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Mismatch and Lexical Retrieval Gestures are Associated with Visual Information Processing, Verbal Production, and Symptomatology in Youth at High Risk for Psychosis

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Abstract

Introduction—Gesture is integrally linked with language and cognitive systems, and recent years have seen a growing attention to these movements in patients with schizophrenia. To date, however, there have been no investigations of gesture in youth at ultra high risk (UHR) for psychosis. Examining gesture in UHR individuals may help to elucidate other widely recognized communicative and cognitive deficits in this population and yield new clues for treatment development.

Method—In this study, *mismatch* (indicating semantic incongruency between the content of speech and a given gesture) and *retrieval* (used during pauses in speech while a person appears to be searching for a word or idea) gestures were evaluated in 42 UHR individuals and 36 matched healthy controls. Cognitive functions relevant to gesture production (i.e., speed of visual information processing and verbal production) as well as positive and negative symptomatology were assessed.

Results—Although the overall frequency of cases exhibiting these behaviors was low, UHR individuals produced substantially more *mismatch* and *retrieval* gestures than controls. The UHR group also exhibited significantly poorer verbal production performance when compared with

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Contributors

Mr. Millman, Ms. Gupta, and Ms. Mejias aided in data collection. Dr. Mittal and Mr. Millman conducted the analyses. Drs. Mittal, Schiffman, and Goss, Mr. Millman, Ms. Gupta, and Ms. Mejias interpreted the findings and drafted the manuscript. Dr. Mittal supervised the administration and attained the funding for this study.

Conflict of Interest

There are no conflicts of interest to report.

controls. In the patient group, *mismatch* gestures were associated with poorer visual processing speed and elevated negative symptoms, while *retrieval* gestures were associated with higher speed of visual information-processing and verbal production, but not symptoms.

Conclusions—Taken together these findings indicate that gesture abnormalities are present in individuals at high risk for psychosis. While *mismatch* gestures may be closely related to disease processes, *retrieval* gestures may be employed as a compensatory mechanism.

Keywords

Gesture; UHR; Prodrome Cognition; Lexical Retrieval; Speech-gesture Mismatches

1. Introduction

Because gesture serves a variety of key communicative and cognitive functions (Feyereisen, 1987; Streek, 1994; Alibali & DiRusso, 1999), investigators have argued that these movements provide a “window to the mind” (Goldin-Meadow, 2003). The field of psychosis research has prioritized the search for readily observable markers that can identify risk or elucidate pathogenic processes, leading researchers to examine gesture in patients with schizophrenia. Studies of individuals with psychosis have observed abnormal gesture activity (Troisi et al., 1998; Meilijson et al., 2004; Lavelle et al., 2013; Walther et al., 2013a;) with specific links to dysfunctional neural integration (Straube et al., 2013a), altered functional connectivity (Straube et al., 2013b), and both frontal cortex function and symptom severity (Walther et al., 2013b). Despite this growing body of evidence, and an earlier study observing gesture deficits in schizotypal personality disorder (SPD; Mittal et al., 2006), to date there have been no investigations of gesture in those at ultra high risk (UHR) for psychosis. Such research is important because gesture may be related to other impairments that are characteristic of this group, such as cognitive function (Seidman et al., 2010; Fusar-Poli et al., 2012). In addition, because gesture appears to be a useful tool for bolstering communicative ability and cognitive function (Alibali & DiRusso, 1999; Goldin-Meadow, 1999), and these domains are often affected in the prodromal period (Cornblatt et al., 2007; Niendam et al., 2007; Eack et al., 2010), understanding this behavior in UHR youth may have important implications for novel treatment development.

In any particular speech-gesture combination the information conveyed in the gesture is typically congruent with the speech. However, in some speech-gesture combinations the information in gesture can conflict with the speech (e.g., the speaker says “to the right” as they simultaneously point to the left). In normative samples, these “speech-gesture mismatches” (*mismatch* gestures) can appear when an individual’s cognitive resources are taxed. For example, researchers have observed increased *mismatch* cases when participants are discussing a difficult math problem or narrating a story with frequent shifts between characters’ physical viewpoints, their own, and their listener’s (Church & Goldin-Meadow, 1986; Melinger & Kita, 2004). Despite the relevance of *mismatch* gestures, this subtype has received limited attention in clinical populations; to date, one study has examined *mismatch* gestures in patients with schizophrenia (Goss, 2011, unpublished dissertation), and no studies have examined this behavior in UHR individuals.

Retrieval gestures occur when individuals make a hand movement while appearing to search for a word or idea. The role of gesture in lexical retrieval renders this behavior particularly important. One view is that semantically related gestures are derived from lexical entries and assist in retrieval of relevant phonological forms (Butterworth & Hadar, 1989; Alibali, et al., 2000). It is also possible that semantically related gestures are a product of spatially encoded information and that, in turn, provide access to lexical entries that contain syntactic and semantic information (Krauss, et al., 1996; Alibali et al., 2000). Both possibilities suggest the gesture boosts activation levels for retrieval and subsequently plays a direct role in the process of speaking (Alibali et al., 2000). Given the importance of *retrieval* gestures and related deficits in psychosis (i.e., broad social cognition and fluency deficits; see Bokat & Goldberg, 2003; Couture et al., 2006), it is somewhat surprising that no studies have examined *retrieval* gestures in schizophrenia or spectrum disorders.

Although the literature linking gesture with cognitive dysfunction in psychosis is limited, several studies in healthy individuals help to identify potential cognitive domains. One strong line of evidence suggests that co-speech gestures facilitate verbal production (Morsella & Krauss, 2004; Hostetter & Alibali, 2007). For example, healthy individuals produced more gesture when restrictions were imposed on their speech; conversely, prohibiting gesture led to slower and more dysfluent speech (Rauscher et al., 1996). In addition, research has suggested that the recognition of gestures is influenced by contextual information (Peigneux et al., 2000; Osiurak et al., 2012). Indeed, in one of the noted studies that examined gesture behavior in psychosis, Walther et al. (2000b) posited that because visual information processing during social situations is affected in schizophrenia (Green et al., 2008), gesture performance in psychosis may also be hampered by poor visual information processing.

The present investigation evaluated *mismatch* and *retrieval* gestures, symptomatology, and both visual information processing speed and verbal production in UHR and control adolescents and young adults. Based on research suggesting broad nonverbal dysfunction in individuals with psychosis (Troisi et al., 1998; Mittal et al., 2006; Eack et al., 2010), and a previous study observing a high frequency of *mismatch* gestures in patients with schizophrenia (Goss, 2011, unpublished dissertation), we predicted that UHR participants would show elevated occurrences of *mismatch* gestures when compared with healthy controls. Group comparisons for *retrieval* gestures were treated as exploratory analyses given the novelty of examining this behavior in a clinical population. As studies have linked *mismatch* gestures with cognitive instability, a feature observed in patients with psychosis (Becker et al., 2012), we predicted that an elevated frequency of these gestures would be associated with decreased visual processing speed, impaired verbal production, and elevated symptom severity in the UHR group. Because studies have found *retrieval* gestures to facilitate cognitive function in healthy individuals (Cook et al., 2008), and UHR individuals show a range of cognitive deficits (Walder et al., 2008; Mittal et al., 2010; Seidman et al., 2010; Fusar-Poli et al., 2012), we predicted that the use of *retrieval* gestures would be associated with improved cognitive functioning in the clinical group.

2. Methods

2.1 Participants

Thirty six control and 42 UHR participants were recruited by Internet advertising, email postings, newspaper ads, and community professional referrals. Exclusion criteria included history of head injury, the presence of a neurological disorder, lifetime substance dependence, an Axis I psychotic disorder, and the presence of any contraindication to the magnetic resonance imaging environment. To be included in the study UHR individuals needed to meet one or more of three criteria from the Structured Interview for Prodromal Syndromes (SIPS): 1) recent onset or escalation of moderate levels of attenuated positive symptoms, 2) a decline in global functioning over the last 12 months accompanying the presence of schizotypal personality disorder, 3) a decline in global functioning over the last 12 months accompanying the presence of a first-degree relative with a psychotic disorder such as schizophrenia. The presence of a psychotic disorder in a first-degree relative or meeting criteria for any Axis I disorder was an exclusionary criterion for controls. The protocol and informed consent procedures were approved by the university institutional review board.

2.2 Clinical Interviews

The SIPS measures several symptom categories of prodromal psychosis, including positive dimensions (unusual thoughts, suspiciousness, grandiosity, perceptual abnormalities, disorganized communication) and negative dimensions (social anhedonia, avolition, emotional expression, expression of self, ideational richness, occupational functioning). The severity of each dimension is represented by the sum of symptom scores within each category. In addition to the SIPS, the Structured Clinical Interview for DSM-IV (First et al., 1995) was used to rule out Axis I psychotic disorders. In this study, raters were advanced doctoral students who were trained over a 2-month period to achieve kappas of ≥.80.

2.3 Gesture

The clinical interviews took place in a quiet laboratory setting equipped with video technology. As in our prior study of different gesture subtypes among a distinct sample of schizotypal adolescents (Mittal et al., 2006), study staff rated the structured interview portion of the recorded interviews for different elements of gesticulation (those gestures occurring during the process of speech). Raters began when the first question of the SIPS was asked and then coded a 15-minute segment for each participant. The coding scheme was adapted from the *Handbook of Methods in Nonverbal Behavior Research* (Scherer & Ekman, 1982) and additional criteria for the coding of gesture subtypes were based on procedures described by McNeill (1992). Specifically, trained raters coded incidences of speech-gesture *mismatches*, defined as gestures that are semantically incongruent with the corresponding lexical content. For example, an individual exhibiting a *mismatch* gesture would be speaking about “climbing up a ladder” but would simultaneously be pointing downward. Coders also noted incidences of *retrieval* gestures. These gestures occur during a pause in speech when an individual is searching for a word or phrase. For example, a person might be talking about their lunch and say “The sandwich was almost the very best I ever tasted, it reminded me of that time I was traveling and ate in that café in….[gesture such as grasping air, creating a baton movement]…France!" In the context of preparing for a broader study of motor behaviors, three raters learned about a range of gesture types for several weeks and underwent training for 3 months by coding video sessions of the diagnostic interviews. Each rater was trained by coding a series of practice tapes until inter-rater reliability exceeded Cronbach's alpha > .80. Raters were kept blind to the hypotheses of this study. The coders were given continuous feedback throughout the training period and reliability was periodically assessed and maintained throughout the coding period.

2.4 Verbal Production and Visual Information Processing Speed

To assess verbal production and visual information processing speed, we selected two tests that tap these constructs and have been recommended for psychosis-spectrum populations (Nuechterlein et al., 2008). To assess visual information processing speed, participants were administered the Trail Making Test: Part A, a timed paper-and-pencil test in which a respondent draws a line to connect consecutively numbered circles placed irregularly on a sheet of paper (Tombaugh, 2004). To assess impairment in verbal production, participants were administered a verbal fluency task (Category Fluency: Animal Naming; Benton et al., 1987), an oral test that measures verbal production by requiring respondents to name as many animals as she/he can in 1 minute. Analyses were conducted on the raw scores (i.e., total seconds for Trail Making and number of unique responses for Animal Naming). As the results for all analyses did not differ from those using corrected *T*-scores (Kern et al., 2008), these standardized scores are presented to facilitate ease of interpretation.

2.5 Statistical Approach

Independent *t*-tests and chi-square tests were utilized to examine for any potential demographic differences between groups. Because gestures occurred infrequently and primarily in the UHR participants, group differences involving gesture were evaluated utilizing the Mann-Whitney *U* test and correlations were evaluated utilizing Spearman correlations (non-parametric equivalents for *t*-test/Pearson's *r*). Group differences in the cognitive variables and symptom variables were examined using independent *t*-tests. Two-tailed tests were employed for comparisons that did not involve a predicted outcome (i.e., demographic differences, group differences in *retrieval* gestures), whereas one-tailed tests were used for predicted outcomes (group differences in *mismatch* gesture and cognitive variables, correlations between gesture types, cognitive variables, and symptoms).

3. Results

Gesture behavior and symptom variables were collected for each of the 78 participants (42 UHR/36control), and a total of 72 participants (37 UHR/35control) completed the brief cognitive battery (note: the remaining cognitive data were incomplete for 6 cases due to test fatigue or incomplete administration). There were no significant group differences for demographic variables including age [$t(76)=1.23$, $p=.22$], gender [$\chi 2(1)=1.06$, $p=.30$] or parental education [$t(75)=.99$, $p=.32$]. See Table 1 for group comparisons of demographic and target variables. As expected, the UHR group displayed elevated positive [$t(76)=14.89$, $p\leq.01$] and negative symptoms [$t(74)=7.56$, $p\leq.01$], as well as lower verbal production performance [$t(70)=2.23$, $p=.02$]. However, while the UHR group showed slightly slower mean visual processing speed performance, there were no significant group differences for this variable [$t(70)=-.01$, $p=.50$].

3.1 Group Differences in Mismatch and Retrieval Gestures

A Mann-Whitney *U* test indicated that there were significantly more incidences of *mismatch* gestures in the UHR group when compared to controls, $z=-2.11$ $p=.02$. There were 7 participants that demonstrated *mismatch* gestures in the UHR group (16.6%; mean=.16, SD=.37) while there was a single case in the controls (3%; mean=.03, SD=.17). Examples of *mismatch* gestures in the current sample include: a participant saying “two times in a year” but simultaneously raising a single finger; a participant saying the phrase “mixing things together” while simultaneously spreading his hands apart; a participant referring to “time being linear” while gesturing a curved line; and a participant noting that “things are improving” but making a downward motion with his hand. A Mann-Whitney *U* test indicated that the UHR group exhibited significantly more *retrieval* gestures, $z=-2.98$, $p\leq .01$. Specifically, 11 participants (26.2%; mean=.36; SD=.69) in the UHR group exhibited these gestures while they were only observed in 1 control participant (3%; mean=.03; SD=.17). An example of a *retrieval* gesture occurred when a participant described an increase in positive symptoms. The subject said “I am a lot more…” then paused, and during the pause, created a rapid, wide, and repetitive circular gesture before continuing with “…conscious of those feelings.” In other cases we observed participants grasping or reaching in the air during pauses before seeming to find the phrase they were looking for.

3.2 Associations Between Gestures, Symptoms, and Cognitive Performance

Non-parametric correlations were conducted to determine the relationship between gesture behavior and both symptoms and cognitive variables in the UHR group (note: these gestures did not occur at a frequency that would allow for analysis in the healthy control group). Spearman correlations indicated that incidences of *mismatch* gestures were associated with elevated negative symptoms ($r=.26$, $p\leq.05$) as well as deficits in visual processing speed ($r=-.30$, $p\leq.05$), while associations with verbal production ($r=-.02$) and positive symptoms ($r=.05$) did not approach significance. In contrast, *retrieval* gestures were associated with both elevated verbal production ($r=.28$, $p\leq.05$) and visual processing speed ($r=.42$, $p\leq.01$), but not positive ($r=.10$) or negative ($r=.09$) symptoms.

4. Discussion

Investigations of gesture behavior have significantly improved our understanding of social and cognitive processes (McNeill, 1992; Goldin-Meadow et al., 1993; Streek, 1994; Alibali & DiRusso, 1999), and several studies have implicated abnormal gesture behavior in schizophrenia and spectrum groups (Trosi et al., 1998; Straube et al., 2013a,b; Walther et al., 2013a,b). However, to date our understanding of gesture behavior in the psychosis risk-period has been limited. In the present investigation we observed that UHR individuals show elevated incidences of *mismatch* and *retrieval* gestures when compared to controls. However, while the former appears to be associated with symptomatology and lower processing speed in the patient group, the latter is not tied to symptoms, but rather is correlated with higher speed of processing and greater verbal production in UHR youth.

The current observation that UHR participants exhibited elevated *mismatch* gestures is consistent with findings that individuals with chronic schizophrenia and disordered speech produced a high frequency of speech-gesture mismatches (Goss, 2011, unpublished dissertation). In turn, the relationship between *mismatch* gestures and negative symptoms is consistent with recent observations that patients with more negative symptoms exhibit higher gesture frequencies (Lavelle et al., 2013). However, it is important to consider that other work (that did not examine the *mismatch* or *retrieval* gestures) suggests negative symptoms are relatively independent of non-verbal communication (Troisi et al., 1998) and social cognition (Sergi et al., 2007). As gesture plays a key role in linking thought with language (McNeill, 1992) and negative symptomatology (which often precedes formal psychosis by several years and tends not to oscillate) is thought to be a core feature of schizophrenia (Bleuler, 1950), *mismatch* gestures may reflect a central aspect of psychosis-spectrum pathology.

We also observed that elevated *mismatch* gestures were associated with deficits in visual information processing speed. This finding is interesting as studies have shown that in healthy individuals, speech-gesture mismatches can actually be induced in through cognitively demanding tasks such as telling complex lies (Franklin, 2007) or explaining difficult math problems (Church & Goldin-Meadow, 1986; Alibali & Goldin-Meadow, 1993). Indeed, *mismatch* gestures can be seen as failures to suppress conflicting or contextually irrelevant information (Funahashi, 2001).

Researchers have observed that gesturing during hesitations in speech can improve lexical retrieval rates in children (Pine et al., 2007) and young adults (Frick-Horbury & Guttentag, 1998). Thus, while the use of *retrieval* gestures can be seen as a normative behavior, the UHR group used them at an elevated rate in the 15-minute videotaped sample. While both groups preformed at a roughly even level in the visual processing speed domain, those in the UHR group who scored higher also employed elevated *retrieval* gestures. One possibility is that the elevated use of this gesture reflected a compensatory mechanism in the UHR group. This link between *retrieval* gestures and elevated verbal production is particularly interesting given a body of literature indicating verbal fluency deficits in UHR individuals (Cosway et al., 2000; Keefe et al., 2006; Pukrop et al., 2006; Pukrop et al., 2007; Simon et al., 2007; Frommann et al., 2011), lexical retrieval dysfunction in schizophrenia (Allen et al., 1993; Covington et al., 2005), and research tying gesture and lexical retrieval in healthy individuals (Hadar & Butterworth, 1997; Krauss & Hadar, 1999). As gesture based treatments have been found to improve word production in neurologically impaired individuals (Rose, Douglas, Matyas, 2002), these findings speak to the potential for future experimental treatment studies.

It is important to note that causality cannot be determined due to the study's correlational design. In addition, the study included a single time-point and longitudinal research is necessary to determine test characteristics as well as the predictive value of gesture in determining illness progression. Further, while this study focuses on gesture production, gesture comprehension is also integral to understanding non-verbal deficits in psychosis. In addition, while the guiding literature tying gesture to cognitive function in schizophrenia is limited, and we chose two cognitive domains that have been linked to gesture, the present battery was short and non-specific (i.e., animal naming gauges several functions in addition to verbal production including semantic memory and language; Morris et al., 1989). Future investigations including a broader set of clinical outcome variables (beyond symptoms alone) as well as additional tests of language production and other relevant cognitive functions are also needed. It is also important to note that because reviewers coded clinical structured interviews, this may have compromised blinding to group status; future studies should include a neutral task instead (e.g., re-telling a story). Finally, while this study detected several cases of *mismatch* and *retrieval* gestures, the overall number of cases was relatively small. Future studies with larger samples will be important for examining these types of gestures and their integral link to cognitive function and symptoms.

Taken together, the present results support the notion that gesture and cognitive processes are intricately intertwined. In UHR youth, specific gestures may serve a compensatory function or reflect pathogenic processes. If longitudinal studies indicate that certain gestures reflect heightened vulnerability for eventual transition to a psychotic disorder, these behaviors may serve as a novel biomarker. Further, If future experimental work indicates that certain gesture types improve cognition, interventions involving gesticulation may hold promise for the treatment of psychosis-spectrum disorders.

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Table 1

Group Differences in Demographics, Cognitive Performance, and Gesture Production

	Healthy	Ultra High-Risk	Total	Differences
Gender				
Males	19(52.8%)	27(64.3%)	47(41.0%)	*N.S.*
Females	17(47.2%)	15(35.7%)	32(59.0%)	
Total	36	42	78	
Age				
Mean Years (SD)	18.1(2.3)	18.6(1.8)	18.4(2.1)	*N.S.*
Parent Education				
Mean Years (SD)	15.2(3.0)	15.8(2.5)	15.5(2.8)	*N.S.*
Symptoms				
Positive				
Mean (SD)	.53(1.2)	12.1(4.5)	6.8(6.7)	$p \leq 0.01$
Negative				
Mean (SD)	.58(1.2)	10.0(7.3)	5.5(7.1)	$p \leq 0.01$
Cognitive Functions				
Verbal Production				
Mean (SD)	55.0(10.0)	49.7(10.4)	52.3(10.7)	$p \leq 0.05$
Visual Processing				
Mean (SD)	49.3(10.5)	49.3(11.0)	49.3(10.7)	*N.S.*
Gesture				
Mismatch				
Mean Rank	36.5	42.0	--	$p \leq 0.05$
Retrieval				
Mean Rank	34.5	43.8	--	$p \leq 0.01$

Note: not significant (N.S.); A chi-square test was employed to compare gender composition between groups, independent *t*-tests were utilized to compare group differences in age, parental education symptoms and cognitive function (cognitive values are reported as T-scores), and a Mann-Whitney *U* test was used to compare gesture types between the groups (Mean rank is reported).