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Evaluating lexical characteristics of verbal fluency output in schizophrenia

Barbara J. Juhasz^{*}, Destinee Chambers, Leah W. Shesler, Alix Haber, and Matthew M. Kurtz

Wesleyan University, Department of Psychology, Middletown, CT 06459

Abstract

Standardized lexical analysis of verbal output has not been applied to verbal fluency tasks in schizophrenia. Performance of individuals with schizophrenia on both a letter (n=139) and semantic (n=137) fluency task was investigated. The lexical characteristics (word frequency, age-of-acquisition, word length, and semantic typicality) of words produced were evaluated and compared to those produced by a healthy control group matched on age, gender, and WAIS-III vocabulary scores (n=20). Overall, individuals with schizophrenia produced fewer words than healthy controls, replicating past research (see Bokas and Goldberg, 2003). Words produced in the semantic fluency task by individuals with schizophrenia were, on average, earlier acquired and more typical of the category. In contrast, no differences in lexical characteristics emerged in the letter fluency task. The results are informative regarding how individuals with schizophrenia access their mental lexicons during the verbal fluency task.

Keywords

Verbal Fluency; Lexical Characteristics; Age-of-Acquisition; Schizophrenia

1. Introduction

Disorganization of language is a prominent feature of schizophrenia, evident in the earliest descriptions of the disorder (e.g. Bleuler, 1950). A commonly used method for studying language deficits at the level of word production in schizophrenia is to conduct a verbal fluency test. In this task, participants are asked to produce as many words as possible which fit into a specific category within a given time limit. The category can be structural (e.g. words starting with the letter “f”), semantic (e.g. animals), or even syntactic (e.g. verbs). There are an abundance of studies which have examined verbal fluency performance in schizophrenia. The majority of them have reported that individuals with schizophrenia produce many fewer total words compared to individuals from a demographically matched control group with effect-sizes in the range of $d=1.0$ or higher (e.g. Heinrichs and Zakzanis, 1998; Bokas and Goldberg, 2003; Henry and Crawford, 2005; Vogel et al., 2009) with associated alterations in activation in prefrontal, striatal and default mode networks (Costafreda et al., 2011). While the finding that verbal fluency performance is impaired in

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Correspondence to: Barbara J. Juhasz, Department of Psychology, 207 High Street, Wesleyan University, Middletown, CT 06459, Phone: 860-685-4978, Fax: 860-685-2761, bjuhasz@wesleyan.edu.

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schizophrenia is robust, the factors responsible for this impairment remain unknown. One strategy has been to compare relative performance on purely lexical versions of the verbal fluency task (referred to as either letter or phonemic fluency) with semantic fluency. The rationale underlying this comparison is that if semantic fluency is more impaired than letter fluency, this may indicate semantic memory impairment (Bokat and Goldberg, 2003). A recent meta-analysis, however, has failed to find a difference in performance on these tasks (Doughty and Done, 2009).

Other studies have investigated the integrity of semantic stores in schizophrenia in verbal fluency tasks by assessing clusters of similar responses (e.g. farm animals in the “animal” category) and switches between the clusters on the task. For example, Elvevåg et al. (2002a) had individuals with schizophrenia and healthy controls complete a semantic fluency task with six categories. In a subsequent testing session, participants were asked to define their own clusters of responses. While healthy controls did make significantly more visits to a given cluster compared to individuals with schizophrenia, this effect was no longer significant once total verbal fluency output was included in the analysis. Other studies have also reported differences in clustering and/or switching which do not remain significant once total verbal fluency output is covaried (e.g. Robert et al., 1997; Bozikas et al., 2005; Landrø and Ueland, 2008). Thus, both approaches to date suggest that if differences in the semantic store in schizophrenia exist, these differences are subtle.

Another way to assess semantic network differences in schizophrenia was accomplished by Nestor et al., (1998) who used a cued recall task with words differing in terms of their network size (how many other words are similar semantically to a given word) and connectivity (how many interconnections there are between words in a given semantic network) on the basis of previously collected norms. Individuals with schizophrenia had lower recall overall and were more influenced by network connectivity compared to control participants. The effect of network size was similar across the groups. This suggests that semantic network patterns may be altered in individuals with schizophrenia. One way to examine this would be to assess the semantic typicality effect which has been found to affect object naming and categorization in healthy adults (e.g. Holmes and Ellis, 2006). However, results from a semantic categorization task (e.g. fish) with typical (trout), atypical (shark), and borderline (eel) exemplars (Elvevåg et al., 2002b) do not support a qualitative difference in semantic representations in individuals with schizophrenia.

In comparison, findings from studies of verbal fluency in healthy samples with higher levels of schizotypal traits that resemble symptoms of schizophrenia do suggest that semantic memory organization is disordered. Kiang and Kutas (2006) in a sample of 60 healthy college students found that participants scoring higher on a scale of schizotypal traits generated more semantically atypical exemplars of the fruit category on a category fluency task both in their initial responses and in overall output. In this study, typicality was measured as the percentage of response for a category generation task based on previously collected norms with young Americans (Yoon et al., 2004).

Combined, the studies reviewed above indicate that while the semantic representations themselves may be intact in schizophrenia and in high schizotypal individuals with attenuated psychotic symptoms, their connections to other concepts may be altered or the use of the connectivity may be functionally different. These behavioral findings are consistent with recent electrophysiological work showing disorganization in functional connections between related concepts in semantic memory (Kiang et al., 2012).

Another possible cause for the deficit observed in verbal fluency in schizophrenia may be that the mental lexicon of individuals with schizophrenia is smaller in size compared to

healthy controls. While models of the mental lexicon differ in details, they typically include stores of words organized in terms of word form (orthographic and phonological) and meaning (semantic network). The studies discussed above have attempted to see whether the semantic network in the lexicon is disorganized or impaired. However, it is also possible that the entire lexicon (including orthographic and phonological word forms) is smaller in individuals with schizophrenia. This hypothesis was addressed by Allen et al., (1993) who had individuals with schizophrenia produce words in a verbal fluency task at five different points in time. While they observed the standard finding that individuals with schizophrenia have a lower total output, the combined number of unique words produced over the five sessions did not differ significantly from a healthy control group's responses. They thus concluded that the size of the lexicon in individuals with schizophrenia is equivalent to healthy controls. This conclusion was also reached by Elvevåg et al. (2001) who reported that the percentage of new responses provided by individuals with schizophrenia at a second and third testing was statistically equivalent to controls. However, using the method of Allen et al. (1993) describe above, Chen et al. (2000) did estimate that individuals with schizophrenia have a smaller lexicon size compared to healthy controls. A reduced storage of words was also implicated in the picture naming study conducted by Leeson et al. (2005) who had 56 individuals with schizophrenia and 24 healthy controls attempt to name 120 pictures on two separate occasions. Individuals with schizophrenia had fewer correct responses overall and statistical models of the pattern of responses suggested both storage and retrieval deficits in schizophrenia.

It should be obvious from this selective review of the verbal fluency deficit in schizophrenia that the cause of this deficit is still unclear. One issue which has not been systematically addressed thus far is whether the words produced by individuals with schizophrenia differ with respect to their lexical and semantic characteristics when compared to a healthy control group's responses. An investigation of this aspect of fluency output would be informative regarding the issues of semantic network organization, overall lexicon size, as well as issues related to *how* the lexicon is accessed.

Lexical characteristics of words have been found to influence word processing in healthy adults. One of the most robust findings in the word recognition literature is that words which are frequently encountered are recognized faster than words which occur with a low frequency. This word frequency effect is found in a variety of tasks including word naming, lexical decision, and silently reading for comprehension (see Schilling et al. (1998) for a comparison of word frequency effects across these three tasks). Paulsen et al. (1996) reported that both individuals with schizophrenia and healthy controls generated more high frequency animal names in their fluency task. However, they do not report whether there were any differences in the frequency of responses between groups. Baskak et al. (2008) examined "peculiar" word use in schizophrenia. They observed that individuals with schizophrenia produced words on a letter fluency task which were produced less frequently by a group of 55 healthy individuals whose responses were combined to make a "pool" of usual words. The method developed by Baskak et al. (2008) to evaluate the number of peculiar words was fundamentally different from the standard conception of word frequency in the psycholinguistic literature, which is based on how often words are encountered in text or in speech. Even so, the fact that individuals with schizophrenia produced more peculiar words than healthy controls may indicate that the average word frequency of responses may be lower in this population.

In addition to word frequency, words which are acquired earlier in life are processed faster into adulthood compared to words which are acquired later. This age-of-acquisition (AoA) effect is also found in a variety of experimental tasks and can be dissociated from word frequency effects, although the two are correlated (see Juhasz, 2005 for a review). AoA is

often measured by having individuals rate the age at which they acquired a given concept. Typically a 1 to 7 scale is used (first developed by Gilhooly and Logie, 1980) where 1 is equal to the word was learned prior to age two and 7 is equal to the word was learned at age 13 or later. These subjective measures have been found to be correlated with more objective ratings of AoA, such as the percentage of children in a given age range which can name a picture (Morrison et al., 1997). There is currently debate as to the locus of the AoA effect in the mental lexicon. One influential theory suggests that AoA effects arise due to decreasing plasticity in the mental lexicon as individuals age (Ellis and Lambon Ralph, 2000). According to this network plasticity hypothesis, early acquired words have an advantage because they are better encoded and AoA effects should be observed at all levels of the mental lexicon. An alternative view is that AoA effects are related to the organization of the semantic lexicon. According to the semantic locus hypothesis (as modeled by Steyvers and Tenenbaum, 2005), early acquired words form “semantic hubs” in the mental lexicon. When the mental lexicon is searched, these highly connected words are easier to access compared to the later acquired, less connected words.

AoA effects (with early acquired words being processed faster than late acquired words) have been found in many populations that demonstrate impairments in language including individuals with various types of aphasia (e.g. Hirsh and Ellis, 1994; Nickels and Howard, 1995; Cuetos et al., 2002; Kittredge et al., 2008), and Alzheimer’s disease (e.g. Forbes-McKay et al., 2005; Venneri et al., 2008; Rodríguez-Ferreiro et al., 2009; Cuetos et al., 2010). A variety of tasks have been employed to examine the effects of AoA in language disordered populations, such as picture naming, verbal fluency, lexical decision, naming-to-description, single word reading and spelling to dictation. Most relevant for the current study, both Forbes-McKay et al. (2005) and Venneri et al. (2008) used a verbal fluency task to investigate the effects of AoA in individuals with Alzheimer’s disease (AD). Individuals with AD produced significantly fewer words than age-matched controls. In addition, they examined the lexical characteristics of the words produced in the semantic fluency task, and found that both average AoA and semantic typicality differed significantly between individuals with AD and a healthy control group. Importantly, Venneri et al. (2008) demonstrated that the combined effects of AoA and semantic typicality when individuals with AD completed a semantic fluency task correlated with the density of grey matter in bilateral medial temporal regions, as well as the left inferior and superior temporal gyri. Thus, in light of putative frontal-temporal origins of many of the clinical and cognitive manifestations of schizophrenia (Reichenberg and Harvey, 2007) AoA and semantic typicality effects are particularly likely to be evident in this population. Kambanaros et al. (2010) recently reported that AoA significantly predicted naming accuracy for actions in individuals with schizophrenia, although it did not significantly predict object naming in the study.

Semantic typicality refers to the degree to which a category exemplar (e.g. apple) reflects a “good” instance of a particular semantic category (e.g. fruit). Seminal work by Rosch (1975) had undergraduates rate the degree of semantic typicality for a number of categories (e.g. fruit, vehicle, bird). Consistency in ratings was measured to be very high (split-half reliabilities being .97 or higher), suggesting that the rating system is valid. In addition, ratings of semantic typicality have been found to correlate significantly with production frequency in category generation tasks but not with the frequency of the exemplar’s name (Mervis et al., 1976). As mentioned above, semantic typicality influences a number of word processing tasks in healthy adults (e.g. Holmes and Ellis, 2006)

The purpose of the current study was to examine the lexical characteristics of words produced by individuals with schizophrenia in a verbal fluency task, following the methodology employed by Forbes-McKay et al. (2005). Performance of individuals with

schizophrenia on both a letter fluency and semantic fluency task was investigated. Word frequency, rated AoA, and word length were assessed for the letter fluency task. These three variables, as well as rated semantic typicality, were assessed for the semantic fluency task. Since semantic typicality refers to the typicality of an exemplar within a semantic category, it is not relevant for letter fluency. The lexical characteristics were then compared to words produced by a healthy control group.

Based on the results of studies reported above, it is possible to generate a number of hypotheses. We hypothesized that overall word output would be less in the schizophrenia group, consistent with multitude of past studies. Based on the results of Baskak et al (2008) in schizophrenia, who found more “peculiar” words, and Kiang and Kutas (2006), who found lower typicality on one category fluency task in schizotypy, we hypothesized that the average word frequency of words produced and average semantic typicality would be lower in schizophrenia consistent with a model in which there are abnormalities in the way in which semantic stores in schizophrenia and related disorders are activated. However, the results of Forbes-McKay et al. (2005) and Venneri et al. (2008) suggest that both the AoA and semantic typicality for words produced would be earlier/higher in the semantic fluency tasks in patients with schizophrenia as compared to controls. Such a finding would support the contention that patients with schizophrenia are more influenced by words with stronger connectivity in their semantic store.

In verbal fluency, individuals are given one minute to provide as many items as possible for a given category. As the trial duration increases, the task most likely becomes more difficult, as easier to access words are provided first. We therefore examined the effects of each of the lexical variables in the second half of the test relative to the first half in order to test whether differences between our groups would strengthen or emerge as the task difficulty increased. In a secondary hypothesis, within the schizophrenia group, we investigated whether symptoms of disorganization would be linked to poorer fluency output, lower word frequency and lower AoA.

2. Method

2.1 Participants

One-hundred and thirty-nine stabilized outpatients meeting DSM-IV criteria for schizophrenia or schizoaffective disorder participated and were recruited from the Institute for Living in Hartford, CT (n=123; 88%), Intercommunity Mental Health Center in East Hartford, CT (n=8; 6%) and Midstate Medical Center in Meriden, CT (n=8; 6%). Diagnosis was confirmed by the patient form of the Structured Clinical Interview for DSM-IV (SCID; First et al, 1995). Exclusion criteria for all potential participants were: (a) known neurological disease, (b) developmental disability, (c) current substance abuse, (d) mental retardation as evidenced by a history of services, or (e) lack of fluency in English. Data for this study were collected at entry to an ongoing study of the effects of cognitive remediation on cognitive and social dysfunction in people with schizophrenia (Kurtz et al., 2007). Twenty adults from the Middletown community were recruited to act as a control group. Prior to participation, they were screened for history of psychiatric illness or treatment, or neurological trauma or illness. All clients and controls provided written informed consent and all procedures met institutional ethical review. Demographic information for the individuals is displayed in Table 1.

2.2 Materials

Verbal fluency output from the 139 individuals with schizophrenia and the 20 control individuals were combined into a master list. For responses to the letter fluency task, words were assessed for their frequency of occurrence, length, and age-of-acquisition (AoA). In

addition, words produced on the semantic fluency task were assessed for their typicality of the category ‘animal’. Word frequency was assessed via the Educator’s Word Frequency Guide (WFG; Zeno et al, 1995) and reflects how often a given word occurs out of 1 million words in the corpus. AoA and semantic typicality ratings were collected from Wesleyan University undergraduates.

2.3 Procedure

2.3.1 Schizophrenia Group—This study presents an archival examination of verbal fluency performance in a group of individuals with schizophrenia. Verbal fluency, along with Vocabulary subtest scores from the WAIS-III (Wechsler, 1997) and clinical and demographic information was collected from individuals with schizophrenia as part of a larger neuropsychological test battery at entry to outpatient rehabilitation over a 10-year period (2001–2010) For the letter fluency task (COWA), individuals were asked to provide as many words starting with F, A, or S each within one minute. For the semantic fluency task, individuals were asked to provide as many animals as they could within one minute (Spreen and Benton, 1977)

2.3.2 Control Group—Individuals were recruited from the area surrounding Wesleyan University for participation in an unrelated reading study. As part of the protocol for that study, they provided demographic information (see Table 1), completed the Vocabulary subtests from the WAIS-III and the same verbal fluency protocol as individuals with schizophrenia. Their responses were recorded by an experimenter and the responses which fit into the categories were subsequently typed into the master list. In addition, some items (less than 2%) which the experimenter was unable to record due to transcription error, but which were nonetheless deemed an appropriate member of the category by the assessor at the time of transcription, only counted towards the number of items.

2.3.3 AoA Rating—All unique words produced by the two groups were combined into a list for AoA ratings. Pluralizations and derivations as well as shortened versions of words were rated separately. The master list was split into 13 individual questionnaires.¹ Each was rated by eight or more Wesleyan University students in exchange for either research participation credit for a course or a small payment. Participants were asked to rate each word in terms of when it was acquired using the Gilhooly and Logie (1980) AoA scale. This scale is from 1 to 7 with 1 representing a word learned between 0–2 years of age and 7 representing a word learned at age 13 or later. The following method was used to assess the reliability of the ratings within this sample. First, the ratings for each questionnaire were split into two equal (or nearly equal in the case of odd numbers) sized groups. Second, correlations between the two group averages were calculated separately for each questionnaire. The average correlation was $r=0.929$ (range 0.890–0.970).

2.3.4 Semantic Typicality Rating—All animals produced by the two groups were combined into a list for ratings (excluding pluralizations and shortened forms). The master list was split into three lists for ratings. Participants were asked to rate how typical each animal was of the overall “animal” category on a 1 to 7 scale where 1 was equal to not being a member of the category at all, and 7 was equal to the word being a good example of the category. Each of the three questionnaires was completed by 11 or 12 Wesleyan University students in exchange for either research participation credit for a course or a small payment.

¹These questionnaires contained filler items not included on the lists of the schizophrenia and control groups as well. Five responses from the schizophrenia group did not receive AoA ratings and therefore do not contribute to the AoA analyses. This represents less than approximately 0.2% of the responses for this group.

² Reliability was assessed in the same manner as for the AoA ratings. Correlations between rater halves were $r=0.834$, $r=0.893$, and $r=0.877$ for the three questionnaires respectively.

2.3.5. Symptom Measures—The Positive and Negative Syndrome Scale (PANSS; Kay et al., 1989) was used to assess symptoms. This measure is a semi-structured interview that generates ratings of signs and symptoms on 30 7-point Likert scale items. Symptom raters for the study maintained interrater reliability through periodic rater training sessions, and all raters were trained to a minimum criterion reliability of .7 intraclass correlation coefficient (ICC), across four jointly viewed, but independently rated interviews.

2.4 Data Analysis

Total number of words produced and the lexical characteristics for those words were averaged for each participant. Differences in group performance were assessed via independent samples t-tests. In addition, a median split was conducted on individual responses in the semantic fluency task. A 2 (group: schizophrenia vs. control) by 2 (output half: first or second) Analysis of Variance was computed on the lexical characteristics. Pearson bivariate correlations were computed within the schizophrenia group to assess relationships between ratings of conceptual disorganization from the PANSS (P2) and characteristics of verbal output. All statistical tests were two-tailed and alpha was set at .05.

3. Results

3.1 Letter Fluency

Responses were combined for the letters F, A, and S. Means are displayed in Table 2. Individuals with schizophrenia produced significantly fewer responses compared to the control group ($t(157) = 3.20$, $p < .05$). The words produced did not differ significantly on frequency, AoA, or length (all $ps > .05$).

3.2 Semantic Fluency

Means are displayed in Table 3. Individuals with schizophrenia also produced fewer words to the “animal” prompt compared to controls ($t(155) = 3.46$, $p < .05$). While word frequency and average word length did not differ between participant group ($ps > .05$), individuals with schizophrenia produced words with a lower average AoA ($t(155) = 2.49$, $p < .05$) and greater semantic typicality ($t(155) = 2.20$, $p < .05$) compared to individuals in the control group.

3.3 Initial Semantic Fluency Responses

In order to assess whether the lexical characteristics of words produced by individuals with schizophrenia differed initially or as a function of increasing difficulty accessing items from the mental lexicon we conducted a post-hoc median split of each individual’s semantic fluency output. Means are displayed in Table 4. If an odd number of responses were provided by an individual, the larger group of items was counted as part of the first half of items. For all four lexical variables, there was a main effect of output half such that initial responses were significantly more frequent ($F(1,155) = 17.58$, $MSe = 573$, $p < .05$), shorter in length ($F(1,155) = 13.61$, $MSe = 0.81$, $p < .05$), earlier acquired ($F(1,155) = 29.44$, $MSe = 0.13$, $p < .05$) and more typical of the category “animal” ($F(1,155) = 15.23$, $MSe = 0.15$, $p < .05$). There were main effects of participant group for AoA ($F(1,155) = 7.05$, $MSe = 0.19$, $p < .05$) and typicality ($F(1,155) = 4.55$, $MSe = 0.22$, $p < .05$). While the means indicated a trend for larger effects of AoA as a function of participant group in the second half of the

²The questionnaires were collected over a number of semesters at Wesleyan University. Individuals were not excluded from participation if they had previously completed a different questionnaire.

output, the interaction was not significant ($p>.05$). No other main effects or interactions were significant ($ps>.05$)

3.3 Relationship Between Symptoms of Disorganization and Verbal Output

There were no significant relationships between ratings of conceptual disorganization from the PANSS and any of the studied characteristics of verbal output from either the letter or semantic fluency task (all $ps>.05$).

4. Discussion

Consistent with our hypotheses, overall, individuals with schizophrenia produced fewer words than healthy controls, replicating the pervasive verbal fluency and executive function deficit reported in the literature (see Bokak and Goldberg, 2003). The results of the current investigation are informative regarding how individuals with schizophrenia access their mental lexicons during the verbal fluency task. In both the letter fluency and semantic fluency task, words produced by individuals with schizophrenia did not differ in average word frequency compared to words produced by healthy controls. This is inconsistent with our hypotheses and the predictions derived from Baskak et al.'s (2008) experiment which found that individuals with schizophrenia produced more "peculiar" words in a verbal fluency task. However, as discussed in the Introduction, their definition of familiar/peculiar is not equivalent to the concept of word frequency in the psycholinguistic literature. The current study demonstrates no differences in how words are accessed and produced on the basis of their frequency of occurrence in schizophrenia. Similar to the word frequency findings, individuals with schizophrenia also did not differ significantly from healthy controls in the average length of words produced in either the letter or semantic fluency tasks.

While, inconsistent with our hypotheses, AoA of words produced did not differ significantly between groups for the letter fluency task, consistent with the hypotheses individuals with schizophrenia did produce significantly earlier acquired words in the semantic fluency task compared to healthy controls. The AoA results from letter and semantic fluency were directly compared to further examine the differential impact of AoA on semantic fluency in this population. Since many factors varied between the tasks, standardized z -scores were created for each individual with schizophrenia compared to the mean and the standard deviation of the health control group. A matched-pairs t -test was then conducted on the standard scores as a function of fluency task. The reduction in AoA ratings compared to the healthy control participants was significantly greater in the semantic fluency task ($z = -0.59$) relative to the letter fluency task ($z = -0.24$; $t(138) = 3.00$, $p<.05$). The fact that the AoA discrepancy is significantly greater in semantic fluency is of relevance to theories of how AoA affects organization of the mental lexicon (see Juhasz, 2005 for a discussion of AoA theories). According to the semantic locus hypothesis (as modeled by Steyvers and Tenenbaum, 2005), it may be the case that individuals with schizophrenia are more influenced by connectivity in their semantic networks compared to healthy adults. This was the conclusion reached by Nestor et al. (1998). They found that words with less connectivity to other words in the semantic network resulted in 4% worse recall in a cued recall task for healthy adults, but 13% worse recall for individuals with schizophrenia. One issue, however, is that Steyvers and Tenenbaum also suggest that highly frequent words are more connected to other concepts as well. The current study is thus informative for theories of AoA effects, as it suggests a dissociation between word frequency and AoA in how the lexicon is accessed in schizophrenia.

Semantic typicality has been found to influence categorization responses in individuals with schizophrenia (Elvevåg et al., 2002b). In the current study, individuals with schizophrenia

produced words in the semantic fluency task which were on average rated as being more typical of the category “animal” compared to healthy controls, suggesting that the typical category exemplars are easier to access for these individuals. This is again inconsistent with the results of Baskak et al. (2008), who found more “peculiar” words produced by individuals with schizophrenia. In addition, the results counter those of Kiang and Kutas (2006). There are several differences between the current study and that reported by Kiang and Kutas (2006) which may explain the discrepant results. First, Kiang and Kutas (2006) examined healthy undergraduates with high schizotypal traits, as opposed to individuals with schizophrenia. Second, their finding of lower semantic typicality was only significant for one out of 5 potential categories, and they did not examine the same semantic category as the current study. Third, they did not observe an overall deficit in semantic fluency in their population, this is often reported for verbal fluency in schizophrenia.

The present results do share similarities with the findings of Forbes-McKay et al., (2005) and Venneri et al., (2008) who examined the lexical characteristics of semantic verbal fluency output in individuals with AD. In both studies, the semantic fluency output of individuals with AD was, on average, earlier acquired and more typical of the semantic category. In these studies AoA and typicality effects were linked to brain damage in left temporal lobe structures known to be affected in the earliest stages of AD. The current findings also suggest that AoA and semantic typicality effects evident in the semantic fluency task selected for this study may be providing a similar index of left temporal lobe dysfunction in patients with schizophrenia. More specifically, recent brain imaging voxel-based morphometry suggests that impaired semantic fluency performance is linked to left frontal/temporal atrophy (Libon et al., 2009) and gray and white matter deficits in schizophrenia have been most reliably reported in the left superior temporal gyrus and the left medial temporal lobe (Honea et al., 2005).

The median split analyses of the semantic fluency test are very informative regarding the process of lexicon activation over the course of the test. At the start, all individuals produce words which are easier to access; the initial produced words are more frequent, shorter, early acquired, and more typical of their semantic category. As time goes on, and easy exemplars are exhausted, individuals must begin to access more difficult words which are lower in frequency, longer, later acquired and less typical. This response pattern during the course of a verbal fluency trial is consistent for individuals with schizophrenia and healthy adults.

While the present results are informative regarding how the mental lexicon is accessed in schizophrenia, there are limitations which need to be considered. The control group was not matched to the schizophrenia group in terms of years of education. However this type of matching can produce the “matching fallacy” in which underperforming healthy controls are matched to educational levels of patients with schizophrenia that have been altered by the disease process. In order to further examine the potential education confound, we entered education level as a covariate into ANCOVAs for letter fluency (examining frequency, length and AoA as dependent measures) and semantic fluency (examining frequency, length, AoA, and semantic typicality as dependent measures). Significant effects of AoA and semantic typicality still emerged for semantic fluency once education was statistically controlled (both $p < .05$). Thus, we do not feel that this difference in education accounts for our reported effects.

Second, while ratings of AoA have been found to be highly correlated with more objective measures of AoA (e.g. Morrison et al., 1997), the ratings for AoA and semantic typicality were collected from an undergraduate college population. Since the verbal fluency participants were on average older than the raters, the AoA ratings may not be as accurate as if ratings were collected from age-matched raters. However, since the individuals with

schizophrenia were matched on average to the healthy controls in terms of age, this limitation should not bias the differences between controls and patients reported in this study. Recent research has specifically examined the potential role of demographic factors in semantic typicality production responses (Yoon et al., 2004) and AoA ratings (Kuperman et al., 2012). Yoon et al. (2004) calculated affinity scores for production responses in a category exemplar generation task as a function of cultural background (Chinese vs American) and age group (17–23 vs 60–75). They concluded that production responses as a function of category vary across cultures but are reasonably consistent across ages *within* a culture. Kuperman et al. (2012) report AoA ratings collected on over 30,000 English words using a web-based questionnaire which allowed them to examine responses from a diverse sample. Education level varied from “no high school” (6% of the sample) to a Master’s or higher degree (10% of the sample). Age varied from 15 to 82 years. Average AoA ratings did not vary as a function of education background, and the correlation between age and AoA was quite small ($r=0.07$).

Nonetheless, the generalizability of AoA ratings from Wesleyan undergraduates to verbal fluency output of considerably older and likely more educationally and economically disadvantaged patient and control samples remains a limitation of the reported findings. Future studies should match age and SES of raters of AoA with study participants. Vocabulary scaled scores were used as a measure of premorbid intellectual function. However we note that studies that have directly compared some commonly used single-word reading measures for estimating premorbid IQ (i.e., NART) and Vocabulary subtest scores from the WAIS have found that oral Vocabulary provides more accurate estimates for people with schizophrenia at below average levels of IQ (see Russell et al., 2000). To further determine the source of the AoA effect in verbal fluency performance, future research may benefit from collecting fluency output on additional semantic categories (e.g. tools, food) in a more constrained experimental setting.

In conclusion, the present results add to the large literature demonstrating a verbal fluency deficit in individuals with schizophrenia. Unlike past studies, the current experiment systematically examined the words produced by individuals with schizophrenia in terms of their lexical characteristics and compared these to a healthy control group. Differences emerged in the semantic fluency task, where words produced by individuals with schizophrenia were earlier acquired and more typical of the semantic category. These results suggest that individuals with schizophrenia demonstrate differences in how semantic information in their lexicon is accessed during the fluency task.

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Table 1

Demographic information.

	Schizophrenia Group	Control Group
Age	33.17 (11.26)	36.80 (10.28)
n	135	20
Education (in years)	13.08 (2.12)	14.11 (1.91) *
n	133	19
Vocabulary scaled score from the WAIS-III	9.89 (3.95)	10.80 (3.35)
n	132	20
Females/Males	35/100	8/12
n	135	20
Illness Duration (in years)	10.42 (10.02)	
n	124	
Number of Hospitalization	4.75 (4.06)	
n	118	
PANSS Positive	18.17 (5.26)	
n	113	
PANSS Negative	19.76 (4.95)	
n	113	

Note. Numbers in parentheses are standard deviations. Positive and Negative symptoms assessed via PANSS (Kay et al., 1989).

* indicates significance at $p < .05$

Table 2

Mean number of responses and lexical characteristics for the combined letter fluency (F,A,S) task.

	Schizophrenia Group (n=139)	Control Group (n=20)
Number of Responses	29.79 (11.10)	38.35 (11.68) *
Average Word Frequency	479.95 (582.35)	383.45 (444.61)
Average AoA	3.36 (0.53)	3.48 (0.49)
Average Word Length	5.53 (0.78)	5.50 (0.61)

Note. Numbers in parentheses are standard deviations.

* indicates significance at $p < .05$

Table 3

Mean number of responses and lexical characteristics for the semantic fluency (Animal) task.

	Schizophrenia Group (n=137)	Control Group (n=20)
Number of Responses	15.45 (4.92)	19.70 (6.42) *
Average Word Frequency	37.33 (16.48)	32.07 (11.89)
Average AoA	2.66 (0.30)	2.84 (0.38) *
Average Typicality	5.96 (0.33)	5.79 (0.35) *
Average Word Length	5.53 (0.68)	5.71 (0.64)

Note. Numbers in parentheses are standard deviations.

* indicates significance at $p < .05$

Table 4

Mean lexical characteristics in the semantic fluency (Animal) task for the first and second half of participants' responses

	Schizophrenia Group (n=137)		Control Group (n=20)	
	First Half	Second Half	First Half	Second Half
Average Word Frequency	44.23 (24.31)	29.27 (21.94)	40.92 (23.07)	21.92 (21.42)
Average AoA	2.54 (0.39)	2.77 (0.40)	2.64 (0.41)	3.07 (0.53)
Average Typicality	6.10 (0.40)	5.82 (0.45)	5.90 (0.50)	5.67 (0.42)
Average Word Length	5.26 (0.87)	5.83 (0.99)	5.44 (0.78)	6.00 (1.04)

Note. Numbers in parentheses are standard deviations.