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3 Running head: CATEGORY FLUENCY IN SCHIZOTYPY  
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8 **Category fluency in psychometric schizotypy: How altering emotional valence and**  
9 **cognitive load affects performance**  
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## Abstract

*Introduction.* In clinical high-risk populations, category fluency deficits are associated with conversion to psychosis. However, their utility as clinical risk markers is unclear in psychometric schizotypy, a group experiencing schizophrenia-like traits that is at putative high risk for psychosis.

*Methods.* We examined whether introducing affective or cognitive load, two important stress vulnerability markers, altered category fluency performance in schizotypy ( $n = 42$ ) and non-schizotypy ( $n = 38$ ) groups. To investigate this question, we developed an experimental paradigm where all participants were administered category fluency tests across baseline, pleasant valence, unpleasant valence, and cognitive load conditions.

*Results.* Compared to the non-schizotypy group, those with schizotypy performed significantly worse in pleasant and unpleasant valence conditions, but not cognitive load or baseline fluency tests.

*Conclusions.* This study demonstrated the role of affect—but not cognitive load—on category fluency in psychometric schizotypy, as group differences only emerged once affective load was introduced. One explanation for this finding is that semantic memory may be unimpaired under normal conditions in psychometric schizotypy, but may be compromised once affective load is presented. Future studies should examine whether fluency deficits—particularly when affect is induced—predict future conversion to psychosis in psychometric schizotypy cohorts.

**Keywords:** emotion; affect; cognition; category fluency; schizotypy

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3 In clinical high-risk populations, category fluency deficits—among the largest and most stable  
4 neurocognitive impairments in schizophrenia (Bokat & Goldberg, 2004; Szoke et al., 2008) —  
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6 have shown promise as a clinical risk marker for psychosis (Becker et al., 2010; Eastvold,  
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8 Heaton, & Cadenhead, 2007; Hawkins et al., 2004). The evidence is less clear, however, for  
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10 using category fluency deficits as a clinical risk marker in psychometric schizotypy—a group at  
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12 putative high risk for psychotic and other psychiatric disorders (Lenzenweger, 2006; Meehl,  
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14 1990; see Chun, Minor, & Cohen, 2013). One strategy for uncovering category fluency deficits  
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16 in psychometric schizotypy is to administer tests with experimental manipulations; ideally,  
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18 manipulations would be designed by modifying stimuli to highlight other potential risk markers.  
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20 Two proposed pathways that may increase risk for conversion to psychosis include: 1) an  
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22 affective pathway, associated with higher levels of positive-like traits and; 2) a cognitive  
23  
24 pathway, associated with greater negative-like traits (Myin-Germeys, Krabbendam, Jolles,  
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26 Delespaul, & van Os, 2002; Morrens et al., 2007; see Myin-Germeys & van Os, 2007). Thus,  
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28 designing a category fluency paradigm that alters affective and cognitive stimuli holds the  
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30 possibility of elucidating which people with psychometric schizotypy may be at the highest risk  
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32 for later conversion.  
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41 For affective manipulations, category fluency tests designed to alter emotional valence  
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43 have already been developed (Rossell, 2006). These tests require participants to name words  
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45 associated with happiness (e.g., pleasant valence) and fear (e.g., unpleasant valence). In an initial  
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47 study, Rossell (2006) observed that both schizophrenia and control groups scored significantly  
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49 lower on emotionally-valenced category fluency tests compared to standard tests (e.g., animals,  
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51 food). To our knowledge, these tests have not been utilized in a psychometric schizotypy  
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3 population. In this study, our aim was to examine whether the schizotypy group demonstrated a  
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5 sharper decline in fluency from baseline to affective tests than the non-schizotypy group.  
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8 Unlike affective tests, category fluency tests have not been previously designed with  
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10 cognitive manipulations. In this study, we created cognitive manipulations by adhering to  
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12 cognitive load theory. Cognitive load theory posits that increasing load reduces one's available  
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14 cognitive resources due to working memory's limited capacity—making it more difficult to  
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16 adequately attend to two tasks at the same time (Sweller, 1983). Although the cognitive load  
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18 effect diminishes performance in healthy adults (Ruthruff, Pashler, & Klaassen, 2001; van  
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20 Merriënboer & Sweller, 2010), it appears to be more pronounced in schizophrenia-spectrum  
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22 populations: Schizophrenia and schizotypal personality disorder cohorts have demonstrated  
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24 increased difficulty, compared to controls, switching between tasks (Nuechterlein, Pashler, &  
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26 Subotnik, 2006) and performing a dual digit span–visual perception test (Harvey, Reichenberg,  
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28 Romero, Granholm, & Siever, 2006). In this study, we compared category fluency performance  
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30 in psychometric schizotypy and non-schizotypy groups across baseline and cognitive conditions.  
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36 In the current study, we had two primary aims. First, category fluency performance in  
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38 schizotypy and non-schizotypy groups was examined across baseline, pleasant valence,  
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40 unpleasant valence, and cognitive load conditions. We expected all participants would perform  
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42 significantly worse on affective and cognitive fluency tests compared to baseline tests, but that  
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44 performance in the schizotypy group would decline more sharply. We also hypothesized that the  
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46 schizotypy group would: a) perform significantly worse overall on category fluency tests and b)  
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48 exhibit significantly worse combined performance (i.e., fluency plus accuracy on the cognitive  
49  
50 task) in the cognitive load condition. Second, we expected that, within the schizotypy group,  
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52 positive and disorganized traits would be associated with worse fluency in pleasant and  
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3 unpleasant valence conditions, whereas negative traits would be linked to worse performance in  
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5 baseline and cognitive load conditions.  
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## 10 **Method**

### 11 *Participants*

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13 Participants were recruited from a university in the Southeastern United States via email to  
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15 complete a schizotypy questionnaire in exchange for course credit and entry into a gift card  
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17 drawing ( $n = 1,296$ ). Schizotypy ( $z$ -score  $> 1.65$  above mean on positive, negative, or  
18  
19 disorganized subscales;  $n = 126$ ) and non-schizotypy groups ( $z$ -score  $<$  mean on each subscale;  $n$   
20  
21 = 380) were determined from questionnaire responses using gender and ethnicity derived means.  
22  
23 Those meeting criteria were invited to the laboratory for further testing. Additional inclusion  
24  
25 criteria were: 1) age 18-30 ( $n$  excluded = 1) and 2) complete data for all category fluency tests ( $n$   
26  
27 excluded = 5). The final sample consisted of 42 schizotypy and 38 non-schizotypy subjects (see  
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29 Table 1 for demographic comparisons). All study procedures were approved by an internal  
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31 institutional review board.  
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34 [INSERT TABLE ONE HERE]  
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### 43 *Measures*

#### 44 *Schizotypal Personality Questionnaire-Brief Revised (SPQ-BR)*

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46 The SPQ-BR (Cohen, Matthews, Najolia, & Brown, 2010) consists of 34 Likert-scale items (1 =  
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48 Strongly Disagree, 5 = Strongly Agree) and was used to determine group status. The SPQ-BR  
49  
50 was developed from the Schizotypy Personality Questionnaire (SPQ; Raine, 1991), has a similar  
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52 three factor structure (positive, negative, disorganized), and has demonstrated strong  
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3 psychometric properties (see Cohen et al., 2010). In previous studies, individuals with elevations  
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5 on psychometric questionnaires—like the SPQ-BR—have exhibited increased risk for psychotic  
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7 and other psychiatric disorders (Cohen & Najolia, 2011; Gooding, Tallent, & Matts, 2005;  
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11 Kwapil, Miller, Zinser, Chapman, & Chapman, 1997).

### 12 13 14 15 *Category fluency tests*

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17 Category fluency tests were administered across four conditions (baseline, pleasant valence,  
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19 unpleasant valence, cognitive load). Subject responses were checked for category accuracy by a  
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21 Research Assistant and the first author of this study, with the first author making final  
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23 determinations for discrepancies. Only valid responses were included in fluency scores.  
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25  
26 Following Rossell's (2006) protocol for affective valence tests, participants were given one  
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28 minute to name examples of words associated with happiness (pleasant valence) and fear  
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30 (unpleasant valence). Examiners provided one example during administration instructions  
31  
32 (pleasant valence: 'dancing', unpleasant valence: 'crocodile').  
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37 Baseline and cognitive load conditions consisted of fruit and vegetable category fluency  
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39 tests. In the cognitive load condition, participants completed a category fluency test while  
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41 simultaneously performing a 1-back task. The 1-back task consisted of 30 consecutive shapes;  
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43 participants were instructed to press 'S' if the shape was the same as the previous shape or 'L' if  
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45 the shape was not the same as the previous shape. Accuracy and a composite score (i.e.,  
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47 combining fluency and accuracy) on the 1-back task were recorded in addition to fluency. Fruit  
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49 and vegetable tests were counter-balanced across baseline and cognitive load conditions. To  
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51 control for differences between fruit and vegetable tests, we approximated normative data by  
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53 first administering them with and without cognitive load to 61 undergraduate students—who  
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3 completed tests for course credit. We observed that scores were approximately 25% greater on  
4 fruit (baseline:  $M = 13.55$  [3.05], cognitive:  $M = 10.03$  [3.66]) compared to vegetable tests,  
5  
6 (baseline:  $M = 12.07$  [4.71], cognitive:  $M = 8.00$  [2.39]) in both conditions. In the current study,  
7  
8 1.5 and 2 points were added to fluency scores for all participants completing vegetable tests in  
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10 baseline and cognitive tasks, respectively. Corrected and uncorrected mean scores (i.e., scores  
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12 without points added) are listed in Table 2.  
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### 20 *Statistical Analyses*

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22 A two-way, mixed repeated measures analysis of variance (ANOVA) was conducted to examine  
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24 hypotheses, with group (schizotypy, non-schizotypy) and condition (baseline, pleasant valence,  
25  
26 unpleasant valence, cognitive load) as independent variables and fluency scores as the dependent  
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28 variable. Individual condition main effects were examined by comparing scores on experimental  
29  
30 fluency tests to baseline fluency across the sample using dependent-samples  $t$ -tests. Between  
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32 group differences were followed up using independent-samples  $t$ -tests. In the cognitive  
33  
34 condition, accuracy on the 1-back task and a composite score (providing equal weight to fluency  
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36 and accuracy) were also compared using independent-samples  $t$ -tests. Finally, bivariate  
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38 correlations were computed within the schizotypy group to investigate if schizotypy traits were  
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40 associated with fluency. Alpha levels were set at .05 for all analyses. Outliers were reduced to  
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42 within 3 SDs of the mean.  
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## 50 **Results**

### 51 *Performance across category fluency conditions*

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3 Means and standard deviations for all category fluency tests are listed in Table 2. The Shapiro-  
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5 Wilk test indicated fluency data was normally distributed. Mauchly's test showed that the  
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7 assumption of sphericity had been violated,  $\chi^2(5) = 0.82, p = 0.008$ . Thus, degrees of freedom  
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9 were corrected using the Greenhouse-Geisser estimate ( $\epsilon = 0.88$ ). The results of the repeated-  
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11 measures ANOVA indicated a significant main effect for condition,  $F(2.64, 76) = 28.82, p <$   
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13  $0.01$ . This main effect was significant when unpleasant valence,  $F(1, 78) = 42.17, p < 0.01$ , and  
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15 cognitive load,  $F(1, 78) = 15.98, p < 0.01$ , were compared to the baseline condition. No  
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17 significant effect was found when pleasant valence and baseline fluency were compared,  $F(1,$   
18  
19  $78) = 0.42, p = 0.26$ .

20  
21 A significant overall group X condition interaction was observed,  $F(2.64, 76) = 2.18, p =$   
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23  $0.049$ . Compared to baseline, trend level group X condition interactions were observed for  
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25 pleasant,  $F(1, 78) = 2.18, p = 0.07$ , and unpleasant valence,  $F(1, 78) = 1.99, p = 0.08$ , but not  
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27 cognitive load,  $F(1, 78) = 0.22, p = 0.32$  (see Figure 1). Significant main effects were found  
28  
29 between groups in pleasant,  $t(78) = 1.77, p = 0.04$ , and unpleasant valence conditions,  $t(78) =$   
30  
31  $1.94, p = 0.03$ , with the schizotypy group exhibiting worse performance in both. No significant  
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33 group differences were observed in baseline,  $t(78) = 0.19, p = 0.43$ , or cognitive load conditions,  
34  
35  $t(78) = -0.28, p = 0.39$ . Accuracy,  $t(78) = 0.29, p = 0.39$ , and composite cognitive scores,  $t(78) =$   
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37  $-0.09, p = 0.47$ , on the cognitive load test did not vary by group.

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39 [INSERT TABLE ONE HERE]

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41 [INSERT FIGURE ONE HERE]

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53 ***Correlations between schizotypy traits and category fluency test performance***  
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3 Within the schizotypy group, there was variability for positive ( $M = 1.27 [0.89]$ , range:  $-0.83 -$   
4  $3.21$ ), negative ( $M = 1.28 [1.10]$ , range:  $-1.34 - 3.23$ ), and disorganized traits ( $M = 1.41 [0.58]$ ,  
5 range:  $-0.12 - 2.66$ ). Correlations revealed a significant inverse association between positive  
6 schizotypy and fluency in the unpleasant valence condition,  $r(42) = -0.34, p = 0.03$ . Significant  
7 relationships were not observed between positive schizotypy and pleasant valence,  $r(42) = -0.23,$   
8  $p = 0.14$ , cognitive load,  $r(42) = -0.18, p = 0.27$ , or baseline fluency,  $r(42) = -0.27, p = 0.08$ .  
9 Disorganization traits were significantly associated with baseline fluency,  $r(42) = 0.35, p = 0.02,$   
10 and exhibited trend-level associations with unpleasant valence,  $r(42) = -0.27, p = 0.09,$  and  
11 cognitive load fluency,  $r(42) = 0.30, p = 0.05,$  but not fluency in the pleasant valence condition,  
12  $r(42) = 0.09, p = 0.57$ . Fluency and negative traits were not associated in baseline,  $r(42) = -0.05,$   
13  $p = 0.77,$  pleasant valence,  $r(42) = -0.17, p = 0.27,$  unpleasant valence,  $r(42) = 0.00, p = 0.98,$  or  
14 cognitive load conditions,  $r(42) = -0.25, p = 0.11$ .

## 34 Discussion

35  
36 The primary aim of this study was to examine how affective valence and cognitive load  
37 influenced category fluency performance in psychometric schizotypy. Compared to a non-  
38 schizotypy group, significant group differences only emerged once pleasant and unpleasant  
39 valence was introduced. Precedence for this finding has been provided by formal thought  
40 disorder studies, where significantly larger increases in disorganization have been observed in  
41 psychometric schizotypy groups from baseline to unpleasant valence conditions (Kerns &  
42 Becker, 2008; Minor, Cohen, Weber, & Brown 2011; but also see Minor & Cohen, 2010).  
43 Category fluency tests tap into a range of neurocognitive areas and are commonly used to assess  
44 semantic memory (Neill, Gurvich, & Rossell, 2014)—an area also heavily involved in formal  
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3 thought disorder (Kerns & Berenbaum, 2002). Thus, retrieving words from semantic memory  
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5 may be unimpaired under normal circumstances in psychometric schizotypy, but may become  
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7 compromised once affective load is presented.  
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11 One notable difference from formal thought disorder research is that disorganization is  
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13 typically only exacerbated in unpleasant valence conditions; in this study, however, fluency also  
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15 decreased in psychometric schizotypy in the pleasant valence condition. One explanation could  
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17 be that those with psychometric schizotypy—similar to people with schizophrenia (Cohen &  
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19 Minor, 2010)—experience greater negative affect than non-schizotypy groups when pleasant  
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21 stimuli are introduced. Negative affect constricts attention, which could have a deleterious effect  
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23 on fluency performance in the pleasant valence condition (Lazar, Kaplan, Sternberg, & Lubow,  
24  
25 2012). Although we did not conduct pre- or post-test assessments, examining the role of positive  
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27 and negative affect following the administration of affective valence fluency tests is an important  
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29 avenue for future research.  
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35 Minor support was observed for hypotheses concerning cognitive load and schizotypy  
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37 traits. Regarding cognitive load, both schizotypy and non-schizotypy groups performed  
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39 significantly worse in this condition compared to baseline. Counter to expectations, however, no  
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41 group differences were found. This may be due to the 1-back task not providing enough of a  
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43 distractor for subjects. Future studies should increase task difficulty when examining the  
44  
45 cognitive load effect. Findings regarding schizotypy traits partially supported previous research  
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47 in schizophrenia and schizotypy suggesting that those with predominantly positive symptoms/  
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49 traits tend to be more reactive when load is introduced compared to individuals with  
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51 predominantly negative symptoms/ traits (Docherty & Hebert, 1997; Minor & Cohen, 2010;  
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3 Myin-Germeys et al., 2002; Schwartz & Myers, 1977). Findings must be replicated, however, as  
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5 positive traits were only associated with category fluency performance in one of four conditions.  
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8 The undergraduate sample serves as both a strength and potential limitation.

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10 Undergraduate samples are commonly recruited in psychometric schizotypy studies (Chapman,  
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12 Chapman, Kwapil, Eckblad, & Zinser, 1994; Gooding et al., 2005; Kerns, 2007; Kwapil et al.,  
13  
14 1997; Minor & Cohen, 2012; Minor et al., 2014), and include people in the peak age of onset  
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16 while allowing researchers to examine constructs without confounding factors typically found in  
17  
18 patient populations (e.g., antipsychotic medications; Chapman et al., 1994). However,  
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20 participation in college courses suggests a higher level of functioning compared to other  
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22 individuals on the schizophrenia-spectrum. Future research should examine category fluency  
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24 performance in people recruited from community samples and results should be compared to  
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26 those in undergraduate cohorts. A second limitation of this study is that positive and negative  
27  
28 affect was not assessed before or after pleasant and unpleasant category fluency tests. Pre- and  
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30 post-test assessments would aid in demonstrating the role of affective load on performance  
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32 across each test and should be administered in future studies.  
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39 In sum, category fluency performance in psychometric schizotypy appears to be  
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41 influenced by affective load. Whereas people with schizophrenia exhibit fluency deficits in  
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43 baseline and affective conditions (Rossell, 2006), significant differences in psychometric  
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45 schizotypy only emerged once pleasant and unpleasant stimuli were introduced. In contrast to  
46  
47 affective load, cognitive load had little impact on fluency when schizotypy and non-schizotypy  
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49 performance was compared. Within schizotypy, positive and disorganized traits were associated  
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51 with decreased fluency; however, findings were inconsistent across conditions. Based on our  
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53 findings, future studies should examine whether category fluency deficits predict future  
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3 conversion to psychosis in psychometric schizotypy—particularly in those who are more reactive  
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5 to affective stimuli. If so, these deficits may have utility as risk markers in both clinical high-risk  
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8 (see Becker et al., 2010) and psychometric schizotypy populations.  
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For Peer Review Only

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Table 1. Demographics and verbal intelligence of schizotypy and non-schizotypy groups.

<i>Variable</i>	Schizotypy ( <i>n</i> = 42)		Non-schizotypy ( <i>n</i> = 38)		<i>p</i>
	Mean	SD	Mean	SD	
Age	19.48	1.61	18.94	1.09	0.09
Gender (% female)	79%		71%		0.44
Ethnicity (% caucasian)	89%		83%		0.60
Verbal intelligence	105.15	10.66	104.19	11.75	0.71

Table 2. Comparison of schizotypy and non-schizotypy groups on category fluency tests.

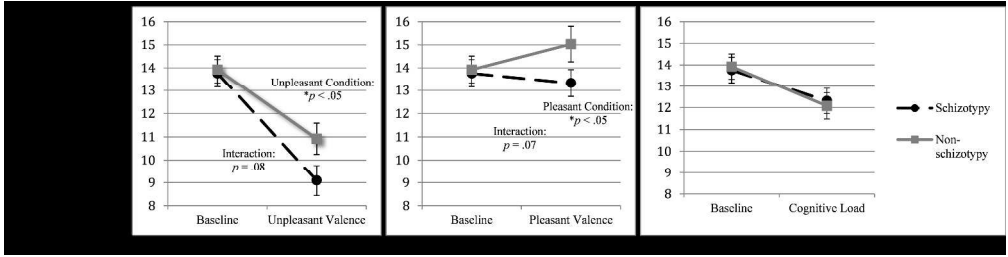
Category Fluency Test	Schizotypy ( $n = 42$ )		Non-schizotypy ( $n = 38$ )	
	Mean	SD	Mean	SD
<i>Baseline</i>				
Uncorrected <sup>a</sup>	13.05	3.88	13.05	3.85
Corrected	13.76	3.86	13.92	3.66
<i>Cognitive Load</i>				
Uncorrected <sup>b</sup>	11.26	4.05	11.24	3.67
Corrected	12.31	3.76	12.08	3.72
<i>Affective</i>				
Pleasant	13.33*	3.84	15.00	4.65
Unpleasant	9.10*	4.26	10.92	4.13

Note: \* $p < .05$  (Between-group comparison); SD: standard deviation; <sup>a</sup>Fruit Mean (SD): Schizotypy ( $n = 22$ ) = 13.50 (3.57), Non-schizotypy ( $n = 16$ ) = 14.56 (3.12); Vegetable Mean (SD): Schizotypy ( $n = 20$ ) = 12.55 (4.24), Non-schizotypy ( $n = 22$ ) = 11.95 (4.02) <sup>b</sup>Fruit Mean (SD): Schizotypy ( $n = 20$ ) = 12.95 (3.75), Non-schizotypy ( $n = 22$ ) = 11.50 (3.32); Vegetable Mean (SD): Schizotypy ( $n = 22$ ) = 9.73 (3.76), Non-schizotypy ( $n = 16$ ) = 10.88 (4.19).

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3 **Figure 1.** Category fluency performance on experimental compared to baseline category fluency  
4 tests across schizotypy and non-schizotypy groups.  
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