condition, significant differences were not observed for disorganized speech, $t(96) = 0.57$, $p = 0.573$, or speech production, $t(96) = -0.20$, $p = 0.984$. Based on these findings, our hypotheses that the schizotypy group would demonstrate reduced speech production was partially supported. Our hypotheses that those with schizotypy would exhibit greater disorganized speech were not supported.

Regarding interaction effects, there was a significant group by condition interaction for speech production, $F(1,96) = 10.67$, $p = 0.002$, but not disorganized speech, $F(1,96) = 0.31$, $p = 0.580$. This suggests that the schizotypy group demonstrated a sharper decline in word production as they progressed from baseline to affective conditions compared to the non-schizotypy group. Thus, our hypotheses involving affective reactivity for disorganized speech and speech production was only partially supported.

[INSERT TABLE ONE HERE]

[INSERT FIGURE ONE HERE]

Speech Disruptions Across Dual-Task Conditions

The results of the repeated measures MANOVA indicated that the main effect of condition was significant, $F(2,95) = 23.80$, $p < 0.001$. Regarding condition, significant individual main effects were found for both disorganized speech, $F(1,96) = 5.57$, $p = 0.020$, and speech production, $F(1, 96) = 42.89$, $p < 0.001$. This suggests that participants demonstrated increased disorganized speech and diminished speech production in dual-task compared to baseline conditions.

A significant overall main effect for group was not observed $F(2,95) = 2.39$, $p = 0.097$. Regarding group, the main effect for disorganized speech reached trend-level significance, $F(1,96) = 3.24$, $p = 0.073$, while the main effect for speech production was not significant, $F(1,96) = .280$, $p = 0.598$. This suggests that when conditions were combined, groups did not differ in disorganization and speech production. Follow-up *t*-tests did reveal one significant finding. Compared to the non-schizotypy group, the schizotypy group exhibited greater disorganization in the dual-task condition, $t(96) = -2.43$, $p = 0.017$. However, the groups did not differ in regard to speech production, $t(96) = 1.00$, $p = 0.320$.

In regard to interaction effects, there was a significant group by condition interaction for disorganized speech $F(1,96) = 5.38$, $p = 0.022$, such that the schizotypy group demonstrated a sharper increase in disorganization compared to controls as they progressed from baseline to dual-task conditions (Figure 2). The group by condition interaction for speech production was

not significant, $F(1,96) = 2.10$, $p = 0.151$. Thus, our hypothesis regarding cognitive reactivity for disorganized speech and speech production were partially supported.

[INSERT FIGURE TWO HERE]

Associations between speech disruptions and social functioning

Relationships between affective-reactivity, cognitive-reactivity and social functioning were examined within each group. In the schizotypy group, affective reactivity for disorganized speech was associated with decreased social functioning (Table 2). This was the only speech variable related to social functioning. No significant associations with social functioning were found in the non-schizotypy group. Thus, our hypothesis that affective- and cognitive-reactivity would be associated with worse social function was partially supported.

[INSERT TABLE TWO HERE]

Discussion

The primary focus of this schizotypy study was to determine the role of affective and cognitive systems in disorganization and diminished speech production. Three key findings were observed. First, compared to the non-schizotypy group, those with schizotypy exhibited diminished speech production in the affective condition and affective reactivity was observed. Second, the schizotypy group displayed greater disorganization in the dual-task condition and cognitive reactivity for disorganization was found. Third, affective reactivity of disorganized speech was linked to worse social functioning within the schizotypy group.

Regarding speech production, the schizotypy group demonstrated affective reactivity—a steeper decline from baseline to affective conditions—in addition to diminished speech

production in the affective condition. This pattern did not emerge in the dual-task condition, suggesting that some component specific to affective systems contributes to diminished speech production. One possible explanation is that individuals with schizotypy may have become disengaged, thus producing less speech, as a means of coping with the negative affect induced by the task. A study by MacAulay and Cohen (2013) observed that people with schizotypy report using avoidant coping strategies – such as behavioral disengagement – more often than those without schizotypy; and within schizotypy, avoidant coping was associated with negative affect. However, replication is needed, as previous schizotypy studies have not found affective reactivity for diminished speech production (Kerns and Becker, 2008; Najolia et al., 2011). Regarding cognitive reactivity, our finding of no group differences is consistent with previous studies in chronic psychosis (Cohen et al., 2014), early-stage psychosis (Minor et al., 2016) and schizotypy (Cohen et al., 2012; Cohen, et al., 2014). Although increased cognitive load results in diminished speech production in schizophrenia-spectrum disorders, it declines at a similar rate as controls.

In contrast with speech production, disorganized speech was elevated for the schizotypy group in only the dual-task condition. Evidence for cognitive reactivity was also observed. One reason why disorganized speech was pronounced in schizotypy when cognitive load was induced centers on this group being more susceptible to the effects of cognitive stress. The one-back task taxes resources observed to be generally deficient in schizotypy compared to non-schizotypy groups (Chun et al., 2013) – therefore, executing task performance on par with the control group may have come at the expense of allocating available cognitive resources toward maintaining organization of speech processes. Furthermore, the schizotypy group's accuracy on the one-back task did not decrease moving from single- (i.e. one-back only) to dual-task (i.e. one-back while

speaking) conditions, another indication that they may have "chosen" to direct their working memory resources toward task performance instead of on the speech task. It is possible that cognitive resources are less deficient at this point on the schizophrenia-spectrum, resulting in decreased performance on one task (i.e. speech organization), while sparing the other (i.e. one-back performance), a general pattern consistent with schizophrenia-spectrum dual-task literature (Granholm et al., 1996). Within the schizophrenia-spectrum literature, findings from our study reflect an opposite pattern, in that others have failed to observe cognitive reactivity for disorganized speech, but note decreased cognitive task performance (Melinder and Barch, 2003; Minor et al., 2016). Interestingly, Le and colleagues (2017) observed cognitive-reactivity in a broader SMI population, but in the opposite direction - disorganized speech decreased moving from baseline to cognitive-load conditions. Overall, there is evidence to suggest that cognitive-load may contribute to the organization of speech processes, but the exact nature of this relationship is unclear.

To understand how cognitive and affective systems may impact real-world behavior, we examined how reactivity was related to social functioning. When examining relationships with speech characteristics, no significant associations with social functioning were observed for the non-schizotypy group or for speech production in the schizotypy group. However, affective reactivity for disorganization was found to be inversely associated with social functioning in schizotypy. This suggests that those with schizotypy who demonstrate increased disorganization when negative affect is induced also exhibit decreased functioning. A similar pattern between affective reactivity and reduced social functioning has been observed in early psychoses patients (Minor et al., 2016) indicating that this relationship occurs early in the course of the illness. The

current study adds to the literature by demonstrating that this relationship extends to individuals with schizotypal characteristics.

Although high levels of affective reactivity may have important implications for schizotypy, it is interesting that group differences for disorganized speech were not observed under affective conditions. Results from this study add to the mixed schizotypy literature regarding affective systems, reactivity, and disorganization. Affective reactivity has consistently been demonstrated in chronic (Docherty and Herbert, 1997; Docherty et al., 1998) and early-stage psychosis samples (Minor et al., 2016). However, the effect is less clear in schizotypy, with studies observing (Kerns and Becker, 2008) or failing to observe group differences in affective reactivity (Minor and Cohen 2010, 2012). It is possible that differences in methodology could account for the divergent findings between studies. For example, Kerns and Becker (2008) recruited people who were high in disorganized schizotypy exclusively, whereas other studies—like the current one—recruited people high in positive, negative, or disorganized traits. However, in the current study, positive, negative, and disorganized traits were not significantly associated with any of the speech variables (see Supplementary Table 1).

This study has several notable strengths. The design allowed for the examination of both cognitive and affective reactivity for disorganization and speech production. This enabled us to simultaneously explore the role of affective and cognitive systems for different aspects of speech. Another strength was the use of behaviorally-based instruments, allowing for the detection of subtle forms of disorganized speech that traditional Likert-rating scales may not identify. There were also important limitations. Though common in schizotypy research (Cohen et al., 2012; Cohen et al., 2014; Kerns and Becker 2008; Minor and Cohen, 2010; 2012), the use of an undergraduate sample is a potential limitation due to generalizability concerns. Given that

these individuals are able to maintain enrollment in college, they are likely functioning at a higher level and may not be representative of the full spectrum of schizotypy. Future studies should examine relationships between the study variables in a community-based sample. Another limitation is that while the manipulation of affective speech conditions (i.e. baseline versus affective) was presumed to evoke negative affect, participants' affective states were not directly assessed. However, previous research has demonstrated that similar speech paradigms are successful in increasing negative affect (Cohen et al., 2010). Finally, while stress was intended to be manipulated by the experimental conditions, it possible that other factors could have elicited additional stress during speech tasks (e.g., performance anxiety), potentially confounding the amount of stress elicited solely from negative affect inducement. Future research should attempt to account for other sources of stress that could have unintentionally affected the results.

In sum, this study provides evidence that cognitive and affective systems are uniquely involved in separate speech characteristics in schizotypy. Whereas cognitive systems appear to have a specified role in the organization of speech, affective systems are more heavily involved in speech production. Although disturbances were not as pronounced as in individuals who have experienced psychosis, mild disorganization and diminished speech production were detected under variable conditions. These findings demonstrate that the underlying mechanisms believed to be involved in formal thought disorder in schizophrenia can be similarly detected in individuals at putative risk for the disorder.

References

Auther, A., Smith, C., Cornblatt, B., 2006. Global Functioning: Social Scale (GF: Social). Glen Oaks, NY: Zucker-Hillside Hospital.

Bedi, G., Carrillo, F., Cecchi, G.A., Slezak, D.F., Sigman, M., Mota, N.B., . . . Corcoran, C.M., 2015. Automated analysis of free speech predicts psychosis onset in high-risk youths. npj Schizophr. 1, 15030.

Bowie, C.R., Gupta, M., Holshausen, K., 2011. Disconnected and underproductive speech in schizophrenia: unique relationships across multiple indicators of social functioning. Schizophr. Res. 131, 152-156.

Burbridge, J.A., Barch, D.M., 2002. Emotional valence and reference disturbance in schizophrenia. J. Abnorm. Psychol. 111, 186.

Chapman, L.J., Chapman, J.P., Kwapil, T.R., Eckblad, M., Zinser, M.C., 1994. Putatively psychosis-prone subjects 10 years later. J. Abnorm. Psychol. 103(2), 171.

Chun, C.A., Minor, K.S., Cohen, A.S., 2013. Neurocognition in psychometrically defined college schizotypy samples: we are not measuring the “right stuff”. J. Int. Neuropsychol. Society. 19, 324-337.

Cohen, A.S., Auster, T.L., McGovern, J.E., MacAulay, R.K., 2014. The normalities and abnormalities associated with speech in psychometrically-defined schizotypy. Schizophr. Res. 160, 169-172.

Cohen, A.S., Hong, S.L., Guevara, A., 2010. Understanding emotional expression using prosodic analysis of natural speech: refining the methodology. J. Behav. Therapy and Exp. Psychiatry. 4, 150-157.

Cohen, A.S., Morrison, S.C., Brown, L.A., Minor, K.S., 2012. Towards a cognitive resource limitations model of diminished expression in schizotypy. J. Abnorm. Psychol. 121, 109.

Docherty, N., 1996. Manual for the Communication Disturbances Index (CDI). Kent State University, Kent, OH.

Docherty, N.M., 2012. Missing referents, psychotic symptoms, and discriminating the internal from the externalized. J. Abnorm. Psychol. 121, 416-423. doi:10.1037/a0026348

Docherty, N.M., Cohen, A.S., Nienow, T.M., Dinzeo, T.J., Dangelmaier, R.E., 2003. Stability of formal thought disorder and referential communication disturbances in schizophrenia. J. Abnorm. Psychol. 112, 469.

Docherty, N.M., DeRosa, M., Andreasen, N.C., 1996. Communication disturbances in schizophrenia and mania. Arch. Gen. Psychiatry, 53, 358-364.

Docherty, N.M., Gordinier, S.W., 1999. Immediate memory, attention and communication disturbances in schizophrenia patients and their relatives. Psychol. Med. 29, 189-197.

Docherty, N.M., Hebert, A.S., 1997. Comparative affective reactivity of different types of communication disturbances in schizophrenia. J. Abnorm. Psychol. 106, 325.

Docherty, N.M., Rhinewine, J.P., Labhart, R.P., Gordinier, S.W., 1998. Communication disturbances and family psychiatric history in parents of schizophrenic patients. J. Nerv. and Ment. Dis. 186, 761-768.

Gooding, D.C., Tallent, K.A., Matts, C.W., 2005. Clinical status of at-risk individuals 5 years later: further validation of the psychometric high-risk strategy. J. Abnorm. Psychol. 114, 170.

Granholm, E., Asarnow, R.F., Marder, S.R. 1996. Dual-task performance operating characteristics, resource limitations, and automatic processing in schizophrenia. Neuropsychol. 10, 11-21.

Hotchkiss, A.P., Harvey, P.D. 1990. Effect of distraction on communication failures in schizophrenic patients. Am. J. Psychiatry, *147*(4), 513 - 515.

Kerns, J.G., Becker, T.M., 2008. Communication disturbances, working memory, and emotion in people with elevated disorganized schizotypy. Schizophr. Res. 100, 172-180.

Kerns, J.G., Berenbaum, H., 2002. Cognitive impairments associated with formal thought disorder in people with schizophrenia. J. Abnorm. Psychol. 111, 211.

Le, T.P., Najolia, G.M., Minor, K.S., Cohen, A.S., 2017. The effect of limited cognitive resources on communication disturbances in serious mental illness. Psychiatry Res. 248, 98-104. doi:10.1016/j.psychres.2016.12.025

MacAulay, R., Cohen, A.S., 2013. Affecting coping: Does neurocognition predict approach and avoidant coping strategies within schizophrenia spectrum disorders? Psychiatry Res. 209, 136-141.

Melinder, M.R., Barch, D.M., 2003. The influence of a working memory load manipulation on language production in schizophrenia. Schizophr. Bull. 29, 473-485.

Minor, K.S., Cohen, A.S., 2010. Affective reactivity of speech disturbances in schizotypy. J. Psychiatric Res. 44, 99-105.

Minor, K.S., Cohen, A.S., 2012. The role of atypical semantic activation and stress in odd speech: implications for individuals with psychometrically defined schizotypy. J. Psychiatric Res. 46, 1231-1236.

Minor, K.S., Cohen, A.S., Weber, C.R., Brown, L.A., 2011. The relationship between atypical semantic activation and odd speech in schizotypy across emotionally evocative conditions. Schizophr. Res. 126, 144-149.

Minor, K.S., Marggraf, M.P., Davis, B.J., Mehdiyoun, N.F., Breier, A., 2016. Affective systems induce formal thought disorder in early-stage psychosis. J. Abnorm. Psychol. 125, 537.

Moskowitz, J., Davidson, M., Harvey, P.D., 1991. The effect of concurrent distraction on communication failures in schizophrenic patients. Schizophr. Res. 5, 153-159.

Najolia, G.M., Cohen, A.S., Minor, K.S., 2011. A laboratory study of affectivity in schizotypy: Subjective and lexical analysis. Psychiatry Res. 189, 233-238.

Plass, J.L., Moreno, R., Brünken, R., 2010. Cognitive load theory: Cambridge University Press.

Raine, A., 1991. The SPQ: a scale for the assessment of schizotypal personality based on DSM-III-R criteria. Schizophr. Bull. 17, 555-564.

Rubino, I.A., D'Agostino, L., Sarchiola, L., Romeo, D., Siracusano, A., Docherty, N.M., 2009. Referential failures and affective reactivity of language in schizophrenia and unipolar depression. Schizophr. Bull. 37, 554-560.

Weinstein, S., McKay, R., Ngan, E.T., 2008. Positive schizotypy is not associated with speech abnormality. Early Intervent. Psychiatry. 2, 98-102.

Wuthrich, V., Bates, T.C., 2005. Reliability and validity of two Likert versions of the Schizotypal Personality Questionnaire (SPQ). Personality and Individual Differences, 38(7), 1543-1548.

Wuthrich, V.M., Bates, T.C., 2006. Confirmatory factor analysis of the three-factor structure of the schizotypal personality questionnaire and Chapman schizotypy scales. J. Personality Assess. 87, 292-304.

Table 1: Group comparisons for disorganized speech, speech production, and cognitive performance across all conditions

	Schizotypy (*n* = 47)	Non-schizotypy (*n* = 51)
Baseline Condition	Mean (SD)	Mean (SD)
Disorganized Speech	0.39 (0.43)	0.44 (0.45)
Speech Production	2.36 (0.59)	2.36 (0.52)
Affective Condition		
Disorganized Speech	0.66 (0.69)	0.62 (0.66)
Speech Production	2.24 (0.60)*	2.46 (0.49)
Dual Task Condition		
Disorganized Speech	0.80 (0.79)*	0.44 (0.65)
Speech Production	2.04 (0.63)	2.16 (0.51)
Cognitive Performance		
Single-task (% Correct)	78.57 (13.41)	78.29 (13.04)
Dual-task (% Correct)	75.91 (15.51)	75.51 (13.32)
Functioning		
Social Functioning	6.98 (1.42)**	7.75 (1.23)

Note. * $p < 0.05$, ** $p < 0.01$

Table 2: Correlations between affective reactivity, cognitive reactivity, and social functioning

	Schizotypy (*n* = 47)	Non-schizotypy (*n* = 51)
	Social Functioning *r*	Social Functioning *r*
Affective Reactivity		
Disorganized Speech	-0.34*	0.05
Speech production	0.01	0.08
Cognitive Reactivity		
Disorganized Speech	-0.12	0.06
Speech Production	-0.19	-0.09

Note. * $p < 0.05$

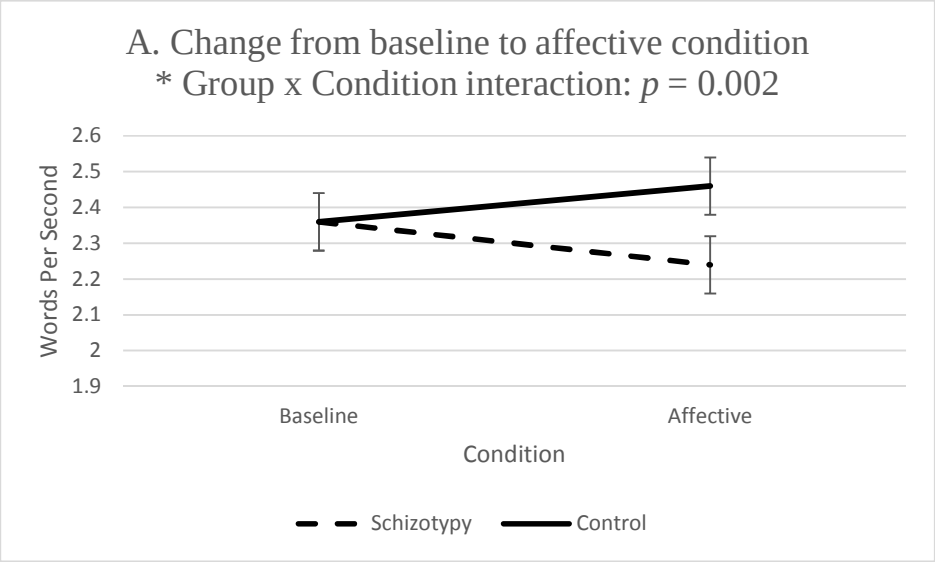

Figure 1. Line graph depicting change in speech production from baseline to affective conditions for schizotypy and control groups.

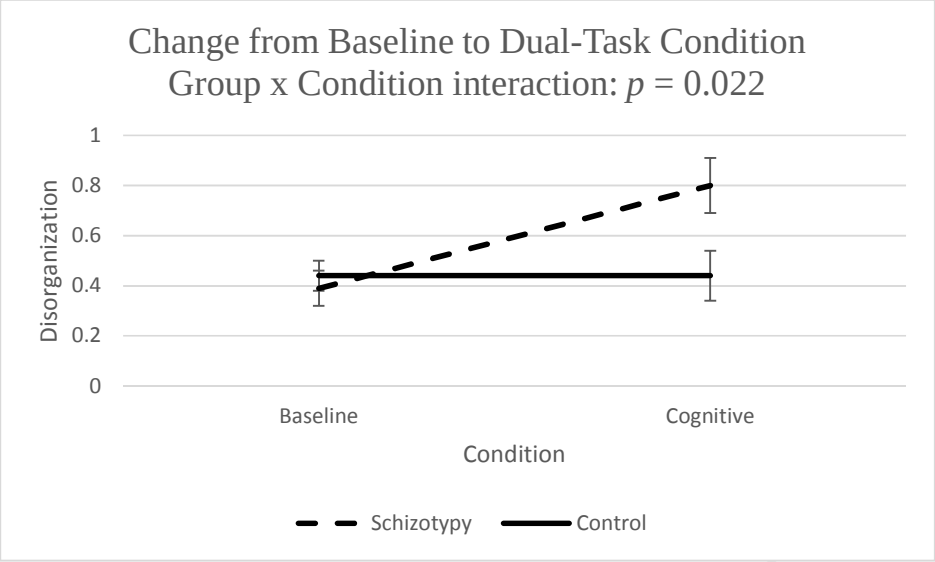

Figure 2. Line graph depicting change in disorganization from baseline to dual-task conditions for schizotypy and control groups.