UNDERSTANDING THE RELATIONSHIP BETWEEN GOAL MAINTENANCE AND DISORGANIZED SPEECH

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ABSTRACT

Disorganized speech in people with schizophrenia is associated with cognitive control deficits, but the specific nature of the relationship remains unclear. The current research examined whether one specific aspect of cognitive control, goal maintenance, is associated with disorganized speech and whether experimentally increasing goal maintenance demands would result in an increase in disorganized speech. In the present study, the A-X CPT and Missing Letter task were used to measure goal maintenance in people with schizophrenia (n = 49) and non-psychiatric controls (n = 28). In addition, the autobiographical memory task was used to measure disorganized speech in four conditions: the standard speech condition, the goal maintenance decrease condition (attending to visually-presented goal information during speech), the goal maintenance increase condition (performing the auditory 1-back with distraction during speech), and the control task speech condition (performing the auditory every-X task during speech). In people with schizophrenia, an increase in disorganized speech was associated with impaired goal maintenance performance in both goal maintenance tasks. In addition, both cognitive task manipulations during speech resulted in an increase in disorganized speech when compared to the standard speech and goal maintenance decrease conditions. Overall, these results provide at least partial support for goal maintenance deficits as a cause of disorganized speech in people with schizophrenia.

UNDERSTANDING THE RELATIONSHIP BETWEEN GOAL MAINTENANCE AND DISORGANIZED SPEECH

Introduction

Schizophrenia is a heterogeneous and debilitating disorder involving neurobiological abnormalities, functional impairment, and chronic symptoms. Disorganized speech, the most common of the disorganization symptoms (Liddle, 1987; Andreasen, Ardnt, Alliger, Miller, & Flaum, 1995), has long been conceptualized as a cardinal symptom of the disorder (Bleuler, 1911/1950). Disorganized speech includes incoherent, tangential, (Berenbaum & Barch, 1995; Kerns & Berenbaum, 2002) and incomprehensible speech (Rochester & Martin, 1979). Disorganized speech is present in people with schizophrenia and their first-degree relatives (Andreasen, 1979; Docherty, DeRosa, & Andreasen, 1996; Docherty, Gordinier, Hall., & Dombrowski, 2004; Kerns & Berenbaum, 2002). Disorganization symptoms have been consistently identified as potentially the most heritable schizophrenia symptoms (Wood, Pantelis, Velakoulis, Yücel, Fornito, & McGorry, 2008), with high levels of disorganization in schizophrenia predicting schizophrenia in relatives (Cardno, Rijsdijk, Murray, & McGuffin, 2008). In addition, disorganized speech can be relatively enduring (Bowie & Harvey, 2005; Bowie Tsapelas, Friedman, Parrella, Whire, & Harvey, 2005; Hafner & an der Heiden, 2003), predicts poorer long-term outcomes (Walker, 1995), and has been associated with premorbid work adjustment (Dikeos, Wickham, McDonald, Walshe, Sigmundsson, Bramon, et al, 2006), poorer functioning (Fuller, Schultz, & Andreasen, 2003; Liddle, 1994), and cognitive deficits (Dominguez, Viechtbauer, Simons, van Os, & Krabbendam, 2009). Given the heritability and poor prognosis, understanding the mechanisms

associated with disorganized speech could have important implications for the prevention and treatment of schizophrenia. For instance, the implementation of cognitive rehabilitation could potentially decrease disorganized speech. Thus, the current research examined the relationship between disorganized speech and specific cognitive deficits.

Cognitive control

One of the core features of schizophrenia is cognitive impairment. Cognitive impairments predate the onset of the disorder, have been found regardless of antipsychotic medication status, are present in people with elevated risk for schizophrenia, and are to a large extent refractory to current treatments (e.g., Becker, Kerns, MacDonald, & Carter, 2008; Green, 2007; Kerns & Becker, 2008; MacDonald, Becker, Carter, 2006). It has long been suggested that one of the central cognitive deficits of schizophrenia involves poor executive functioning, or cognitive control impairments (e.g., Bleuler, 1911/1950; Kraepelin, 1919/1971; Cohen & Servan-Schreiber, 1992). Cognitive control is the "ability to behave in accord with rules, goals, or intentions, even when this runs counter to reflexive or otherwise highly compelling competing responses" (Rougier Noelle, Braver, Cohen, & O'Reilly, 2005, p. 7338). Cognitive control performance is associated with activity in the prefrontal cortex (PFC; Miller & Cohen, 2001; Rougier et al., 2005). In people with schizophrenia, cognitive control deficits have been associated with PFC deficits, dopamine (DA) depletion in the PFC (e.g., Cohen & Servan-Schreiber, 1992; Finlay, 2001), and gamma-aminobutyric acid (GABA) dysfunction in the PFC (e.g., Lewis, Cho, Carter, Ecklund, Forster, Kelly, et al., 2008). Additionally, cognitive control deficits are poorly treated (Green, 2007), are associated with poor functional outcomes (Green, 1996; Green, Kern, & Heaton, 2004), and are

associated with increased disorganized speech (Kerns & Berenbaum, 2002, 2003). However, critically, it has been argued that cognitive control involves multiple component mechanisms (O'Reilly, 2006; Tranel, Anderson, & Benton, 1994). Hence, it is critical for research to examine specific cognitive control mechanisms and their associations with disorganized speech (Kerns, Nuechterlein, Braver, & Barch, 2008).

Goal Maintenance

A potentially integral part of cognitive control is goal maintenance (i.e., context processing) or the maintenance of internal representations or task context (Braver, Barch, Keys, Carter, Cohen, Kaye, et al., 2007; Cohen & Servan-Schreiber, 1992). Maintenance of important goal information (i.e., context) in the PFC is thought to bias activity in other brain regions responsible for task execution (Miller & Cohen, 2001). This is thought to be important in at least two situations: 1) to overcome automatic but situationally-inappropriate responses (Cohen, Braver, O'Reilly, 1996; Cohen & Servan-Schreiber, 1992) and 2) to maintain goals in the presence of distraction (Postle, 2005; Sreenivasn & Jha, 2007). For instance, PFC goal maintenance is thought to allow for the achievement of goal-directed behavior, such as reaching a particular speech goal (Dell, Burger, & Svec, 1997; Kerns, Cohen, Stenger, & Carter, 2004).

An example of a task thought to involve goal maintenance specifically in order to overcome a prepotent (or automatic) response is the A-X version of the continuous performance task (A-X CPT; Barch, 2005; Servan-Schreiber, Cohen, & Stiengard, 1996). On this task, a target letter is an X, but only if it was preceded by an A cue. The majority of trials involve seeing an A followed by an X. Hence, a prepotent response develops to respond to the X as a target. Goal maintenance is needed to maintain the identity of a

non-A cue letter to overcome the prepotent response of responding to X as a target and instead correctly respond “non-target”. The role of goal maintenance in the performance of this task has been supported by previous computational modeling, behavioral, and neuroimaging research (e.g., Braver et al., 2001; Cohen et al., 1996). For example, goal maintenance demands on the A-X CPT are associated with activity in the dorsolateral prefrontal cortex (DLPFC; Barch, Braver, Nystrom, Forman, Noll, & Cohen, 1997; MacDonald, Carter, Kerns, Ursu, Barch, Holmes, et al., 2005).

An example of a task thought to involve goal maintenance to maintain task information in the face of interference or distraction is the Missing Letter task developed by Cohen and colleagues (Cohen, Barch, Carter, & Servan-Schreiber, 1999). On this task, two sentences are presented one at a time followed by a set of probe letters that could make up a word except one letter is missing. Participants need to say a word that fits the letters aloud. At times, a possible response to the probe letters is meaningfully related to the first or second sentence heard. Goal maintenance is thought to be involved in maintaining the first sentence in spite of the distraction of the second sentence in order to make a goal-relevant response. Previous behavioral and imaging research supports the role of goal maintenance on the Missing Letter task (Cohen et al., 1999; Kerns, Cohen, et al, 2004). For instance, performance of the Missing Letter has been found to correlate with both A-X CPT and Stroop task performance (Cohen et al., 1999), two well-established goal maintenance tasks. Moreover, maintenance of goal information on this task has been found to activate the same left DLPFC region that is also activated on the A-X CPT task (Becker, Cho, Cohen, Kerns, & Carter, 2009; Kerns, Cohen, et al., 2004).

Additionally, the role of goal maintenance in maintaining information in the face of distraction is supported by animal research. Without distraction, animals with PFC damage can perform working memory tasks as posterior brain regions maintain target information. However, in the presence of distraction, PFC-damaged animals exhibit impaired performance because posterior regions also process the distraction items (Miller, Erickson, & Desimone, 1996). In contrast, the PFC exhibits sustained processing of targets in the face of distraction. Hence, it appears that a critical role of PFC goal maintenance, in addition to overcoming a prepotent response, is maintenance in the face of distraction (Postle, 2005, 2006).

People with schizophrenia and people with an elevated risk for schizophrenia have been found to exhibit goal maintenance deficits, which appear to be associated with DLPFC dysfunction (e.g., Becker et al., 2008; Cohen & Servan-Schreiber, 1992; MacDonald & Carter, 2003). In addition, goal maintenance has been recommended by the NIMH-funded CNTRICS working group for further schizophrenia research because it is a well-established construct and appears to be impaired in schizophrenia (Barch & Smith, 2008; Kerns et al., 2008). Additionally, goal maintenance and has been related to poor functioning in people with schizophrenia (Green, Kern, Braff, & Mintz, 2000). Furthermore, preliminary research has found that enhancing PFC GABA activity through $GABA_A$ receptors in people with schizophrenia improves goal maintenance task performance (e.g., in the AX-CPT) (Lewis et al., 2008). Therefore, it is possible that remediation of goal maintenance deficits (using medications enhancing GABA activity or using cognitive rehabilitation) could decrease associated symptoms such as disorganized

speech. Furthermore, reduction in these deficits and associated symptoms could improve daily functioning in people with schizophrenia.

Goal Maintenance and Language Production

In general, the possibility that impairments in goal maintenance could be involved in speech symptoms (e.g., disorganized speech) is consistent with basic theory and research on language production. Language production is a complex goal-directed behavior (Dell et al., 1997). Most if not all models of language production posit that it requires the formation and maintenance of a higher-level speech plan to guide speech and to monitor for errors and for inadequate speech (Bock & Griffin, 2000; Bock & Levelt, 1994; Harley, 2008; Levelt, 1989). Hence, language production models posit a role for goal maintenance in guiding ongoing speech.

Models of language production generally distinguish between at least three different stages (Bock & Griffin, 2000; Bock & Levelt, 1994; Harley, 2001; Levelt, 1989). One stage is *conceptualization* and involves conceiving and maintaining a speech goal. Conceptualization involves monitoring planned speech messages for appropriateness and maintaining a speech message for use by other language production stages. It is also important in maintaining what has previously been said in order to know whether one has gotten off track. A second stage of language production is *formulation* (or grammatical encoding) involving both lexicalization (i.e., selecting specific words) and syntactic planning (i.e., putting words together to form a sentence). A third stage is *execution* involving detailed phonetic and articulatory planning (i.e., turning words into sounds).

Of these three language production stages, poor goal maintenance could clearly disrupt the conceptualization stage and lead to disorganized speech. Given models of language production, poor goal maintenance should result in poor maintenance of speech messages, poor control of other language production stages, and poor monitoring of ongoing speech performance. For example, poor goal maintenance could lead to not maintaining a speech message long enough to reach a particular speech goal, resulting in tangential speech and the interjection of off-topic contextually-inappropriate information into speech. In addition, poor goal maintenance could lead to poor monitoring of speech as people would have a harder time knowing whether they had either moved off track from a speech goal or had not successfully reached a speech goal if the goal was no longer being successfully maintained. Hence, the potential effects of poor goal maintenance on language production seem consistent with disorganized speech in schizophrenia (Kerns & Berenbaum, 2003; Kerns, 2007a, 2007b). For example, disorganized speech includes speech that is tangential and strays from a speech topic (Andreasen, 1979a; Holzman, 1978). Thus, language production theory appears to predict the association between goal maintenance and disorganized speech, but few studies have directly tested this (Dell et al., 1997).

In addition, a role for PFC goal maintenance in guiding language production is consistent with some previous fMRI research. For example, automatic semantic retrieval appears to be associated with temporal lobe activity (e.g., Badre & Wagner, 2007; Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004). However, goal-directed access to semantic knowledge is associated with activity in the PFC (e.g., Gabrieli, Poldrack, & Desmond, 1998; Poldrack, Wagner, Prull, Desmond, Glover, & Gabrieli,

1999). This is enabled by direct connections between areas of the PFC and temporal lobe examined using diffusion-weighted imaging (DWI) tactography (Croxson, Johansen-Berg, Behrens, Robson, Pinsk, Gross, et al., 2005). In addition, post-retrieval inhibition of competing lexical information was associated with PFC activity but not with temporal lobe activity (Gold, Balota, Jones, Powell, Smith, & Andersen, 2006). However, if PFC goal maintenance is critical for language production, then it would be predicted that goal maintenance would be required to maintain a goal in the face of distraction but not in the absence of distraction. One previous fMRI study examined this association using the Missing Letter task without distraction in healthy controls (Kerns, Cohen, et al., 2004). Kerns and colleagues found that both increased PFC activity and decreased temporal lobe activity during goal maintenance predicted subsequently making goal-relevant responses. The same pattern of decreased temporal lobe activity was found in a similar study in patients with schizophrenia (Becker et al., 2009). Importantly, decreased temporal lobe activity could be indicative of sustained and focused processing of the goal. Therefore, based on this study, as in animal research, it is possible that goal maintenance may not be critical for language production in the absence of distraction. Hence, the current research will use the Missing Letter task with distraction to examine whether goal maintenance is critical for goal-relevant language production in the presence of distraction.

Goal Maintenance and Language Production in Schizophrenia

Based on the reviewed language production research and theory, it appears that there might be an association between goal maintenance and normal language production. This research and theory suggests that goal maintenance impairments may be associated with disorganized speech (i.e., language production symptoms). Additionally, a theory of

language dysfunction in schizophrenia suggests that language dysfunction may arise from PFC goal maintenance impairments (Cohen & Servan-Schreiber, 1992). According to this theory and connectionist modeling used to test the theory, decreased effects of dopamine in the PFC may lead to a disturbance in the internal representation of task context (i.e., goal maintenance; Cohen & Serven-Schreiber, 1992). Importantly, this theory suggests that the disturbance in the maintenance of task context leads to difficulty in maintaining a language goal to overcome a prepotent response. Consistent with this, in research examining the interpretation of homonyms, people with schizophrenia showed impairment in overcoming a prepotent response in order to respond correctly with the non-dominant homonym interpretation implied by the context of the sentence (Chapman, Chapman, & Miller, 1964). In addition, other schizophrenia research has found reduced N400 activity when overcoming an automatic response to a homograph (Salisbury, O'Donnell, McCarley, Nestor, & Shenton, 2000). Additional research found reduced DLPFC activity when responding to a semantically incongruent sentence (Kuperberg, West, Goff, & Lakshmanan, 2008). These findings provide support for the involvement of goal maintenance in language processing and exemplify how language dysfunction in schizophrenia may arise as a result of poor goal maintenance. However, the majority of research on language and goal maintenance in schizophrenia has examined language comprehension but not language production.

For language production symptoms, there is still only limited direct evidence suggesting that poor goal maintenance is associated with disorganized speech. Consistent with such an association, research has found that computationally-complex, broad measures of cognitive control (N-back), which presumably involve goal maintenance, are

associated with disorganized speech (e.g., Kerns & Becker, 2008; Kerns & Berenbaum, 2002, 2003). However, based on these studies, the specific relationship between disorganized speech and goal maintenance is unclear. Two previous studies have found evidence that poor goal maintenance task performance on the A-X CPT is associated with disorganization symptoms, including disorganized speech (Barch, Carter, MacDonald, Braver, & Cohen, 2003; Cohen et al., 1999). However, those studies did not specifically examine disorganized speech, instead measuring disorganization more broadly (e.g., including disorganized behavior), and involved non-detailed live clinical ratings of disorganization. Therefore, Cohen and colleagues (1999) specifically recommended that future research examine whether detailed linguistic disorganized speech ratings would be associated with poor goal maintenance.

One recent study found evidence that poor performance on a task thought to involve goal maintenance was associated specifically with disorganized speech in people with schizophrenia (Becker, Cicero, Cowan, & Kerns, under review). Specifically, the study examined whether detailed linguistic ratings of disorganized speech, as measured by the Communication Disturbances Index (CDI), was associated with deficits in either goal maintenance or in working memory storage capacity. Using the Preparing to Overcome Prepotent Response (POP) task (Barber & Carter, 2005; Kerns, 2006), results showed that poor goal maintenance performance was associated with increased disorganized speech in people with schizophrenia, $r = -.40$ (Becker et al., under review). In contrast, deficits in working memory capacity, examined using the running memory span (RMS) task (i.e., a relatively pure measure of working memory storage capacity; Cowan, Elliott, Saults, Morey, Mattox, Hismjatullina, et al., 2005), were not significantly

associated with FTD, r = -.14 (Becker et al., under review). These results suggest that disorganized speech may be associated with poor goal maintenance and not with problems in working memory capacity. However, this study did not use the most well-validated goal maintenance task, the A-X CPT.

Another study found that poor working memory (A-X CPT and Reading Span task composite score) was significantly associated with disorganized speech (Berenbaum, Kerns, Vernon, & Gomez, 2008) as measured by the Scale for the Assessment of Thought, Language, and Communication (TLC; Andreasen, 1986). However, this study did not examine goal maintenance as measured by the A-X CPT as a separate entity. Thus, to my knowledge, no previous study has specifically examined the association between the A-X CPT and disorganized speech as measured by the CDI.

The CDI is a sensitive measure of disorganized speech used extensively in previous research with people with schizophrenia, their relatives, college students, and in studies examining effects of experimental speech manipulations on disorganized speech (e.g., Becker et al., under review; Docherty, Strauss, Dinzeo, & St.-Hilaire, 2006; Kerns, 2007a, 2007b; Kerns & Becker, 2008; Kerns & Berenbaum, 2003). The CDI rates the number of speech unclarities, with an unclarity being any speech passage in which the meaning is sufficiently unclear to impair the overall meaning of the speech passage (Docherty, 1996). The CDI was developed as an extension of a previous measure of unclear referents in speech that has been used frequently in previous schizophrenia research (Rochester & Martin, 1979). It is strongly associated with older measures of disorganized speech such as the TLC (Docherty et al., 1996). Importantly, the CDI is a more sensitive measure of speech disorder than the TLC, potentially making it useful for

research examining associations between disorganized speech and cognitive task performance. CDI disorganized speech ratings involve fairly precise quantitative ratings that will vary dimensionally without floor effects. One of the advantages of the CDI is that it is such a sensitive measure of speech disorganization that it has been used successfully with college students (e.g., Kerns, 2007a; Kerns & Becker, 2008). Therefore, the CDI should have been sensitive enough to detect the effects of various speech conditions in the current study.

If poor goal maintenance actually causes elevated disorganized speech, then experimentally increasing goal maintenance demands during speech should cause an increase in disorganized speech. Previous research has examined whether increasing goal maintenance demands causes an increase in disorganized speech in healthy controls. To increase goal maintenance demands, participants completed a speech task while performing a 1-back with distraction task (i.e., participants needed to remember a target letter in the face of interference from a distraction letter). As previously mentioned, goal maintenance tasks with distraction appear to critically rely on PFC goal maintenance (e.g., Postle, 2005). Two previous studies found that experimentally increasing goal maintenance demands during speech caused an increase in disorganized speech in healthy controls (Kerns, 2007a; Kerns & Berenbaum, 2003). In contrast, performing a sustained attention task which did not increase goal maintenance demands during speech did not cause an increase in disorganized speech in healthy controls (Kerns, 2007a). Hence, increasing goal maintenance demands causes an increase in disorganized speech in healthy controls. However, these speech manipulations were not matched on difficulty and have not yet been examined in people with schizophrenia. In fact, previous

schizophrenia research has yet to find evidence that an experimental manipulation during speech can cause an increase in disorganized speech in chronic, medicated individuals with schizophrenia (Barch & Berenbaum, 1997; Melinder & Barch, 2003; Moskovitz, Davidson, & Harvey, 1991).

In one study, researchers presented participants with two stories describing a series of events, with each story followed by three questions that the researchers asked, one unstructured question and two structured questions (Barch & Berenbaum, 1997). Prior to being told the stories, participants were given one of two sets of instructions. One set of instructions told the participants that they would be hearing a story and then asked questions following the story (i.e., the low context condition). The second set of instructions told participants that they would hear a story followed by questions, and the instructions also told participants what the story was about and what type of questions they would be asking (i.e., high context condition). The researchers predicted that the degree of context would impact the level of disorganized speech (i.e., low context leading to higher levels of disorganized speech and high context leading to lower levels of disorganized speech). Additionally, the researcher predicted that the type of question would impact the level of disorganized speech (i.e., structured questions leading to less disorganized speech and unstructured questions leading to increased disorganized speech). Results of this study showed that disorganized speech was increased after unstructured questions compared to structured questions. However, there was no effect of context on disorganized speech. Thus, experimentally manipulating context in this study did not result in an increase in disorganized speech (Barch & Berenbaum, 1997). However, it appears that this study's context manipulation may not be increasing goal

maintenance demands during the language production aspect of speech, instead increasing/decreasing goal maintenance demands prior to speech (i.e., during language comprehension).

In a second study, researchers presented participants with a single and dual task speech interview (Melinder & Barch, 2003). Two sets of interview questions were constructed, each including 17 open-ended questions. The interviews used for the single and dual task interviews were counterbalanced across participants. During the dual task interview, participants completed a Category Monitoring task. This task is a measure of working memory that requires maintenance of a single piece of target information that remains the target for an extended duration and the processing of additional stimuli at the same time. The speech data from both interviews were coded using the TLC. The researchers hypothesized that working memory performance during the interview would increase disorganized speech. Results showed that disorganized speech, as measured by discourse coherence, did not significantly increase during the dual-task interview, contrary to the researchers' predictions (Melinder & Barch, 2003). One possible explanation for these null findings is the task used in this study was a working memory task and did not specifically increase goal maintenance demands; therefore, disorganized speech was not increased.

In a third study, participants were administered two speech conditions, one with distraction and one without distraction (Moskovitz et al., 1991). During the distraction condition, participants listened to a male voice reading text from a middle school-level science book. Participants were asked a set of 22 questions, with 4 minutes of speech occurring during the distraction condition and 4 minutes of speech occurring during the

non-distraction condition. The speech data from both interviews were coded using the TLC. The researchers hypothesized that hearing the distraction would increase disorganized speech in people with schizophrenia. Results showed that there was a significant difference in disorganized speech in the distraction and non-distraction conditions in unmedicated individuals with schizophrenia. However, in medicated individuals with schizophrenia, the distraction condition did not lead to an increase in disorganized speech compared to the non-distraction condition. The difference in results may be due to unmedicated individuals with schizophrenia being highly distractible compared to medicated individuals with schizophrenia. Based on other non-speech research, it appears that unmedicated individuals with schizophrenia have general difficulty with performing dual tasks (i.e., performing a CPT and a word-list shadowing task simultaneously; Serper, Bergman, & Harvey, 1990) which does not improve with practice. Alternatively, medicated individuals with schizophrenia were able to perform both tasks after practicing both tasks together (Serper et al., 1990). Therefore, people with schizophrenia may not be likely to show a difference in disorganized speech unless a specific cognitive process that influences speech was manipulated. Thus, one possible explanation for the null findings in the medicated participants is that the distraction condition did not manipulate goal maintenance demands and therefore, did not lead to an increase in disorganized speech.

If goal maintenance deficits are associated with disorganized speech in people with schizophrenia, then experimentally increasing goal maintenance demands during speech should cause an increase in disorganized speech. Furthermore, if goal maintenance deficits are associated with disorganized speech, experimentally decreasing

goal maintenance demands should cause a decrease in disorganized speech. These results would have important implications for the treatment of disorganized speech (e.g., using cognitive rehabilitation to decrease goal maintenance demands thereby decreasing disorganized speech).

Current Research

The current study examined the association between goal maintenance and disorganized speech. If poor goal maintenance is related to disorganized speech in schizophrenia, at least two predictions follow. First, disorganized speech in schizophrenia should be associated with poor goal maintenance task performance. In the current research, it was predicted that goal maintenance performance in the A-X CPT and in the Missing Letter task would be associated with increased disorganized speech, as measured by the Communication Disturbances Index (CDI). Second, experimentally varying goal maintenance demands should increase or decrease disorganized speech in people with schizophrenia. In the current research, it was predicted that increasing goal maintenance demands during speech using an auditory 1-back with distraction task would increase disorganized speech in that condition compared to a standard speech task and a control task speech condition. Additionally, it was predicted that decreasing goal maintenance demands during speech, by providing context information during speech, would decrease disorganized speech compared to a standard speech condition.

Methods

Participants

Participants were 49 people who met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; DSM-IV; American Psychiatric Association, 1994) criteria for

schizophrenia or schizoaffective disorder and 28 non-psychiatric controls who did not meet criteria for any Axis I disorder. Participants with schizophrenia were non-acute inpatients at a state psychiatric hospital (with a largely forensic population). Non-psychiatric controls were recruited from a central Missouri community. Participant demographic information is presented in Table 1. The groups differed significantly in ethnicity and differed at the trend level in parental education; however, this did not account for any of the group differences discussed below. Participants were between the ages of 18-60. Note that although the level of disorganized speech is higher in acute than in chronic phases of schizophrenia (e.g., Andreasen et al., 1995), disorganized speech in chronic patients has been found to be stable, even past the age of 65 (Bowie, Tsapelas, et al., 2005). Statistically removing variance shared with age has not altered associations between speech symptoms and cognitive control task performance (e.g., Becker et al., under review; Kerns, 2007b). Participants were also without a history of serious head injury, without substance dependence in the past 6 months, and did not meet demographically matched norms for dementia on the Mini-Mental Status Exam.

Measures

Clinical Symptom Ratings. Diagnoses were based on the psychotic, mood, and substance use disorders sections of the Structured Clinical Interview for the DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1998) and a review of clinical records. Three trained masters level clinicians conducted the diagnostic interviews and made the diagnoses and symptom ratings. Past week levels of general symptoms were measured with the Brief Psychiatric Rating Scale (BPRS; Overall & Gorman, 1962) and the Scales

for the Assessment of Negative Symptoms (SANS; Andreasen, 1982) and Positive Symptoms (SAPS; Andreasen, 1984).

Cognitive Tasks

A-X CPT. The two goal maintenance tasks that were used in the current study were the A-X CPT, arguably the most well-validated goal maintenance task, and the Missing Letter task. On the A-X CPT (Braver et al., 2001; Cohen et al., 1999), as can be seen in Figure 1, participants see a series of letters presented on the screen one at a time. The target probe is an X but only if the previous cue letter was an A. Goal maintenance plays a role in two trial types, BX (i.e., B as in non-A) trials and AY trials (i.e., Y as in non-X). In BX trials, participants need goal maintenance to maintain the cue identity to overcome the prepotent response tendency of responding to the X as a target. In AY (i.e., Y as in non-X) trials, goal maintenance makes participants more likely to respond to the Y as a target. Poor goal maintenance does not cause generalized poor performance but specifically poor performance on BX trials and better performance on AY trials. Additionally, a signal detection measure, d-prime context, was used to examine the difference between AX hits and BX false alarms, with a larger difference reflecting better goal (or context) maintenance (as used in Cohen et al., 1999). In this study, we expected that disorganized speech would be associated with poor BX trial performance but better AY performance and with a smaller d-prime context score. Participants completed 180 total trials, with 18 BX trials and 18 AY trials, with a cue-probe delay of 6 seconds (modified task from Braver et al., 2001).

Missing Letter Task. On the Missing Letter task, as can be seen in Figure 2, participants hear two sentences, each presented for 1.5s to 3.5s (Cohen et al., 1999;

Cohen & Servan-Schreiber, 1992) and separated by a delay of 3s. After the two sentences and another delay of 3s, participants see a set of probe letters that could make up a word except that one letter is missing (e.g., w_ist). Participants have to say aloud the first word that they can think of that fits the letters. In each trial, one of the two sentences provide context for the response to the probe letters (e.g., for the probe w_ist, participants could say wrist or waist). Goal maintenance is thought to be involved in order to retain the gist of sentence 1 while processing sentence 2 (Cohen et al., 1999). Participants need to process both sentences because they have to intermittently answer a true/false question about the sentences. Trials vary by whether the sentences are related to a dominant (i.e., prepotent) or non-dominant (i.e., non-prepotent) probe response. The probes have been extensively pilot-tested, and it is known in the absence of hearing sentences how likely people are to make certain responses to the probes. The dependent variable for this task is the difference in the proportion of dominant responses made on dominant trials versus on non-dominant trials (Becker et al., 2009; Kerns, Cohen, et al., 2004). Scores were calculated separately for when sentence 1 is the context sentence and when sentence 2 is the context sentence (Cohen et al., 1999). A larger score reflects being more likely to give the dominant response on dominant trials and being less likely to give the dominant response on non-dominant trials (i.e., better goal maintenance). There were 4 blocks of 21 trials for a total of 36 first sentence context trials, 36 second sentence context trials, and 12 true-false trials.

Psychometric Control Task. People with schizophrenia show deficits on almost all tasks that require a voluntary response relative to controls. Therefore, one issue for schizophrenia research is to examine specific, rather than generalized deficits (Chapman

& Chapman, 1974). In the current research, the main issue is whether disorganized speech is specifically associated with poor performance on the A-X CPT and Missing Letter tasks or whether disorganized speech is associated with generalized poor performance. To examine this, a psychometric control task, the Masked Priming task, which is closely matched to the Missing Letter task but does not involve goal maintenance, was used for comparison with the Missing Letter task. On this task, participants see a prime word (e.g., attitude) briefly presented for 66 milliseconds (ms). Immediately after the word, a pattern mask consisting of a row of XXXX's appears for 250 ms. Then a set of probe letters that could make up a word (e.g., a_titude) is presented. Participants say a word that fits the probe letters (e.g., 'attitude' or 'altitude'). Thus, the prime word (either dominant or non-dominant) can influence responses to the probe. The dependent variable is the same as in the Missing Letter task. Participants completed four blocks of 20 trials for a total of 80 trials. Critically, testing with 22 patients with schizophrenia revealed that this task has been matched to the Missing Letter task in difficulty (i.e., proportion of responses biased toward the goal or prime; Missing Letter = .26; Masked Priming = .29). The Masked Priming task has also been matched to the Missing Letter in true score variance (Missing Letter = .026; Masked Priming = .031) to ensure that the Missing Letter task is not more psychometrically discriminating (Strauss, 2001). If disorganized speech in people with schizophrenia is associated with Missing Letter task performance but not with Masked Priming task performance, it can be concluded that disorganized speech is specifically related to Missing Letter task performance rather than to a generalized deficit.

Disorganized Speech Measures

Experimental Speech tasks. To elicit speech to make disorganized speech ratings, participants were given a structured interview (i.e., a modified version of the Autobiographical Memory Test; Williams & Broadbent, 1986). The interview asked them to recall a specific memory (e.g., Tell me a specific memory about a time you were outdoors), and participants were told that they could say as much or as little as they wanted (Becker et al., in review). While people spoke, goal maintenance demands were experimentally manipulated. The speech task included 4 conditions, with one standard speech condition, two manipulations of goal maintenance demands (decrease or increase) and one control task speech manipulation. A total of 8 minutes of speech was collected for each condition. In previous research, the minimum amount of time people speak for each memory is 30 seconds. Therefore, a maximum of 16 memories were used for each condition (for a total of 64 possible memories across all conditions) to ensure that 8 minutes of speech were collected for each condition. The order of memories was randomized across participants.

For the standard speech condition, participants were asked to recall a maximum of 16 memories in the absence of any type of manipulation. This condition was used as a comparison condition for the other three speech conditions. One speech condition to which the standard speech condition was compared was the decreased goal maintenance demand manipulation condition (i.e., GM decrease). In the GM decrease condition, participants spoke while external goal information (i.e., the memory cue) was presented to them on an index card. Participants were able to use this external source of goal information to help control their speech. This manipulation is similar to research on goal

maintenance that has found that people with poor cognitive control have difficulty with goal maintenance tasks like the Stroop, primarily when they involve a low proportion of incongruent trials (Kane & Engle, 2003). It is thought that with a low proportion of incongruent trials that participants must rely on internal maintenance of goal information in order to perform the task (Cohen & Servan-Schreiber, 1992). However, with a high proportion of incongruent trials, external reminders of task set (e.g., response conflict) are thought to be sufficient to allow for maintenance of task set. For the GM decrease condition, by providing people with external goal information while they were speaking, this should have lessened the impact of poor goal maintenance and therefore should have reduced the amount of disorganized speech.

Another speech condition to which the standard speech condition was compared was the increased goal maintenance demand manipulation condition (i.e., GM increase). In the GM increase condition, participants spoke while performing a modified 1-back with distraction task. The 1-back with distraction task was modified from its previous use with college students (Kerns & Berenbaum, 2003; Kerns, 2007a). First, to make it easier for participants to know when they needed to respond, letters that participants needed to pay attention to were presented in a female voice whereas the letters they could ignore were presented in a male voice. Second, participants heard a letter once every 7.5 seconds (compared to 2.5 seconds in analogue studies with college students), meaning that they would only have to respond once every 15 seconds. During the speech task, the interviewer verbally gave the memory cue to the participant when cued by the computer screen to insure that no letter was currently being presented. Previous schizophrenia

speech research has successfully used an auditory presentation of questions with an auditory presentation of dual task stimuli (Moskovitz et al., 1991).

Another speech condition to which the standard speech and GM increase conditions were compared was the control task speech condition. The control task speech condition was the second condition during which participants performed a cognitive task while speaking but where goal maintenance demands are not thought to be involved. On the control task speech condition, as participants spoke, they heard letters through headphones every 3.5 seconds and had to press "1" whenever they heard 'X', which occurred half of the time (Kerns, 2007a). Therefore, on average, participants had to respond every 7 seconds. Note that participants had to respond more frequently on the control task speech condition than on the 1-back with distraction task (i.e., in the GM increase condition). In extensive pilot testing with college students, the effect of responding more rapidly to the every-X task was compared with the effect of relatively infrequent responding during the 1-back with distraction task. Importantly, the amount of speech produced during speech interviews that were conducted during the performance of these cognitive tasks was not significantly different. In fact, several time-presentations for the every-X task (i.e., an X presented every 2.5s, 3s, 3.5s, 5s) were piloted in separate studies (with *n*'s > 20). During these pilot studies, participants were administered two different types of speech tasks (i.e., an autobiographical memory task and a verbal fluency task) during which they performed both the 1-back with distraction task and the every-X task. Based on the analyses examining amount of speech produced in the two speech tasks during the two cognitive task speech manipulations, the presentation of the X every 3.5s most closely matched the amount of speech produced in the 1-back task.

Hence, on the control task speech condition, participants responded once every 7 seconds, but they responded once every 15 seconds in the goal maintenance increase condition. The order of the GM increase condition and control task speech condition were counterbalanced. Following the hypothesis that increasing goal maintenance demands increases disorganized speech, it was expected that there would be increased disorganized speech in the GM increase condition compared to the standard speech and control task speech conditions.

Based on previous experience rating disorganized speech in studies involving experimental speech manipulations, my impression is that disorganized speech seems to decrease during the course of the study session. Additionally, I expected the most difficulty in detecting differences between the standard speech condition and the GM decrease condition. Therefore, the standard speech and the GM decrease conditions were administered in the beginning of the study and were counterbalanced. The difference between these two conditions was predicted to be the most subtle and having these conditions in the beginning increased the likelihood of detecting differences between the two conditions. The GM increase and the control task speech conditions were administered later on in the study session and were counterbalanced. If anything, I expected that the later administration of the GM increase and control task speech conditions would make it more difficult to detect differences between these conditions and the standard speech condition.

Disorganized speech ratings. The speech interviews were audiotaped using digital sound recorders. Typed transcripts were made of the interviews and were used to make disorganized speech ratings. All disorganized speech ratings were made by 4

research assistants who were trained by me and supervised by my advisor. The measure of disorganized speech was the Communication Disturbances Index (CDI; Docherty, 1996; Docherty et al., 1996), which involves deciding if a speech passage is sufficiently unclear such that the overall meaning is impaired (Docherty, 1996). As previously mentioned, the CDI is a sensitive measure of disorganized speech and is highly correlated with other measures of disorganized speech (Docherty et al., 1996). Interrater reliability for the total CDI score, measured using an intraclass correlation (Shrout & Fleiss, 1979), treating the raters as random effects and the mean of the four raters as the unit of reliability, was 0.92. Following Docherty and colleagues (Docherty et al., 1996; Docherty 2005), raw CDI scores were corrected for total amount of speech; hence, reported CDI scores in Table 1 are the number of speech unclarities per 100 words of speech.

Procedure and Data Analysis

Once informed consent was obtained, participants completed the standard speech and GM decrease conditions, which were counterbalanced. Participants then completed the Missing Letter task followed by the GM increase and control task speech conditions, which were counterbalanced. Before performing the GM increase condition, participants practiced the 1-back with distraction task for several minutes to ensure that it was well-rehearsed. Similarly, before the control task speech condition, participants practiced the every-X task for several minutes to ensure that it was well-rehearsed. Next, participants were administered the SCID followed by the A-X CPT. Finally, participants completed the psychometric control task, the Masked Priming Task.

To examine whether poor goal maintenance is associated with disorganized speech, I examined the correlation between goal maintenance performance on the A-X

CPT and Missing Letter tasks and disorganized speech in the standard speech condition. Individual task performance scores as well as a composite variable (i.e., the average of the standardized performance scores on both tasks) were examined. I predicted a significant association between goal maintenance performance deficits and disorganized speech in people with schizophrenia. I also examined the psychometric control task, the Masked Priming Task, and its correlation with disorganized speech in the standard speech condition and predicted no association. Furthermore, I predicted that the correlation between the Missing Letter task and disorganized speech would be significantly larger than the correlation between the psychometric control task and disorganized speech. To test this, I used a test of correlated correlation coefficients (Meng et al., 1992). Additionally, to test whether decreasing or increasing goal maintenance demands decreases or increases disorganized speech, I compared each speech manipulation and its specific control condition in people with schizophrenia. For instance, I compared the GM decrease condition with the standard speech condition and predicted decreased disorganized speech in the GM decrease condition in schizophrenia. I also compared the GM increase condition with the standard speech and control task speech conditions and predicted increased disorganized speech in the GM increase condition in schizophrenia. In addition, I compared the effect of the control task speech condition with the standard speech condition and predicted no difference in disorganized speech as these two conditions were not expected to differ in goal maintenance demands.

Results

Cognitive Task Performance

A-X CPT. First, goal maintenance task performance in people with schizophrenia and non-psychiatric controls was examined. In a two (group: schizophrenia and controls) by two (trial type: BX versus AY trials) analysis of variance (ANOVA) examining accuracy rates, there was a main effect of group, F (1, 74) = 24.66, $p < 0.001$. People with schizophrenia were significantly less accurate than non-psychiatric controls, as can be seen in Table 2. Additionally, there was a main effect of trial type, F (1, 74) = 38.30, $p < 0.001$, with decreased accuracy on BX trials compared to AY trials. Furthermore, there was a significant interaction between group and trial type, F (1, 74) = 24.23, $p < 0.001$. As can be seen in Figure 3, people with schizophrenia were significantly less accurate during BX trials than during AY trials when compared to non-psychiatric controls, t (74) = 4.92, $p < 0.001$, which is indicative of poorer goal maintenance in people with schizophrenia. Similarly, in another analysis of goal maintenance performance, d-prime context (i.e., AX hits minus BX false alarms), people with schizophrenia performed significantly worse than control participants (t (74) = 6.45, $p < 0.001$).

In a second two (group: schizophrenia versus controls) by two (trial type: BX versus AY trials) ANOVA examining reaction times (RTs) in the A-X CPT, there was a main effect of group, F (1, 70) = 10.14, $p < 0.005$. People with schizophrenia were significantly slower than non-psychiatric controls, as can be seen in Table 2. However, there was no main effect of trial type, F (1,70) = 0.49, $p = 0.49$, and as can be seen in Figure 4, there was no interaction between group and trial type, F (1,70) = 0.44, $p = 0.51$.

In addition to examining the performance of all individuals on the A-X CPT, I conducted an analysis excluding participants with relatively poor performance during BX trials, which possibly reflected a poor understanding of those trials. Therefore, in additional analyses, participants with less than 20% correct on BX trials were removed (new sample sizes: schizophrenia n = 30, control n = 27). In a two (group: schizophrenia and controls) by two (trial type: BX versus AY trials) ANOVA examining accuracy rates, results were similar to those reported above in the full sample. Specifically, there was a main effect of group, F (1, 54) = 9.38, $p < 0.005$, with significantly lower accuracy rates in people with schizophrenia compared to non-psychiatric controls, as can be seen in Table 1A in the Appendix. Additionally, there was a main effect of trial type, F (1, 54) = 14.77, $p < 0.001$, with decreased accuracy on BX trials compared to AY trials. Furthermore, there was a significant interaction between group and trial type, F (1, 54) = 9.51, $p < 0.005$. People with schizophrenia were significantly less accurate during BX trials than during AY trials when compared to non-psychiatric controls, t (54) = 3.15, $p < 0.005$, which is indicative of poorer goal maintenance in people with schizophrenia. Similarly, examining d-prime context provided additional evidence that people with schizophrenia had significantly worse goal maintenance performance compared to control participants t (54) = 4.68, $p < 0.001$.

In a two (group: schizophrenia versus controls) by two (trial type: BX versus AY trials) ANOVA examining RTs after individuals with < 20% BX accuracy were removed from the analysis, results were similar to those reported above in the full sample. There was a main effect of group, F (1, 54) = 9.14, $p < 0.005$, as people with schizophrenia were significantly slower than non-psychiatric controls, as can be seen in Table 1A in the

Appendix. Additionally, there was a main effect of trial type, F (1, 54) = 4.51, $p < 0.05$, with slower RTs on BX trials compared to AY trials. In contrast, there was no interaction between group and trial type, F (1, 54) = 1.34, $p = 0.25$.

Missing Letter. In addition to the A-X CPT, goal maintenance performance in the Missing Letter task was examined. In a two (group: schizophrenia and controls) by two (sentence type: sentence 1 versus sentence 2) ANOVA examining the difference in the proportion of dominant responses made on dominant trials versus non-dominant trials, there was a main effect of group, F (1, 75) = 27.11, $p < 0.001$. Specifically, as can be seen in Table 2, there was a significantly smaller difference in the proportion of dominant responses (i.e., poorer goal maintenance performance) in people with schizophrenia compared to controls. Additionally, there was a main effect of sentence type, F (1, 75) = 40.12, $p < 0.001$. There was a significantly smaller difference in the proportion of dominant responses (i.e., poorer goal maintenance performance) made when sentence 1 was the context sentence compared to when sentence 2 was the context sentence. Furthermore, as seen in Figure 5, there was a significant interaction between group and sentence type, F (1, 75) = 6.67, $p < 0.05$. The difference between goal-relevant responses to sentence 1 and to sentence 2 is significantly smaller in people with schizophrenia compared to non-psychiatric controls. In addition, in an independent samples t-test examining performance during the true/false sentences, people with schizophrenia performed significantly worse compared to non-psychiatric controls, t (68) = 4.91, $p < 0.001$. Thus, people with schizophrenia had difficulty maintaining the context of the auditory sentences.

Psychometric control task. To examine cognitive performance in a task that did not involve goal maintenance demands, performance in a psychometric control task, the Masked Priming task, was examined. In the current study, the Masked Priming task was matched to the Missing Letter task in true score variance (Missing Letter = .021; Masked Priming = .028); therefore, the Missing Letter task was not more psychometrically discriminating than the psychometric control task (Strauss, 2001). An independent samples t-test was conducted examining the difference in the proportion of dominant responses made after dominant primes versus non-dominant primes in people with schizophrenia compared to non-psychiatric controls. As can be seen in Table 3, people with schizophrenia exhibited significantly poorer performance compared to non-psychiatric controls, t (73) = 8.73, $p < 0.001$. People with schizophrenia exhibited a significantly smaller difference in the proportion of dominant responses compared to non-psychiatric controls.

Cognitive Task Associations

A-X CPT and Missing Letter. Next, the association between goal maintenance as measured by the A-X CPT and goal maintenance as measured by the Missing Letter task was examined in people with schizophrenia and non-psychiatric controls. As can be seen in Table 4, in people with schizophrenia, d-prime context was associated with goal-relevant responding related to both sentence 1 and sentence 2. In contrast, in controls, increased A-X CPT goal maintenance (i.e., larger d-prime context) was associated with increased goal-relevant responding in the Missing Letter task sentence 1. Conversely, as expected, in non-psychiatric controls, d-prime context was not associated with goal-relevant responding related to sentence 2. In fact, in non-psychiatric controls d-prime

context was significantly more strongly associated with goal-relevant responding related to sentence 1 compared sentence 2, Z = 2.19, $p < 0.05$.

Missing Letter and Psychometric Control Task. Next, the association between the two conditions in the Missing Letter task and the psychometric control task, the Masked Priming Task, was examined in people with schizophrenia and non-psychiatric controls. As can be seen in Table 4, goal-relevant responding in the Missing Letter task during trials where sentence 1 was the context sentence was significantly associated with performance in the psychometric control task in both groups. However, goal-relevant responding when sentence 2 was the context sentence was not correlated with performance during the psychometric control task in either group. In controls, the difference between these two correlations was significantly different, Z = 2.8, $p < 0.05$. In people with schizophrenia, the difference between these two correlations was significant at the trend level, Z = 1.26, $p = 0.10$.

Speech Tasks

Disorganized Speech. Next, I examined the amount of disorganized speech in the speech conditions. In an independent samples t-test, people with schizophrenia exhibited significantly greater disorganized speech in the standard speech condition compared to non-psychiatric controls, t (75) = 6.96, $p < 0.001$, as can be seen in Table 4. In another independent samples t-test, people with schizophrenia exhibited significantly greater disorganized speech in the GM decrease condition compared to non-psychiatric controls, t (75) = 5.72, $p < 0.001$. However, in a paired samples t-test, people with schizophrenia showed no significant difference between disorganized speech in the GM decrease and the standard speech conditions, t (48) = 0.03, $p = 0.98$. Similarly, non-psychiatric controls

showed no significant difference between disorganized speech in the GM decrease and the standard speech conditions, t (27) = 1.44, p = 0.16.

In another independent samples t-test, people with schizophrenia exhibited significantly greater disorganized speech in the GM increase condition compared to non-psychiatric controls, t (75) = 5.83, $p < 0.001$, as can be seen in Table 4. Similarly, people with schizophrenia exhibited significantly greater disorganized speech in the control task speech condition compared to non-psychiatric controls, t (75) = 7.02, $p < 0.001$. In addition, in paired-samples t-tests, people with schizophrenia showed significantly increased disorganized speech during the GM increase condition compared to the standard speech, t (48) = 3.22, $p < 0.005$ and GM decrease conditions, t (48) = 3.20, $p < 0.005$. Similarly, in non-psychiatric controls, disorganized speech was greater in the GM increase condition compared to the standard speech condition at the trend level, t (27) = 1.64, p = 0.11. In contrast, people with schizophrenia and non-psychiatric controls showed no difference in disorganized speech in the GM increase condition compared to the control task speech condition, (t (48) = 0.86, p = 0.39; t (27) = 0.43, p = 0.67).

In addition to the GM increase comparisons, I examined the difference between disorganized speech in the control task speech condition and the standard speech condition. In a paired samples t-test, people with schizophrenia exhibited increased disorganized speech in the control task speech condition compared to the standard speech condition, t (48) = 3.25, $p < 0.005$. Furthermore, people with schizophrenia exhibited significantly greater disorganized speech in the control task speech condition than in the GM decrease condition, t (48) = 3.17, $p < 0.005$. Similarly, non-psychiatric controls

showed significantly increased disorganized speech in the control task speech condition compared to the standard speech condition, t (27) = 2.10, $p < 0.05$.

In addition to comparing the speech conditions, I examined potential order effects in the speech tasks in two different analyses. As previously mentioned, there were two sets of speech tasks: 1) the standard speech and GM decrease conditions and 2) the GM increase and control task speech conditions, with administration order of the speech tasks counterbalanced within both sets. The first analysis examined whether there was a difference in disorganized speech between the first speech task administered and the second speech task administered within each set. In the first set of speech tasks, as can be seen in Table 5, people with schizophrenia and non-psychiatric controls exhibited no significant difference in disorganized speech between the first and second speech tasks, t (48) = 0.48, p = 0.66, and t (27) = 0.07, p =0.95, respectively. In contrast, in the second set of speech tasks, people with schizophrenia exhibited increased disorganized speech in the second speech task compared to the first speech task t (48) = 2.18, $p < 0.05$. At the same time, non-psychiatric controls showed a similar difference at the trend level, t (27) = 1.64, p = 0.11. Hence, only during the cognitive speech task manipulations was disorganized speech increased for the second speech task administered compared to the first speech task administered.

In a second set of between-groups analyses, disorganized speech was examined in individuals who completed (a) the standard speech condition first versus the GM decrease condition first; and (b) the GM increase condition first versus the control task speech condition first. Separate analyses were conducted for people with schizophrenia and non-psychiatric controls. As can be seen in Table 6, there were no significant differences in

individuals with schizophrenia or in non-psychiatric controls, p's > 0.28. Similarly, disorganized speech was examined in individuals who participated in (a) the standard speech second versus GM decrease second; and (b) the GM increase second versus the control task speech second, with no significant between-group differences.

Word Counts during Speech. The amount of speech produced during the speech tasks was also examined. In four independent samples t-tests, people with schizophrenia produced significantly less speech compared to non-psychiatric control participants, all p's < 0.005, as can be seen in Table 4. In two paired samples t-tests, people with schizophrenia showed no difference in amount of speech in the standard speech compared to the GM decrease condition, t (48) = 0.19, p = 0.85, but non-psychiatric controls differed at the trend level, t (27) = 1.64, p = 0.11. Conversely, compared to the standard speech condition, people with schizophrenia produced significantly less speech in the GM increase condition, t (48) = 6.15, p < 0.001, and the control task speech condition, t (48) = 6.05, p < 0.001. At the same time, compared to the GM decrease condition, there was significantly less speech in the GM increase condition, t (48) = 5.43, p < 0.001, and the control task speech condition, t (48) = 5.18, p < 0.001, in people with schizophrenia. Furthermore, compared to the GM decrease condition, there was significantly less speech in the GM increase condition, t (27) = 3.75, p < 0.005, and the control task speech condition, t (27) = 3.55, p < 0.005, in non-psychiatric controls. However, there was no significant difference in amount of speech produced between the GM increase and the control task speech conditions, t (48) = 0.04, p = 0.97, in individuals with schizophrenia.

Cognitive Task Speech Manipulations. As previously mentioned, both the GM increase condition and the control task speech condition involved the participants performing auditory cognitive tasks during speech (i.e., the 1-back with distraction task and the every-X task, respectively). Next, I examined performance on those dual tasks during speech. As can be seen in Table 4, in two independent samples t-tests examining the difference in hit rates and false alarms in people with schizophrenia compared to non-psychiatric controls, there was a significant group difference in both the 1-back with distraction and the every-X task. Specifically, people with schizophrenia performed significantly worse than controls in the 1-back with distraction, t (75) = 5.31, $p < 0.001$ and in the every-X task, t (75) = 2.57, $p < 0.05$. Additionally, performance on the 1-back with distraction task was significantly worse compared to the every-X performance in people with schizophrenia, t (48) = 9.60, $p < 0.001$, and non-psychiatric controls, t (27) = 4.16, $p < 0.001$.

Next I examined associations between performance in the cognitive tasks performed during speech with A-X CPT and Missing Letter task goal maintenance task performance. As can be seen in Table 3, the cognitive task manipulation during the GM increase condition (i.e., the 1-back with distraction) was significantly associated with goal maintenance performance in A-X CPT and the Missing Letter task in people with schizophrenia and controls. This suggests that the 1-back with distraction task did in fact manipulate goal maintenance demands. Conversely, in general, the cognitive task manipulation during the control task speech condition (i.e., the every-X task) was not associated with goal maintenance task performance in either group. However, there was

one significant association between the every-X task and goal-relevant responding to sentence 1 in the Missing Letter task in non-psychiatric controls.

In addition to examining all individuals who completed the four speech conditions, I conducted analyses examining differences in the speech conditions excluding participants who did not respond with a key press during the majority of the dual cognitive tasks. Importantly, in additional analyses (new sample sizes: schizophrenia n = 41, control n = 28), differences in disorganized speech, amount of speech, and dual task performance between speech conditions were the same as the differences presented above in the full sample, as can be seen in Table A2 in the Appendix.

Associations between Cognitive Task Performance and Speech Variables

Disorganized Speech Associations. Next I examined the associations between goal maintenance task performance and disorganized speech. As can be seen in Table 7, disorganized speech in the standard speech task, as well as disorganized speech in the other three speech conditions, was significantly associated with decreased accuracy during the goal maintenance condition of the A-X CPT. In other words, increased disorganized speech was significantly associated with poor goal maintenance task performance in people with schizophrenia. However, disorganized speech was not associated with reaction times in the goal maintenance conditions of the A-X CPT. Importantly, these associations between disorganized speech and impaired goal maintenance performance in the A-X CPT remained the same when participants with relatively poor performance on BX trials were not included in the analyses (d-prime context: all *rho*'s > -0.37 and all *p*'s < 0.05). In contrast, as can be seen in Table 8, in

control participants, increased disorganized speech was associated with a larger difference in BX and AY accuracy (i.e., good goal maintenance performance).

In addition to examining the association between disorganized speech and the A-X CPT, I examined the relationship between disorganized speech and performance on the Missing Letter task. As can be seen in Table 7, disorganized speech as measured by the standard speech and the GM decrease conditions was not significantly associated with goal-relevant responding to sentence 1 in the Missing Letter task in people with schizophrenia. Conversely, in people with schizophrenia, disorganized speech in the control task speech condition was significantly associated with impairments in goal-relevant responding to sentence 1 in the Missing Letter task. Additionally, GM increase was associated with impairments in goal-relevant responding to sentence 1 at the trend level in people with schizophrenia. Alternatively, disorganized speech in the standard speech, GM increase, and control task speech conditions was significantly associated with impairments in goal-relevant responding to sentence 2 in the Missing Letter task in individuals with schizophrenia. In contrast, as shown in Table 8, in non-psychiatric controls, disorganized speech in all four of the speech conditions was not associated with goal-relevant responding to sentence 1 or sentence 2 in the Missing Letter task.

Next, I examined the associations between disorganized speech and a goal maintenance composite score (i.e., average z-scores of the A-X CPT and Missing Letter). As can be seen in Table 7, overall, increased disorganized speech in all four speech conditions was associated with poorer goal maintenance performance in people with schizophrenia. In contrast, as can be seen in Table 8, disorganized speech was not associated with goal maintenance performance in non-psychiatric controls.

To examine whether disorganized speech was associated specifically with goal maintenance or with a generalized deficit, I examined associations between disorganized speech and the psychometric control task, the Masked Priming task. As can be seen in Table 7, as expected, disorganized speech in all four speech conditions was not associated with performance in the psychometric control task in people with schizophrenia. Therefore, Missing Letter performance, but not psychometric control task performance, was associated with disorganized speech. Hence, disorganized speech is associated with Missing Letter performance and not a generalized deficit.

To examine the difference between the disorganized speech and Missing Letter sentence 1 correlation and the disorganized speech and psychometric control correlation, a test of correlated correlation coefficients (Meng et al., 1992) was conducted. Examining disorganized speech during the GM increase condition revealed a difference at the trend level in people with schizophrenia, $Z = 1.53$, $p = 0.06$. A second test was conducted to examine the difference between the disorganized speech and Missing Letter sentence 2 correlation and the disorganized speech and psychometric control correlation. Once again, examining disorganized speech during the GM increase condition showed a significant difference in people with schizophrenia, $Z = 1.86$, $p < 0.05$. In other words, the association between disorganized speech and impairments in goal-relevant responding on the Missing Letter task was stronger than the relationship between disorganized speech and performance during the psychometric control task. However, there was no significant difference between the disorganized speech and Missing Letter correlation and the disorganized speech and psychometric control correlation when

examining disorganized speech during the standard speech condition in people with schizophrenia.

In addition to the stand-alone cognitive tasks, correlations were run examining the associations between performance on the cognitive tasks that participants performed during speech (i.e., 1-back with distraction and every-X tasks) and disorganized speech. As can be seen in Table 7, performance during the 1-back with distraction task (i.e., GM increase) was negatively correlated with disorganized speech at the trend level in people with schizophrenia. Therefore, poorer goal maintenance performance was associated with increased disorganized speech. Conversely, performance during the every-X task was not correlated with disorganized speech in people with schizophrenia. In non-psychiatric controls, performance during the 1-back with distraction task was not correlated with disorganized speech, as can be seen in Table 8. In contrast, controls' performance during the every-X task was significantly correlated with disorganized speech, with poorer performance (i.e., a smaller difference in hits and false alarms) being associated with an increase in disorganized speech.

In addition to examining the associations between disorganized speech and cognitive task performance in all participants, additional analyses were conducted excluding participants who did not respond during the majority of the 1-back with distraction task or the every-X task (new sample size: schizophrenia n = 41). Importantly, the associations between disorganized speech and impairments in goal maintenance task performance in people with schizophrenia were similar to the associations presented above in the full sample, as can be seen in Table A3 in the Appendix. Note that the associations between the GM increase condition and goal-relevant responding to Missing

Letter sentence 1 and between the standard speech condition and goal-relevant responding to Missing Letter sentence 2 are no longer significant.

Word Count Associations. The associations between the amount of speech produced during the speech tasks and goal maintenance task performance were also examined. As can be seen in Table 9, the amount of speech produced during the standard speech and GM decrease conditions was not associated with goal maintenance task performance during the A-X CPT in people with schizophrenia. In contrast, the amount of speech in the GM increase and control task speech conditions was significantly associated with goal maintenance performance during the A-X CPT in people with schizophrenia. Specifically, a decrease in the amount of speech was associated with impaired goal maintenance task performance in people with schizophrenia. Importantly, after conducting tests of correlated correlation coefficients, it appears that there is a pattern of significantly increasing correlations in people with schizophrenia between the amount of speech produced and goal maintenance performance. In particular, the amount of speech during the GM increase and control task speech conditions was significantly more strongly associated with goal maintenance task performance than the amount of speech during the standard speech condition ($Z = 2.07$, $p < 0.05$; $Z = 2.18$, $p < 0.05$, respectively). Similarly, the amount of speech during the GM increase and control task speech conditions was significantly more strongly associated with goal maintenance task performance than the amount of speech during the GM decrease condition ($Z = 2.07$, $p < 0.05$; $Z = 1.89$, $p < 0.05$, respectively). In contrast, the amount of speech produced during the four speech tasks was not associated with goal maintenance performance in the A-X CPT in non-psychiatric controls, as can be seen in Table 10.

Importantly, both disorganized speech and amount of speech during the two cognitive task manipulations were associated with impairments in goal maintenance performance in the A-X CPT. Therefore, I conducted partial correlations examining the relationship between goal maintenance performance in the A-X CPT and disorganized speech in the two cognitive task manipulation speech conditions while controlling for amount of speech. Results showed that disorganized speech in the control task speech condition was significantly associated with impaired goal maintenance performance after controlling for amount of speech ($r_{ab.c}$ = -0.42, p < 0.005). However, disorganized speech in the GM increase condition was no longer associated with impaired goal maintenance performance after controlling for amount of speech ($r_{ab.c}$ = -0.12, p = 0.41).

In addition to examining the association between amount of speech produced and the A-X CPT, I examined the relationship between amount of speech and performance on the Missing Letter task. As can be seen in Table 9, the amount of speech produced during all four speech conditions was associated with goal-relevant responding to sentence 1 in people with schizophrenia. However, only the amount of speech produced during the GM increase and control task speech conditions was associated with goal-relevant responding to sentence 2 in people with schizophrenia. Importantly, and similar to the A-X CPT, a pattern of significantly increasing correlations emerged between the amount of speech produced in the different speech conditions and goal–relevant responding to sentence 1 in people with schizophrenia. Specifically, the amount of speech during the GM increase and control task speech conditions was more strongly associated with goal-relevant responding to sentence 1 compared to the amount of speech during the standard speech condition (Z = 2.29, $p < 0.05$; Z = 1.54, $p = 0.06$, respectively). Similarly, the amount of

speech during the GM increase and control task speech conditions was more strongly associated with goal-relevant responding to sentence 1 compared to amount of speech during the GM decrease condition ($Z = 2.35$, $p < 0.05$; $Z = 1.50$, $p = 0.07$, respectively). In contrast, as can be seen in Table 10, the amount of speech produced during the four speech tasks was not associated with goal-relevant responding in the Missing Letter task in non-psychiatric controls.

Next, I examined the associations between amount of speech produced and a goal maintenance composite score (i.e., average z-scores of the A-X CPT and Missing Letter). As can be seen in Table 9, in people with schizophrenia and in non-psychiatric controls, amount of speech produced was not associated with the goal maintenance composite score. Similarly, the amount of speech produced in the four speech conditions was not associated with performance in the psychometric control task in people with schizophrenia and non-psychiatric controls.

In addition to the stand-alone cognitive tasks, correlations were run examining the associations between performance on the cognitive tasks that participants performed during speech (i.e., 1-back with distraction and every-X tasks) and amount of speech. As can be seen in Tables 9 and 10, in general, amount of speech produced during speech interviews was not associated with performance on these dual cognitive tasks in both people with schizophrenia and non-psychiatric controls.

Symptoms and Cognitive Performance

In addition to examining disorganized speech symptoms in people with schizophrenia, the associations between two other symptom factors, negative and positive symptoms, and goal maintenance task performance were examined. As can be seen in

Table A4 in the Appendix, there were no significant associations between negative symptoms (i.e., a composite variable including alogia, flat affect, and anhedonia) and goal maintenance task performance. In contrast, positive symptoms (i.e., a composite variable including delusions and hallucinations) were associated with d-prime context in the A-X CPT, with goal-relevant responding to sentence 2 in the Missing Letter task, and with the 1-back with distraction task. However, importantly, when disorganized speech was controlled for, positive symptoms were no longer associated with goal maintenance performance in the A-X CPT (d-prime context: $p = 0.15$). Furthermore, disorganized speech in the standard speech, GM decrease, and control task speech conditions was associated with goal maintenance performance in the A-X CPT even after controlling for positive symptoms (all *rho's* > -0.36; *p*'s < 0.05).

Discussion

The current study examined the relationship between disorganized speech and goal maintenance in people with schizophrenia. There were several novel and important results in the current research that to my knowledge have been found for the first time. First, it was found that disorganized speech, as measured by the Communication Disturbances Index (CDI), is associated with goal maintenance performance in the A-X CPT and with performance in the Missing Letter task in people with schizophrenia. More importantly, to my knowledge, this is the first study that experimentally increased disorganized speech, as measured by a linguistically detailed measure of disordered speech, in chronic, medicated people with schizophrenia. Specifically, disorganized speech increased during a speech interview while goal maintenance demands were experimentally increased compared to a standard speech task. Also, for the first time,

people with schizophrenia exhibited a pattern of significantly increasing correlations between decreased amount of speech (i.e., alogia) and impairments in goal maintenance performance in people with schizophrenia. Specifically, alogia during the cognitive task speech manipulations was significantly more strongly associated with poor goal maintenance task performance compared to alogia during standard speech task performance. Overall, these results help to further understand the nature of disordered speech in people with schizophrenia.

Disorganized Speech and Goal Maintenance

Previous research had suggested that disorganized speech is associated with impaired goal maintenance performance. For instance, disorganized speech has been found to be associated with working memory performance and goal maintenance performance (e.g., Becker et al., under review; Berenbaum et al., 2008; Cohen et al., 1999). Importantly, some of these previous studies used a broad measure of disorganization rather than a linguistically detailed measure of disorganized speech (e.g., Cohen et al., 1999; Barch et al., 2003). Other previous studies used a complex measure of working memory that did not specifically measure goal maintenance (e.g., Berenbaum et al., 2008; Kerns & Becker, 2008). However, to my knowledge, the relationship between disorganized speech, as measured by a linguistically detailed and sensitive measure of disorganized speech (i.e., the CDI), and the most well-validated measure of goal maintenance (A-X CPT) had not been previously examined. The current research replicated and extended previous research findings, as disorganized speech in four different speech conditions was associated with impaired goal maintenance performance in the A-X CPT. Furthermore, disorganized speech in the four speech conditions was

associated with performance on the goal maintenance task performed during speech (i.e., the 1-back with distraction), which was also associated with goal maintenance performance in the A-X CPT. Overall, these results suggest that disorganized speech is associated with deficits in goal maintenance performance.

In addition to the A-X CPT, goal maintenance performance was examined with the Missing Letter task which has been used in previous research (e.g., Cohen et al., 1999; Kerns, Cohen, et al., 2004) and has been found to be associated with goal maintenance performance in the A-X CPT (e.g., Cohen et al., 1999). Research has found that disorganization symptoms, as measured by live clinical ratings, are associated with goal maintenance performance in the Missing Letter task (Cohen et al., 1999). However, to my knowledge, the relationship between disorganized speech, as measured by linguistically detailed ratings, and goal maintenance in the Missing Letter task had not been examined. Consistent with previous research, goal-relevant responses to the first sentence in the Missing Letter were associated with goal maintenance performance in the A-X CPT in both people with schizophrenia and non-psychiatric controls. Additionally, goal-relevant responses to the second sentence in the Missing Letter were not associated with goal maintenance performance in the A-X CPT in non-psychiatric controls. This pattern of results is consistent with the idea that goal-relevant responding to the first sentence requires goal maintenance; whereas, goal-relevant responding to the second sentence does not require goal maintenance (e.g., Cohen et al., 1999) in non-psychiatric controls. In contrast, in people with schizophrenia, goal-relevant responses to the second sentence were also associated with goal maintenance performance in the A-X CPT. Additionally, contrary to previous research (Cohen et al., 1999), impairments in goal-

relevant responding to the first sentence were not significantly associated with disorganized speech in the standard speech condition in people with schizophrenia. However, there was an association in schizophrenia between impairments in goal-relevant responding to the first sentence and disorganized speech during the cognitive task speech manipulation conditions. Furthermore, there was an association between goal-relevant responding to the second sentence and disorganized speech in the standard speech condition in people with schizophrenia.

Overall, these results potentially suggest that people with schizophrenia were performing the Missing Letter task in a different way than non-psychiatric controls. In particular, people with schizophrenia may have had difficulty maintaining the context of both sentences. Hence, people with schizophrenia may have processed the first sentence at the expense of the second sentence. For example, people with schizophrenia may have been focused on maintaining the first sentence and therefore, did not fully encode the second sentence. Alternatively, people with schizophrenia may have had difficulty remembering the first sentence once the second sentence was presented and therefore, may have been attempting to remember the first sentence during the delay between the second sentence and the probe letters. Therefore, it seems likely that people with schizophrenia were performing the Missing Letter task differently compared to control participants. Hence, in control participants, goal-relevant responding to the first sentence potentially reflects goal maintenance ability. However, for people with schizophrenia, goal-relevant responding to both sentences to some extent potentially reflected goal maintenance ability.

Importantly, it appears that disorganized speech was specifically associated with performance in the Missing Letter task and not associated with a generalized deficit, as there was no association between disorganized speech and performance in the psychometric control task. Additionally, disorganized speech in the GM increase condition was more strongly associated with goal-relevant responding to sentence 1 and sentence 2 in the Missing Letter task than to performance in the psychometric control task. Note that while there was shared variance between the goal maintenance tasks and the psychometric control task, this shared variance was not correlated with disorganized speech in any of the speech conditions.

Speech Manipulations and Goal Maintenance

In addition to examining basic associations between disorganized speech and goal maintenance, the current study examined whether manipulating goal maintenance demands would lead to an increase in disorganized speech. While previous research has attempted to experimentally increase disorganized speech in chronic, medicated individuals with schizophrenia, none of the previous studies have been successful (Barch & Berenbaum, 1997; Melinder & Barch, 2003; Moskovitz et al., 1991). In the current research, for the first time, chronic, medicated people with schizophrenia exhibited an increase in disorganized speech during two cognitive task speech manipulations compared to a standard speech task. However, contrary to the original hypothesis, disorganized speech during the goal maintenance increase (i.e., GM increase) condition was not significantly different from disorganized speech during the control task speech condition. There are at least three possible interpretations for this. First, it is possible that goal maintenance demands were manipulated in both speech conditions, and hence, they

were both associated with increased disorganized speech. Second, it is possible that the manipulation of another cognitive process (i.e., not goal maintenance) resulted in the increase in disorganized speech in both conditions. Third, it is possible that although increased goal maintenance demands resulted in increased disorganized speech in the goal maintenance increase condition, the manipulation of another cognitive process resulted in increased disorganized speech in the control task speech condition. Each of these interpretations will be discussed one at a time.

One potential explanation for the increase in disorganized speech in both the GM increase condition and the control task speech condition is that goal maintenance demands were increased in both conditions. Support for this interpretation is evident in the convergent validity of the measures. Specifically, in schizophrenia, disorganized speech in both conditions was associated with impairments in three different goal maintenance task measures: (a) the A-X CPT; (b) the Missing Letter task; and (c) the 1-back with distraction task performed during speech. Importantly, performance in the 1-back with distraction task was associated with goal maintenance performance in the A-X CPT and the Missing Letter task. Thus, it appears that the goal maintenance task speech manipulation, the 1-back with distraction, successfully manipulated goal maintenance demands during speech. In contrast, the performance in the every-X task was not associated with goal maintenance performance; hence, one could not argue that the task itself measured goal maintenance. However, given that disorganized speech during the every-X task was associated with goal maintenance performance in three different tasks, it appears that goal maintenance was manipulated in that condition. It is possible that people with schizophrenia needed to use goal maintenance to maintain their speech goal

while being distracted by the information presented in the dual cognitive task. Additional support for the interpretation that goal maintenance resulted in the increase in disorganized speech is evident from the discriminant validity of the measures. In particular, disorganized speech was not associated with the psychometric control task that did not involve goal maintenance demands. Thus, there are several pieces of evidence, including both convergent and discriminant validity, that support the interpretation that poor goal maintenance leads to disorganized speech in people with schizophrenia.

The relationship between increased goal maintenance demands and disorganized speech suggests that disorganized speech symptoms in schizophrenia could be a result of problems maintaining goals to guide ongoing behavior. This is consistent with previous language production research which has found that goal-relevant and contextually-appropriate speech relies in part on maintaining speech goals (Dell et al., 1997; Kerns et al., 2004). Hence, perhaps the reason that people with schizophrenia produce speech that is difficult to understand or that strays off topic is because of difficulty maintaining a speech topic to coordinate ongoing speech (Holzman, 1978; McGrath, 1991; Cohen, Targ, Servan-Schreiber, & Spiegel, 1992).

A second possible explanation for why disorganized speech was increased during both the GM increase condition and the control task speech condition is that another cognitive process or another factor such as task difficulty or task order effects resulted in the increase. From this view, manipulating goal maintenance demands did not result in the increase, but it was the manipulation of a different cognitive process or factor that resulted in the increase in disorganized speech. However, if disorganized speech were associated with another cognitive process, it would be expected that disorganized speech

in these conditions would not be significantly associated with the multiple measures of goal maintenance included in the current study. Thus, the increase in disorganized speech does not appear to be due another cognitive process. However, further research is needed to examine whether other cognitive processes lead to an increase in disorganized speech.

To assess whether task difficulty might account for the increase in disorganized speech, I examined the amount of speech produced in each condition. The amount of speech between the two cognitive task manipulation speech conditions was not significantly different. However, the amount of speech between the two cognitive task manipulation speech conditions and the standard speech and GM decrease conditions was significantly different. Thus, I conducted an analysis of covariance (ANCOVA) examining the difference between the two cognitive task manipulation speech conditions and the standard speech condition, with the difference in amount of speech in these conditions as the covariate. Results showed that disorganized speech in people with schizophrenia in both the GM increase and control task speech conditions was significantly increased compared to disorganized speech in the standard speech condition after accounting for amount of speech. Therefore, task difficulty does not appear account for the increase in disorganized speech during the cognitive task speech manipulations.

Next, assessment of whether order effects of the speech conditions might account for the increase in disorganized speech showed that disorganized speech during the second cognitive task manipulation speech condition administered was higher than the first. Thus, it is possible that disorganized speech could have naturally increased during the study, resulting in an increase in disorganized speech during the two cognitive task manipulation speech conditions compared to the standard speech condition, which was

always administered first. If this were true, one would expect an increase in the second speech task administered during the first set of speech conditions as well. However, there was no evidence of order effects during the first set of speech tasks. Thus, it is unlikely that the increase in disorganized speech in the two cognitive task manipulation speech conditions could be due to order of speech condition administration and not because of increased goal maintenance demands during these cognitive tasks.

Based on the current research, it does not appear that another cognitive process or another factor such as task difficulty or order effects resulted in the increase in disorganized speech in the GM increase and control task speech conditions. Hence, these results provide at least partial support for goal maintenance demands as a cause of disorganized speech in people with schizophrenia.

A third possible explanation for why disorganized speech was increased for both the GM increase and the control task conditions is that a cognitive process in addition to goal maintenance resulted in the increase in disorganized speech. For instance, goal maintenance demands may increase disorganized speech in the GM increase condition, but another cognitive process may increase disorganized speech in the control task speech condition. One piece of evidence that may support this possibility is that the dual cognitive task in the GM increase condition (i.e., the 1-back with distraction) was associated with goal maintenance task performance in the A-X CPT. In contrast, the dual cognitive task in the control task speech condition (i.e., the every-X task) was not associated with goal maintenance task performance in the A-X CPT. However, ultimately, as previously mentioned, disorganized speech in both the GM increase and control task speech conditions were associated with goal maintenance performance

impairments in all three goal maintenance tasks. Thus, according to the current research, it appears one can tentatively conclude that manipulating goal maintenance demands resulted in an increase in disorganized speech. It is also possible that goal maintenance demands could lead to an increase in disorganized speech, and yet, the manipulation of another cognitive process could still cause a relative increase in disorganized speech. This issue needs to be examined further in future research.

Importantly, the current research found that not only did an experimental increase in goal maintenance demands result in increased disorganized speech, but also using a dual task that by itself did not seem to involve goal maintenance also resulted in increased disorganized speech. However, this finding appears inconsistent with previous research in which performing a category rating dual task during speech did not result in an increase in disorganized speech in people with schizophrenia (Melinder & Barch, 2003). One possible reason for this discrepancy in results is the difference in the basic speech tasks used. Melinder and Barch (2003) used an interview that involved participants discussing their daily lives and describing themselves. In contrast, the current research used a speech interview that involved people recalling memories. It is possible that the basic speech task was more difficult in the current study and therefore more sensitive to increases in cognitive demands. A second possible explanation for the discrepancy in results in the two studies is the difference in the measurement of disorganized speech. Melinder and Barch (2003) used the Scale for the Assessment of Thought, Language, and Communication (TLC), and the current study used the CDI. As previously mentioned, the CDI is a more sensitive measure of disorganized speech than the TLC. For instance, the CDI is such a sensitive measure of speech disorganization that

it has been used successfully with college students (e.g., Kerns, 2007a; Kerns & Becker, 2008). Thus, the speech task used and the more sensitive measurement of disorganized speech used in the current study may have helped to reveal the relationship between increased cognitive demands and disorganized speech.

A third possible explanation for the discrepancy in results is a difference in the difficulty level of the dual tasks used in the previous study versus the current study. For instance, the dual task used in the previous research (i.e., the Category Monitoring Task) may have been more challenging than the dual cognitive tasks used in the current research (Melinder & Barch). For example, the category monitoring task involved more frequent responding than the every X task in the current study (every 4 seconds versus every 7 seconds). At the same time, the basic judgment in the category monitoring task (deciding whether a word is a member of a semantic category) is likely more challenging for people with schizophrenia than the every X task (deciding whether a letter is an X). Therefore, perhaps counterintuitively, the relatively challenging Category Monitoring Task may have simply reduced the amount of speech that people produced (so that they could focus more on the cognitive task) without increasing disorganized speech. In fact, this explanation is consistent with previous hypotheses about how increasing cognitive demands in schizophrenia might not necessarily result in increased speech disorganization but instead result in a reduction in speech amount and complexity (Barch & Berenbaum, 1997). Thus, the cognitive speech task manipulation used in the current study may have helped to reveal the relationship between increased cognitive demands and disorganized speech.

Hence, as previously mentioned, an increase in goal maintenance demands appear to lead to an increase in disorganized speech in people with schizophrenia. Thus, one would expect that decreasing goal maintenance demands would decrease disorganized speech. However, there was no significant difference between the goal maintenance decrease condition and the standard speech condition in people with schizophrenia. One possible explanation for this would be that people with schizophrenia could not effectively use the goal information presented to them because they were not sufficiently trained to do so. Therefore, if people with schizophrenia were placed in attention shaping groups to learn how to attend to additional visually presented information or to learn how to maintain a speech goal, this may lead to a reduction in disorganized speech.

Therefore, one issue for future research would be to examine whether decreasing goal maintenance demands lead to a reduction in disorganization symptoms. The association between disorganized speech and poor goal maintenance suggests that treatments that influence goal maintenance and perhaps the functioning of the PFC might reduce the level of speech symptoms. For example, adjunctive medications that increase activity in the PFC and therefore reduce goal maintenance deficits, such as drugs influencing GABA (Lewis et al., 2008), could decrease disorganized speech. Additionally, cognitive rehabilitation treatments such as attention shaping (Silverstein, Spaulding, Menditto, Savitz, Liberman, Berten, 2009) that improve goal maintenance may also decrease disorganized speech in schizophrenia.

Future research could also examine whether disorganized speech is associated with physiological dysfunction during the performance of goal maintenance tasks (MacDonald et al., 2005). Based on previous research on goal maintenance (Miller &

Cohen, 2001; Braver, Gray, Burgess, 2007), it is expected that disorganized speech should be associated with prefrontal cortex dysfunction in schizophrenia. In addition, given consistent evidence that disorganized speech is associated with the genetic liability for the disorder (Rietkerk, Boks, Sommer, Liddle, Ophoff, Kahn, 2008), future research could examine whether disorganized speech in first-degree relatives is associated with poor goal maintenance and prefrontal cortex dysfunction (Becker et al., 2008).

Another issue for future research is to further examine whether other cognitive deficits, in addition to goal maintenance, leads to increases in disorganized speech. For instance, future research could examine whether deficits in a broader range of cognitive control functions (Friedman & Miyake, 2004) are associated with increases in disorganized speech. One cognitive control function, interference resolution, has been found to be associated with disorganized speech in people with schizophrenia, at least when combined with poor complex working memory performance (Kerns & Berenbaum, 2003). In addition, in an analogue study that experimentally increased disorganized speech in healthy controls, high interference in combination with high goal maintenance demands resulted in the greatest increase in disorganized speech (Kerns and Berenbaum, 2003). Thus, future research could experimentally manipulate interference resolution separately and in conjunction with goal maintenance demand manipulations in schizophrenia to examine the impact that inference resolution versus goal maintenance has on disorganized speech.

Decreased Speech Amount and Goal Maintenance

Previous research suggested that decreased or poverty of speech, or alogia, may be associated with poor goal maintenance. For instance, in one study, clinician-rated

alogia was significantly associated with poor goal maintenance task performance, as measured by the POP Task (Becker et al., under review). However, results from previous studies examining associations between cognitive control task performance and alogia in schizophrenia have not been consistent (Berenbaum et al., 2008; Kerns, 2007; Melinder & Barch, 2003). One possible explanation for the variation across studies is the complexity of the basic speech task. Potentially studies that employ simpler and less taxing speech tasks are less likely to find associations between alogia and poor cognitive control (Berenbaum et al., 2008; Kerns, 2007a). In contrast, studies that use more demanding speech tasks might be more likely to find associations between alogia and cognitive control (Becker et al., under review; Melinder & Barch, 2003). The multiple speech conditions in the current study that varied in their speech difficulty for the first time allowed me to examine whether the size of associations between alogia and poor goal maintenance increase with increasing speech task difficulty. In the current research, overall alogia was associated with poor goal maintenance. This makes sense as even the basic speech task was seemingly more challenging in the current study than in some previous studies (Berenbaum et al., 2008; Kerns, 2007a). At the same time, importantly, the association between alogia and goal maintenance impairments increased significantly for the two conditions that involved performing cognitive dual tasks during speech. Hence, it does appear that alogia is associated with poor goal maintenance, especially when demands on speech are more challenging. Thus, overall, goal maintenance deficits appear to have an impact on speech in multiple ways, resulting in both disorganized speech and alogia.

One issue for future research would be to further examine associations between alogia and goal maintenance using speech tasks that include an even broader range of difficulty than in the current research. Another issue for future research would be to examine the neural correlates of alogia. For example, previous research has consistently found that goal maintenance demands activate the DLPFC (e.g., MacDonald et al., 2005). Hence, future research could examine whether alogia/flat affect is associated with evidence of dysfunction in brain regions such as the DLPFC.

Limitations

The current research had a few limitations that are important to mention. One limitation was the order in which the speech tasks were administered. For instance, the standard speech condition was only administered during the first set of speech tasks which limited the ability of the study to completely rule out a natural increase in disorganized speech during the second set of speech tasks. However, there was no natural increase in disorganized speech evident from the first speech task administered to the second speech task administered within the first set of speech tasks. Therefore, the increase in disorganized speech during the cognitive speech manipulations (i.e., the second set of speech tasks) was likely due to increased goal maintenance demands and not due to order effects of the speech tasks.

Another limitation of the current research is the poor performance during BX trials in the A-X CPT in people with schizophrenia. This poor performance is consistent with research suggesting that people with schizophrenia very quickly lose the task goal and need to regain the task goal frequently (Meiran, Levine, Meiren, & Henik, 2000). Importantly, goal maintenance performance in the A-X CPT, once the poor performers

were excluded, remained correlated with other goal maintenance measures (e.g., the 1-back with distraction task).

Summary

The current results provide further support for a role of goal maintenance demands in disordered speech. In particular, the basic association between disorganized speech and goal maintenance tasks as well as an increase in goal maintenance demands resulting in an increase in disorganized speech suggests that goal maintenance plays at least a partial role in disorganized speech. Additionally, the association between a progressive decrease in amount of speech produced (i.e., alogia) and poorer goal maintenance task performance suggests a relationship between goal maintenance deficits and alogia.

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Table 1

Demographic and Clinical Data

Variable	Schizophrenia (n = 49)	Controls (n = 28)
Gender (% Male)	88%	89%
Race/ethnicity (% African-American)	37%	4%
Age (years)	41.4 (12.0)	43.1 (9.6)
Education (years)	12.9 (7.7)	16.1 (1.8)
Parental Education	11.8 (1.7)	12.7 (2.1)
MMSE	26.1 (2.6)	29.2 (0.8)
Symptoms		
Disorganized speech (CDI)	2.36 (1.17)	0.74 (0.50)
Flat Affect (SANS : possible 0-5)	3.0 (1.30)	0.27 (0.60)
Alogia (SANS : possible 0-5)	1.0 (1.11)	0.0 (0.0)
Anhedonia (SANS : possible 0-5)	2.0 (1.40)	0.38 (0.80)
SANS Global Total	9.35 (3.47)	0.69 (1.01)
Delusions (BPRS: possible 1-7)	5.0 (1.49)	1.04 (0.20)
Hallucinations (BPRS: possible 1-7)	3.0 (2.13)	1.04 (0.20)
BPRS Total	47.80 (10.14)	26.08 (1.74)
SAPS Global Total	6.76 (3.47)	0.08 (0.27)

(continued)

Variable	Schizophrenia (n = 49)	Controls (n = 28)
Medications		
Antipsychotics (%)	100%	0%
Mood Stabilizers (%)	46%	0%
Anti-depressants (%)	56%	0%
Anticholinergics (%)	19%	0%

Note. MMSE = Mini Mental Status Exam; CDI = Communication Disturbances Index; SANS = Scale for the Assessment of Negative Symptoms; BPRS = Brief Psychiatric Rating Scale; SAPS = Scale for the Assessment of Positive Symptoms

Table 2

Cognitive Task Performance

Variable	Schizophrenia (n = 49)	Controls (n = 28)
BX Accuracy	0.48 (0.39)	0.89 (0.21)
AY Accuracy	0.93 (0.08)	0.94 (0.07)
BX-AY Accuracy difference	-0.45 (0.39)	-0.05 (0.23)
D-prime context	0.35 (0.38)	0.85 (0.22)
BX RTs	810.02 (289.71)	690.39 (281.59)
AY RTs	808.91 (238.05)	638.81 (86.93)
BX-AY RT difference	1.12 (353.31)	51.58 (235.35)
ML Sentence1 Dominant	0.60 (0.17)	0.71 (0.11)
ML Sentence1 Nondominant	0.43 (0.13)	0.38 (0.12)
ML Sentence1 Difference	0.17 (0.21)	0.33 (0.17)
ML Sentence2 Dominant	0.63 (0.17)	0.81 (0.07)
ML Sentence2 Nondominant	0.37 (0.14)	0.26 (0.12)
ML Sentence2 Difference	0.26 (0.25)	0.55 (0.17)
ML Sentence1-Sentence2 Difference	0.09 (0.21)	0.22 (0.19)
Psychometric Control Task	0.33 (0.20)	0.72 (0.17)

Note. ML = Missing Letter

Table 3

Cognitive Task Correlations

Variable	d' context	ML Sent1	ML Sent2	ML Control	GMI CT	CTSC
d' context	-	0.50**	0.05	0.40*	0.39*	0.25
ML Sent1	0.32*	-	0.39*	0.54**	0.40*	0.41*
ML Sent2	0.36*	0.58**	-	-0.05	0.41*	0.02
ML Control	0.22	0.31*	0.14	-	0.08	0.10
GMI CT	0.45**	0.23†	0.29*	0.08	-	0.51**
CTSC	0.03	0.21	0.21	-0.05	0.44**	-

Controls

Patients

Note. d' context = d-prime context; ML Sent1 = Missing Letter Sentence 1 context; ML Sent2 = Missing Letter Sentence 2 context; ML Control = Psychometric Control task for the Missing Letter task; GMI CT = dual cognitive task during the GM increase condition; CTSC = dual cognitive task during the control task speech condition; Schizophrenia patient data are reported below the diagonal, and control data are presented above the diagonal.

*$p < 0.05$, **$p < 0.01$, †$p = 0.11$

Table 4

Speech and Task Performance in Four Speech Conditions

Condition/Variable	Schizophrenia (n = 49)	Controls (n = 28)
	Disorganized Speech	
Standard Speech	2.36 (1.17)	0.74 (0.50)
GM Decrease	2.36 (1.35)	0.84 (0.48)
GM Increase	3.18 (2.05)	0.88 (0.41)
Control Task Speech	2.93 (1.47)	0.92 (0.45)
	Word Counts	
Standard Speech	826.45 (312.68)	1103.86 (251.07)
GM Decrease	820.86 (271.27)	1172.32 (269.94)
GM Increase	641.51 (265.04)	1047.68 (248.07)
Control Task Speech	642.39 (275.45)	1051.82 (254.71)
	Dual Task Performance	
GMI CT: Distraction 1-back (Hits – FAs)	0.32 (0.27)	0.66 (0.20)
CTSC: Every-X (Hits – FAs)	0.70 (0.18)	0.80 (0.14)

Note. GM = Goal Maintenance; FAs = False Alarms; GMI CT = dual cognitive task during the GM increase condition; CTSC = dual cognitive task during the control task speech condition

Table 5

Disorganized Speech: First versus Second Speech Task

Condition/Variable	Schizophrenia (n = 49)	Controls (n = 28)
First Set of Tasks (SS and GMD)		
First Speech Task	2.39 (1.35)	0.79 (0.53)
Second Speech Task	2.32 (1.16)	0.78 (0.45)
Second Set of Tasks (GMI and CTSC)		
First Speech Task	2.75 (1.47)	0.84 (0.40)
Second Speech Task	3.35 (2.01)	0.96 (0.45)

Note. SS = Standard Speech condition; GMD = GM Decrease condition; GMI = GM Increase condition; CTSC = Control Task Speech Condition

Table 6

Disorganized Speech: Between-Group Speech Condition Comparison

Condition/Variable	Schizophrenia (n = 49)		Controls (n = 28)	
Standard Speech versus GM Decrease Condition				
	SS	GMD	SS	GMD
First Task:	2.28 (0.99)	2.50 (1.64)	0.84 (0.67)	0.75 (0.35)
Second Task:	2.44 (1.34)	2.20 (0.97)	0.64 (0.22)	0.93 (0.58)
GM Increase versus Control Task Speech Condition				
	GMI	CTSC	GMI	CTSC
First Task:	2.97 (1.67)	2.51 (1.21)	0.92 (0.11)	0.77 (0.12)
Second Task:	3.14 (2.43)	3.30 (1.60)	0.84 (0.41)	1.05 (0.44)

Note. For each speech condition within each set of speech tasks, approximately half of the participants completed the condition first and the other half of the participants completed the condition second. SS = Standard Speech condition; GMD = GM Decrease condition; GMI = GM Increase condition; CTSC = Control Task Speech Condition

Table 7

Disorganized Speech and Cognitive Task Performance in Schizophrenia

Variable	Standard Speech	GM Decrease	GM Increase	Control Task Speech
ML Sent1	-0.22	-0.18	-0.25†	-0.34*
ML Sent2	-0.29*	-0.20	-0.34*	-0.27†
BX-AY ACC	-0.42**	-0.49**	-0.33*	-0.51**
D-prime Context	-0.51**	-0.56**	-0.40**	-0.58**
GM Comp	-0.38**	-0.38**	-0.30*	-0.35*
ML Control	-0.13	-0.08	0.02	-0.23
GMI 1-back	-0.47**	-0.56**	-0.32*	-0.39**
SC Every-X	-0.08	-0.19	-0.39**	-0.05

Note. ML Sent1 = Missing Letter Sentence 1; ML Sent2 = Missing Letter Sentence 2; ACC = Accuracy; GM Comp = goal maintenance composite; ML Control = Psychometric Control task

*$p < 0.05$, **$p < 0.01$, $^{\dagger}p = 0.06$-0.08

Table 8

Disorganized Speech and Cognitive Task Performance in Non-Psychiatric Controls

Variable	Standard Speech	GM Decrease	GM Increase	Control Task Speech
ML Sent1	0.18	0.10	0.26	0.06
ML Sent2	-0.08	-0.23	0.18	-0.09
BX-AY ACC	0.50**	0.12	0.16	0.38*
D-prime Context	0.22	-0.08	0.04	0.07
GM Comp	-0.07	-0.14	0.17	0.06
ML Control	-0.05	0.12	0.14	-0.09
GMI 1-back	-0.12	-0.23	0.08	-0.28
SC Every-X	-0.09	-0.20	0.07	-0.42*

Note. ML Sent1 = Missing Letter Sentence1; ML Sent2 = Missing Letter Sentence2; ACC = Accuracy; GM Comp = goal maintenance composite; ML Control = Psychometric Control task; GMI = goal maintenance increase; CTSC = control task speech condition; GMD = goal maintenance decrease; SS = standard speech

*$p < 0.05$, **$p < 0.01$, $p = 0.06$-0.08

Table 9

Word Counts and Cognitive Task Performance in Schizophrenia

Variable	Standard Speech	GM Decrease	GM Increase	Control Task Speech
ML Sent1	0.29*	0.25†	0.51**	0.42**
ML Sent2	0.21	0.16	0.36*	0.27†
BX-AY ACC	0.14	0.10	0.34*	0.29*
D-prime Context	0.18	0.15	0.39**	0.37*
GM Comp	0.13	0.06	0.23	0.18
ML Control	-0.02	-0.06	0.04	0.04
GMI 1-back	0.13	0.11	0.22	0.21
SC Every-X	0.05	0.06	0.14	0.17

Note. ML Sent1 = Missing Letter Sentence1; ML Sent2 = Missing Letter Sentence2; ACC = Accuracy; GM Comp = goal maintenance composite; ML Control = Psychometric Control task; GMI = goal maintenance increase; CTSC = control task speech condition; GMD = goal maintenance decrease; SS = standard speech

*$p < 0.05$, **$p < 0.01$, $p = 0.06$-0.08

Table 10

Word Counts and Cognitive Task Performance in Non-Psychiatric Controls

Variable	Standard Speech	GM Decrease	GM Increase	Control Task Speech
ML Sent1	0.08	0.28	0.13	0.14
ML Sent2	-0.13	0.02	-0.11	0.05
BX-AY ACC	-0.02	0.21	0.32	0.13
D-prime Context	0.21	0.25	0.23	0.26
GM Comp	0.09	0.12	0.19	0.26
ML Control	0.13	0.03	0.07	0.03
GMI 1-back	0.25	0.07	0.07	0.30
SC Every-X	0.30	0.31	0.19	0.36†

Note. ML Sent1 = Missing Letter Sentence1; ML Sent2 = Missing Letter Sentence2; ACC = Accuracy; GM Comp = goal maintenance composite; ML Control = Psychometric Control task; GMI = goal maintenance increase; CTSC = control task speech condition; GMD = goal maintenance decrease; SS = standard speech

*$p < 0.05$, **$p < 0.01$, $p = 0.06$-0.08

Figures

Figure 1

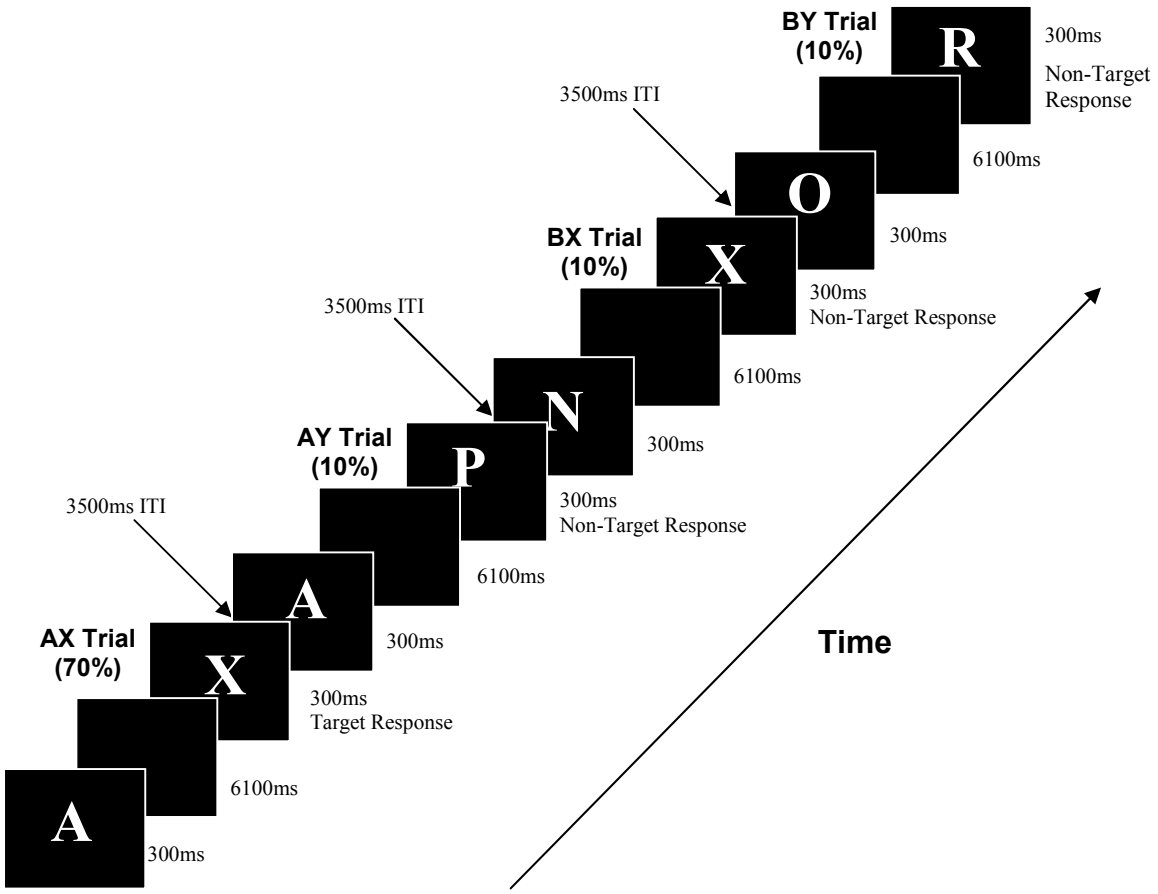


Figure 2

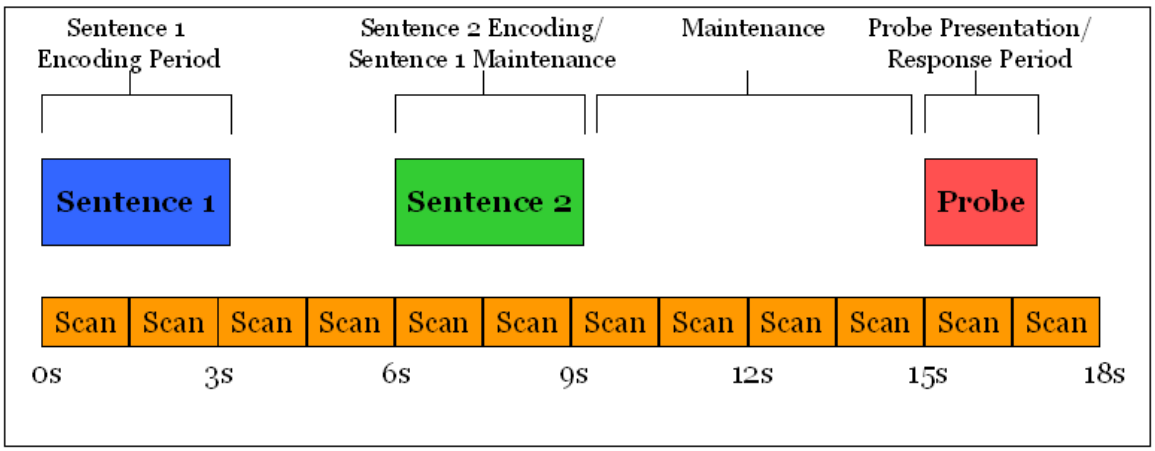

Sentence 1
Encoding Period
Sentence 2 Encoding/
Sentence 1 Maintenance
Maintenance
Probe Presentation/
Response Period
Sentence 1
Sentence 2
Probe
Scan
Scan
Scan
Scan
Scan
Scan
Scan
Scan
Scan
Scan
Scan
Scan
0s
3s
6s
9s
12s
15s
18s

Figure 3

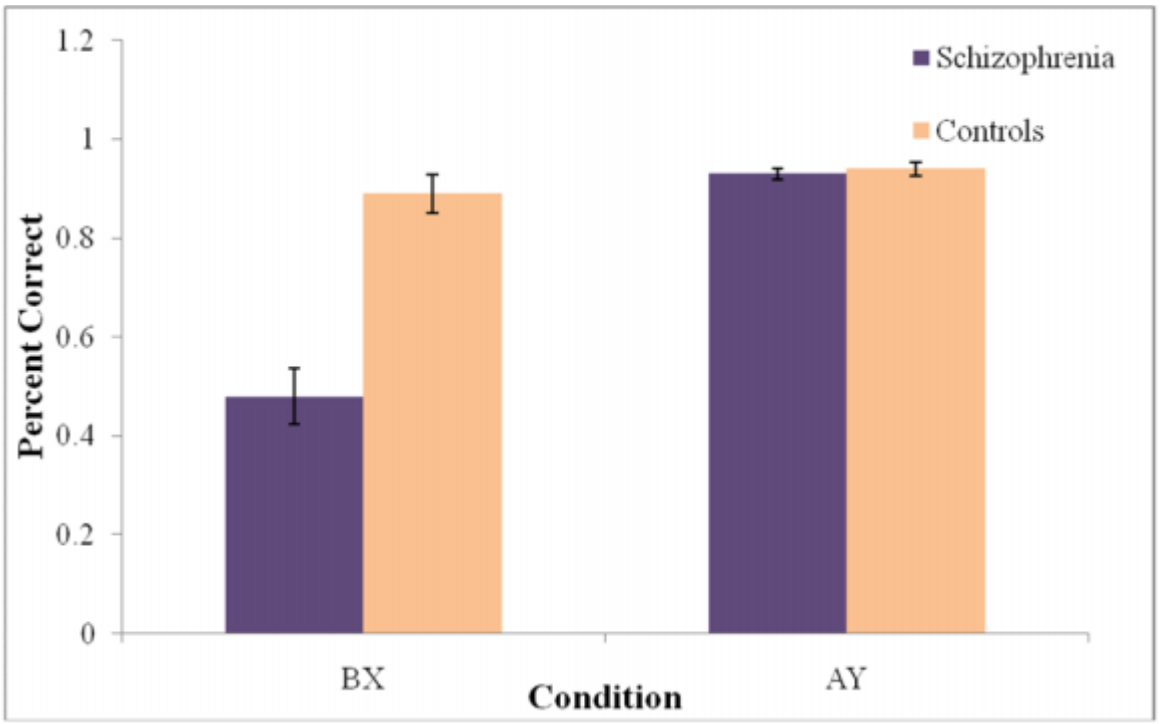

1.2
1
0.8
0.6
0.4
0.2
0
Percent Correct
Schizophrenia
Controls
BX
AY
Condition

Figure 4

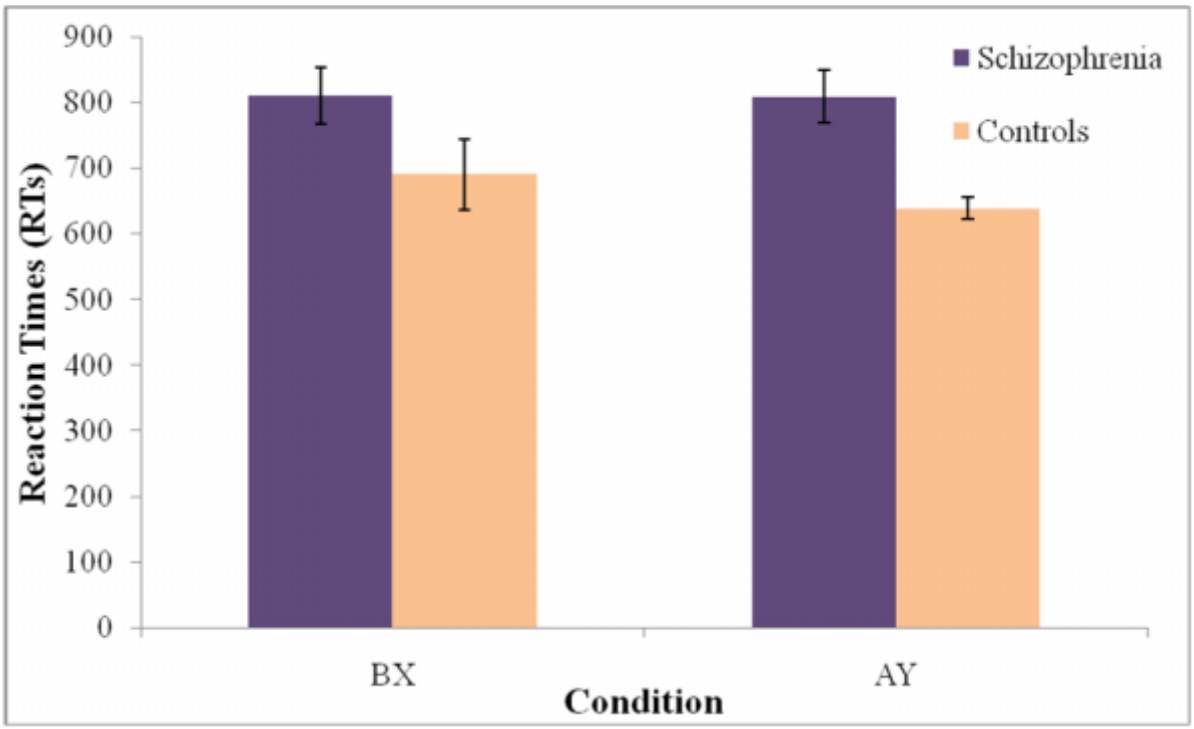
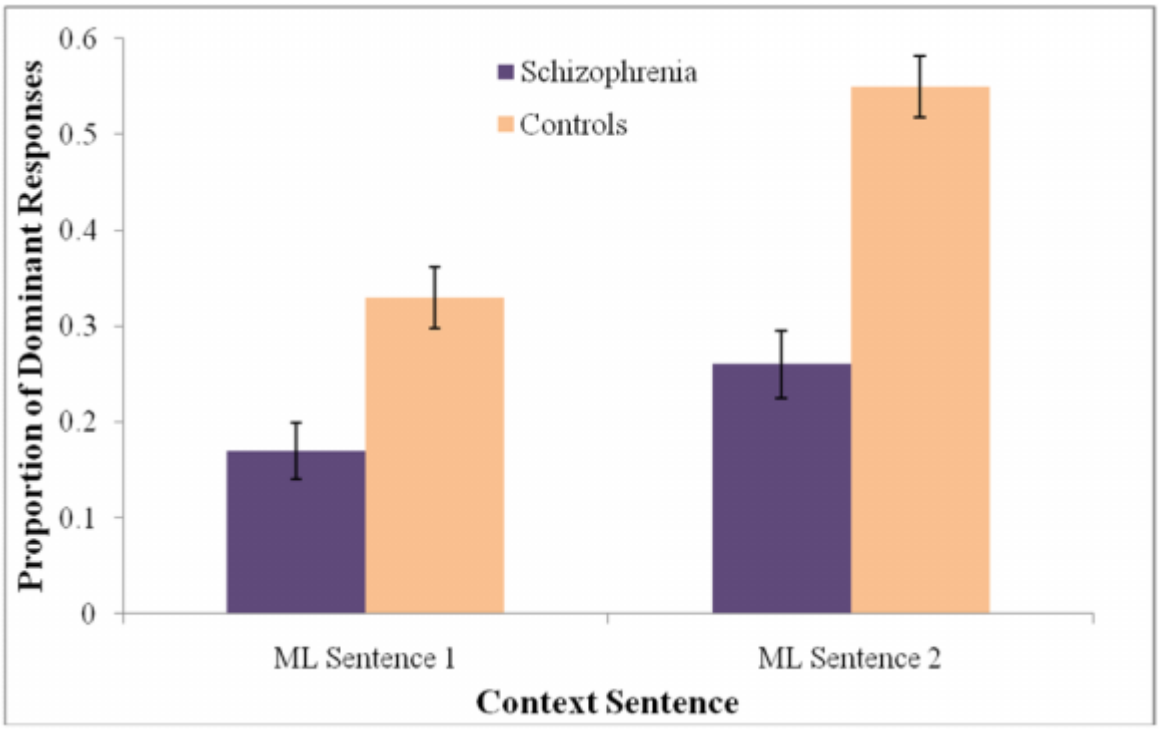

900
800
700
600
500
400
300
200
100
0
Reaction Times (RTs)
Schizophrenia
Controls
BX
AY
Condition

Figure 5


Proportion of Dominant Responses
0.6
0.5
0.4
0.3
0.2
0.1
0
Schizophrenia
Controls
ML Sentence 1
ML Sentence 2
Context Sentence

Appendix Tables

Table A1

A-X CPT Performance in Participants with > 20% BX Accuracy

Variable	Schizophrenia (n = 29)	Controls (n = 27)
BX Accuracy	0.73 (0.27)	0.92 (0.13)
AY Accuracy	0.93 (0.09)	0.94 (0.07)
BX-AY Accuracy difference	-0.20 (0.25)	-0.02 (0.16)
D-prime context	0.57 (0.31)	0.88 (0.15)
BX RTs	839.82 (268.19)	664.81 (251.63)
AY RTs	752.36 (151.85)	639.02 (88.58)
BX-AY RT difference	87.46 (203.11)	25.80 (195.42)

Table A2

Speech and Task Performance in a Modified Sample

Condition/Variable	Schizophrenia (n = 41)	Controls (n = 28)
	Disorganized Speech	
Standard Speech	2.23 (1.15)	0.74 (0.50)
GM Decrease	2.14 (1.23)	0.84 (0.48)
GM Increase	2.98 (1.96)	0.88 (0.41)
Control Task Speech	2.77 (1.40)	0.92 (0.45)
	Word Counts	
Standard Speech	849.12 (329.53)	1103.86 (251.07)
GM Decrease	843.46 (287.24)	1172.32 (269.94)
GM Increase	669.61 (275.35)	1047.68 (248.07)
Control Task Speech	658.27 (270.09)	1051.82 (254.71)
	Dual Task Performance	
GMI CT: Distraction 1-back (Hits – FAs)	0.37 (0.26)	0.66 (0.20)
CTSC: Every-X (Hits – FAs)	0.73 (0.15)	0.80 (0.14)

Note. GM = Goal Maintenance; FAs = False Alarms; GMI CT = dual cognitive task during the GM increase condition; CTSC = dual cognitive task during the control task speech condition

Table A3

Disorganized Speech and Cognitive Performance in a Modified Schizophrenia Sample

Variable	Standard Speech	GM Decrease	GM Increase	Control Task Speech
ML Sent1	-0.19	-0.18	-0.21	-0.29†
ML Sent2	-0.24	-0.20	-0.28†	-0.27†
BX-AY ACC	-0.48**	-0.49**	-0.33*	-0.49**
D-prime Context	-0.53**	-0.54**	-0.37*	-0.51**
GM Comp	-0.40*	-0.28†	-0.28†	-0.33*
ML Control	-0.16	-0.14	-0.07	-0.25
GMI 1-back	-0.47**	-0.49**	-0.30†	-0.41**
SC Every-X	0.00	-0.08	-0.30†	-0.04

Note: ML Sent1 = Missing Letter Sentence 1; ML Sent2 = Missing Letter Sentence 2; ACC = Accuracy; GM Comp = goal maintenance composite; ML Control = Psychometric Control task

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{\dagger}p = 0.06\text{-}0.09$

Table A4

Negative and Positive Symptoms and Cognitive Task Performance in Schizophrenia

Variable	Positive Symptoms	Negative Symptoms
ML Sentence1	-0.13	-0.03
ML Sentence2	-0.44**	-0.13
BX-AY ACC	-0.15	-0.11
D-prime Context	-0.36*	-0.13
GM Composite	-0.52**	-0.17
ML Control	-0.20	-0.05
GMI 1-back	-0.26†	-0.09
SC Every-X	-0.04	-0.15

Note. ML = Missing Letter; ACC = Accuracy; GM = goal maintenance; ML Control = Psychometric Control task

*$p < 0.05$, **$p < 0.01$, †$p = 0.06$

VITA

Theresa Becker was born in Pittsburgh, Pennsylvania to Lawrence and Carol Becker. She has three younger siblings, two sisters and a brother. She lived and attended K-12 in Pittsburgh, and also attended the University of Pittsburgh studying psychology. After working in Pittsburgh for an additional year, Theresa took a clinical cognitive neuroscience research job in Sacramento, California and took a long but fun road trip across the country to her new home in Sacramento. She lived and worked there for two years and had the opportunity to explore various beautiful west coast cities, parks, and beaches. After two years, she decided to move to Columbia, Missouri to attend graduate school at the University of Missouri. So, once again, Theresa took a long trip (but not as long as the first) across the country to yet another new home. She lived in Columbia, Missouri for six years during which time she attended graduate school studying clinical psychology, completed a 2.5-year clinical externship at Fulton State Hospital, and taught at Stephens College. During that time, Theresa met some life-long friends including her fiancé, Bryan Zolnikov who she dated for a year and then got engaged to in Maui, Hawaii! After six years, Theresa matched at a clinical internship at the VA Puget Sound-American Lake in Tacoma, Washington. Therefore, she (and her fiancé) took another long but exciting trip across the country in hopes to settle down permanently in the Pacific North West. During internship, Theresa has had the opportunity to explore the gorgeous landscape of the PNW and was offered an ideal post-doctoral fellowship at the University of Washington in Seattle - just a short trip from Tacoma. Theresa also found out that she and Bryan are going to be parents and is expecting the wonderful bundle of joy in late October 2012! The adventures in her life have only just begun!!