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## Speech illusions and working memory performance in non-clinical psychosis

Tina Gupta<sup>a,\*</sup>, Jordan E. DeVylder<sup>b</sup>, Randy P. Auerbach<sup>c,d</sup>, Jason Schiffman<sup>e</sup>, Vijay A. Mittal<sup>a,f,g,h</sup>

<sup>a</sup> Department of Psychology, Northwestern University, Evanston, IL, USA

<sup>b</sup> Graduate School of Social Service, Fordham University, NY, USA

<sup>c</sup> Center for Depression, Anxiety and Stress Research, McLean Hospital, Belmont, MA, USA

<sup>d</sup> Department of Psychiatry, Harvard Medical School, Boston, MA, USA

<sup>e</sup> Department of Psychology, University of Maryland, Baltimore County, Baltimore, MD, USA

<sup>f</sup> Department of Psychiatry, Northwestern University, Evanston, IL, USA

<sup>g</sup> Institute for Policy Research, Northwestern University, Evanston, IL, USA

<sup>h</sup> Department of Medical Social Sciences, Northwestern University, Evanston, IL, USA

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### ABSTRACT

Psychotic disorders are characterized by auditory verbal hallucinations (AVHs), and research has shown that AVHs are linked to deficits in working memory. Our understanding of AVHs across the psychosis continuum is limited. To date, little research has tested whether hallucination proneness (HP) is linked with abnormalities on experimental multispeaker babble tasks. Few investigations have been conducted to determine how task performance might be linked to cognitive functioning. The objective of the current study is to better understand this empirical gap. A total of 70 adults (30 healthy controls and 40 HP individuals) were administered an experimental task in which they listened to multispeaker babble and were instructed to report any words or chains of consecutive words (CCWs) perceived. Participants also were administered nonverbal and verbal working memory tasks. Findings revealed that relative to the control group, the HP individuals perceived more words and longer CCWs during the task. While there were no significant differences in working memory tasks between the HP and control groups, longer CCW's were associated with decreased verbal working memory scores in the HP group. AVH proneness may occur across a continuum of psychosis and may be linked with other theoretically relevant cognitive vulnerability factors.

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### 1. Introduction

Psychosis symptoms typically occur as part of a continuous distribution of experiences (Kelleher and Cannon, 2011; van Os, 2002). Within this context, 5–8% of persons within the general population experience non-clinical psychosis (NCP) and these individuals represent the lower end of a psychosis severity continuum (van Os, 2002). NCP groups differ from other individuals on the psychosis continuum in that they are healthy individuals who report symptoms called psychotic-like experiences (PLEs; also termed psychosis experiences) such as fleeting hallucinations that are low in frequency. Identifying vulnerability factors among NCP groups can shed important light on the etiology of psychotic symptoms, in the absence of many of the types of variables that confound research in individuals with psychotic disorders (e.g., medications).

Auditory verbal hallucinations (AVHs) may occur across a continuum; AVHs refer to the perception of sounds or voices in the absence of external auditory stimuli (Bentall, 1990; Sommer et al., 2010; van Os, 2002). The concept of hallucination proneness (HP) relies upon self-report measures that may suggest a predisposition towards experiencing hallucinations on the basis of intermittent positive symptoms and/or schizotypy traits; schizotypy characteristics are traits in contrast to states and these individuals may share similar vulnerabilities as other groups on the psychosis continuum (Siever et al., 2002). Despite a compelling literature linking AVHs to deficits in working memory (WM) in schizophrenia (Hoffman et al., 1999; Jenkins et al., 2017) and emerging support indicating WM is affected across a psychosis continuum (Lee and Park, 2005; Rossi et al., 2016; Ziermans, 2013) there is a paucity of research utilizing experimental paradigms to evaluate non-clinical HP populations (Barkus et al., 2007; Bentall and Slade, 1985), particularly as it relates to linking proneness to AVHs with WM dysfunction.

Studies examining psychotic-like experiences and AVHs have utilized a variety of different paradigms in healthy and HP individuals (based on self-report measures), and schizophrenia populations

\* Corresponding author at: Department of Psychology, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208, USA.

E-mail address: [tinagupta2021@u.northwestern.edu](mailto:tinagupta2021@u.northwestern.edu) (T. Gupta).

(Barber and Calverley, 1964; Barkus et al., 2007, 2011; Mintz and Alpert, 1972; Ven and Merckelbach, 2003; Young et al., 1987). One task that has been used with psychosis and psychosis risk samples is the *Babble Stimulus* (Hoffman, 1999). In this task, participants may be asked to listen to simultaneous streams of speech with a high density of phonetic information and report any words or chains of consecutive words (CCW) perceived (Hoffman, 1999). Multispeaker babble tasks may be more sensitive and capable of detecting low levels of proneness that would be missed by traditional interview or self-report measure approaches. There have been a few studies that have used multispeaker babble tasks to better understand AVHs among schizophrenia (Hoffman et al., 1999) and at risk populations (Hoffman et al., 2007) in which individuals reported perceiving speech illusions.

Prior research also has suggested speech illusions may be associated with cognitive functions such as working memory (Daalman et al., 2011; Hoffman et al., 1999; Rossi et al., 2016; Ziermans, 2013). Working memory aids in storing and processing information, also modulating bottom up and top down mechanisms (Hugdahl, 2009). While ongoing work continues to establish links between AVHs and working memory deficits in schizophrenia (Gisselgård et al., 2014; Hoffman et al., 1999; Jenkins et al., 2017), our understanding of the association across the broader psychosis continuum is limited. However, there are some studies that have found relationships with verbal working memory in individuals from the general population prone to hallucinations (Daalman et al., 2011; Rossi et al., 2016). Daalman et al. (2011), aimed to establish a cognitive profile for otherwise healthy individuals experiencing proneness symptoms assessed by the PSYRATS Auditory Hallucination Rating Scale and observed that high scores (high HP) were related to cognitive deficits including verbal working memory but also inhibition, lexical access and reasoning, and verbal distractibility. In contrast, Korponay and colleagues (2014) found high levels of subclinical positive symptoms in nonpsychiatric controls were related to better performance on cognitive tasks including working memory. Of particular relevance to the present study is work conducted by Hoffman et al. (1999) in which the *Babble Stimulus* was implemented to hallucinating and non-hallucinating patients with schizophrenia. It was found that hallucinating patients exhibited poorer performance on the multispeaker babble task and likewise experienced deficits in verbal working memory. The present study is an extension of this work and seeks to look at specific links between multispeaker babble and verbal working memory in an undergraduate college sample with HP, to understand whether these associations generalize to a non-clinical HP sample. If we see similar performance on the multispeaker babble task as psychosis and at-risk populations, it could be that tasks as such may highlight proneness to symptoms such as AVHs.

The present investigation aims to improve our understanding of proneness to AVHs and working memory among HP individuals using a multispeaker babble task. Participants were administered the *Babble Stimulus* (Hoffman, 1999), and based of previous studies in this area (Hoffman et al., 1999), first, we hypothesized that HP individuals would report hearing more words and have longer CCWs during the multispeaker babble task relative to controls. Then, participants were administered a battery of working memory tasks, and consistent with findings linking working memory deficits to AVH in schizophrenia (Hoffman et al., 1999; Jenkins et al., 2017), we hypothesized that elevated scores on the experimental task would be associated with poorer working memory performance across tasks in the HP group.

## 2. Materials and methods

### 2.1. Participants

A total of 70 college students (HP = 40, and controls = 30) aged 18–26 ( $M = 19.10$ ,  $SD = 1.54$ ) were recruited through the Adolescent Development and Preventive Treatment (ADAPT) program using the University of Colorado Boulder's undergraduate research subject pool.

All procedures were approved by the University Institutional Review Board (IRB). A total of 1248 undergraduate students were given the Launay-Slade Scale Revised (LSHS-R) (Bentall and Slade, 1985), an HP inventory. The Brief Psychiatric Rating Scale (BPRS) (Overall and Gorham, 1976) was administered to ensure that participants with high psychosis levels would not be included and were therefore excluded from the study as this could confound results (no participants were excluded based on this criterion).

### 2.2. Clinical symptoms

The LSHS-R (Bentall and Slade, 1985) was used to identify HP individuals. This measure is one of the most widely-used instruments to examine psychotic-like experiences in the general population (Barkus et al., 2007; Mittal et al., 2013; Pelletier et al., 2013; Van 't Wout et al., 2004; Vellante et al., 2012). This scale is reliable and well-validated (Bentall and Slade, 1985; Fonseca-Pedrero et al., 2010; Morrison et al., 2002; Waters et al., 2003) and it measures the prevalence of abnormal perceptual and unusual thought experiences on a four-item Likert scale ranging from “Never” to “Nearly Always.” Exemplar items include questions centered around perceptual phenomena, “In the past I have experienced hearing a person's voice and found that no one was there,” “I have n the voice of the devil,” “I have been troubled by hearing voices in my head,” as well as symptoms of unusual or bizarre thinking, “Sometimes a passing thought will seem so real that it frightens me,” “People in my daydreams seem so true to life that I sometimes think they are real”. The option to participate in the study was made available to those scoring in the top and bottom 10th percentile of the total sum score on the LSHS ( $\geq 23$  or  $\leq 3$ ) (Mittal et al., 2012). Out of the 250 individuals invited to the study, a total of 70 elected to participate. Of the 70 participants, 30 reported low scores on the LSHS (controls) and 40 reported high scores on the LSHS (HP).

### 2.3. Babble stimulus

The *Babble Stimulus* (Hoffman, 1999) provides an audio of six speakers overlapping in speech reading neutral texts, which end up sounding like white noise in which no words are discernable. The length of the stimulus is a total of 2.5 min and participants are instructed to list any individual words or CCWs they perceive while listening to the multispeaker babble. Consistent with prior work (Hoffman et al., 1999, 2007; Hoffman, 1999), the number of words extracted from the multispeaker babble and the number of words uttered in the longest CCWs perceived are both treated as target variables.

### 2.4. Cognitive measures

Participants were administered two tests of working memory: the Wechsler Memory Scale-Third Edition Nonverbal Span (Wechsler, 1997b), a test of nonverbal working memory and Letter-Number Sequencing (Wechsler, 1997a), a test of verbal working memory. In the Wechsler Memory Scale-Third Edition Nonverbal span, participants are given a board with 10 cubes spaced throughout and are instructed to mimic by taping the cubes a particular sequence that the administrator taps. Letter-Number Sequencing requires the administrator to say a sequence of letters and numbers and participants are asked to reorder this sequence and repeat them back to the administrator. For both tasks, the total number of correct responses were recorded and then these raw scores were converted to standardized  $t$ -scores, correcting for both age and gender.

### 2.5. Data analyses

SPSS Statistics 23 was used to conduct behavioral analyses. Group differences in continuous and categorical demographic variables were evaluated with independent  $t$ -tests and Chi-square tests. Independent

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