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Neuropsychological differentiation of adaptive creativity and schizotypal cognition

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Abstract

Both creativity and schizophrenia-spectrum disorders have been associated with activation of remote semantic concepts, but this activation results in innovative output in one case and communication disturbances in the other. The present study examined the relationship between monitoring semantic information (which relies on executive brain function), creativity, and characteristics of schizotypy in an undergraduate population. Results indicate that executive function differentiates the use of semantic information in creativity and schizotypy. Specification of the balance between executive monitoring and activation of semantic information is important for determining how communication disturbances manifest, and for the measurement of creativity and schizotypy in the general population.

Keywords

schizotypy; creativity; semantic; memory; executive function

1. Introduction

Both creativity and schizophrenia-spectrum disorders have been associated with hyperactivation of unusual or remote ideas or words (e.g., Mohr et al., 2001), but this activation results in innovative output in one case and communication disturbances in the other. Hyperactivation of semantic information can loosely be attributed to differences in brain-hemisphere function (e.g., Leonhard & Brugger, 1998). Normatively, the left hemisphere is important for accessing dominant meanings of words and the right hemisphere facilitates access to remote meanings (Abdullaev & Posner, 1997). Individuals with schizophrenia-spectrum characteristics rely more on right-hemisphere and less on left-hemisphere language functions than is typical (e.g., Grimshaw, Bryson, Atchley & Humphrey, 2010; Kostova, de Loye, & Blanchet, 2011; Pizzagalli et al., 2001; Taylor et al., 2002), which may lead to increased access to remote meanings and/or using semantic information in an inappropriate or unusual context (Fisher et al., 2004). Right-hemisphere activity in schizotypy has also been associated with enhanced creativity domains, such as divergent (Folley & Park, 2005) and convergent thinking (Weinstein & Graves, 2002),

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suggesting that schizotypy is associated with hemispheric differences in the use of semantic information.

Other than right-hemisphere involvement during activation of remote ideas, information-processing similarities and differences between creativity and schizotypy have not been specified. The lack of clarity may be due to various definitions and assessments of schizotypy and creativity leading to a lack of correlation between measures (Weinstein & Graves, 2001) and difficulty making conclusions about how schizotypy and creativity are related. This lack of clarity may also be due to incomplete assessment of skills that may mediate creative use of semantic information. For example, monitoring creative output (which requires executive function) is not often assessed in studies of creativity and schizotypy, though one study did find that measures of frontal function positively mediated better performance on aspects of creative cognition (insight problem-solving and imagery) in patients with schizophrenia and controls (Abraham, Windmann, McKenna & Gunturkun, 2007).

The relationship of executive function to semantic associations may influence whether remote associations promote creative verbal information processing or whether they disrupt verbal information processing. Activation of remote associates may initially increase with schizotypy (especially with positive schizotypal characteristics, e.g. Weinstein & Graves, 2002) but decrease as illness and corresponding deficits in executive function (e.g., monitoring associations) increase. This pattern is similar to the suggestion that creativity increases with moderate schizotypy, but decreases with severity of psychopathology (Nelson & Rawlings, 2010), resembling an inverted U-shape. Indeed, nonlinear relationships between schizotypy and performance on verbal fluency (Tsakanikos & Claridge, 2005) and divergent thinking (Stoneham & Coughtrey, 2009) tasks have been reported. This U-shaped function can be captured by sampling three groups (rather than just high vs. low scorers), a strategy leveraged in the present report that has previously been effective in examining subtle relationships between schizotypy and creativity (e.g., Rhue & Lynn, 1987; Zanes et al., 1998).

The Deese/Roediger-McDermott (DRM) recognition memory paradigm (Deese, 1959; Roediger & McDermott, 1995) is informative for investigating the monitoring of semantic information. Participants learn lists of words which activate semantic associates creating a gist representation. The activation-monitoring model states that activation and monitoring of highly-associated concepts determine whether false alarms (FAs) to lures are triggered (Roediger et al., 2001). Intact maintenance of semantic gist leads to high rates of FAs. Fewer FAs can be due to poor gist maintenance that prevents activation of semantic associates. Fewer FAs can also be due to monitoring item-specific information (e.g., number of letters) to differentiate words from gist information, whereas increased FAs may be associated with lack of monitoring item-specific information. Performance on the DRM paradigm has been mixed in patients with schizophrenia (low FA rate; Huron & Danion, 2002: no difference in FAs between patients and controls; Elvevåg et al., 2004; Lee et al., 2007; Moritz et al., 2004; Peters et al., 2007). In nonclinical samples, decreased FAs were associated with the cognitive-perceptual factor on the Schizotypal Personality Questionnaire (Dagnall & Parker, 2009) and with the combination of increased schizotypal positive symptoms and decreased performance on an executive function measure measuring right prefrontal function (Fisher et al., 2007).

Mixed findings on the DRM task may be due to individual differences in the balance of activation and monitoring of semantic information. As outlined above, activation of semantic information may have a U-shaped relationship with creativity and schizotypy (Nelson & Rawlings, 2010). Thus, prior studies that have used the DRM paradigm to study schizophrenia-spectrum samples may have captured the two ends of the function without modeling the middle or high point of the curve, resulting in no difference between groups. In addition, exactly how monitoring semantic information is related to schizophrenia-spectrum symptoms vs. creativity has not been examined. Decreased lure accuracy in schizotypy was associated with cognitive performance (Dagnall & Parker, 2009; Fisher et al., 2007), supporting executive monitoring as important for mediating use of semantic information. Investigating how this process is similar or different in schizotypy and creativity can clarify issues about measurement of creativity and schizotypy in the general population and shed light on how communication disturbances in schizophrenia-spectrum disorders manifest.

The present study investigated (1) the relationship between schizotypy, creativity, and activation and monitoring of semantic information and (2) whether this relationship is associated with measures of executive function. It was hypothesized that the relationship between lure accuracy and schizotypy would resemble an inverted-U shaped curve (Figure 1). FAs to lures would increase as symptoms increase, but would decrease as symptoms cross a threshold of severity and monitoring skills diminish. In addition, the balance between activation and monitoring would shift with proportion of FAs. Specifically, along the descending (right-side) arm of the inverted U, schizophrenia-spectrum symptoms would increase, and semantic activation would decrease, while item-specific information becomes more prominent. This pattern would lead to fewer FAs due to the absence of semantic gist, consistent with reduced FAs in patients with schizophrenia. Individuals near the midpoint of the U would make the most FAs, as monitoring abilities of activated semantic associates would be poor. These relationships were investigated in a subclinical schizotypy population (the left and central areas of Figure 1).

2. Material and methods

2.1 Participants

Over 1,000 undergraduate students participated in large-group questionnaire-testing sessions that included Perceptual Aberration and Magical Ideation scales (Chapman et al., 1978; Eckblad & Chapman, 1983), the Schizotypal Personality Questionnaire (SPQ; Raine, 1991), and the Creative Experiences Questionnaire (CEQ; Merckelbach et al., 2001). A factor analysis of Chapman and SPQ scale scores yielded three factors (positive, negative, disorganized). The disorganized factor was not as reliable as the first two factors and was not used. Participants for the behavioral study were chosen according to high (≥65%ile) and low (≤35%ile) scores on the positive and negative factors and scores on the CEQ, yielding eight participant types (2×2×2): high on all three constructs, high on two (positive and negative, positive and creativity, negative and creativity), high on one (positive, negative, creativity), or low on all three. This stratified sampling method ensured a range of scores on all three relevant constructs, and was not intended to be used as a grouping strategy.

The sample consisted of 69 (39 female) right-handed, paid participants (mean age = 18.7 years, S.D. = 2.4). Due to technical difficulties, reaction time (RT) data on the computer task was not recorded for two participants, who were not included in relevant analyses. The entire sample (n=69) completed all questionnaires and neuropsychological assessments. Experimenters were blind to participants' Chapman, SPQ, and CEQ scores.

To determine whether a U-shaped relationship exists between positive schizotypy and monitoring of semantic information, schizotypy scales and lure accuracy were evaluated. As Odd Beliefs (from the SPQ) and Perceptual Aberration accounted for unique variance of lure accuracy in a model with predictors of frontal executive function in our prior work (Fisher et al., 2007), three groups were created using an average of Odd Beliefs (OB) and Perceptual Aberration (PA), three groups using PA alone, and three using OB alone. In each combination, the intermediate group had fewer FAs to lures than the other two groups and the high and low groups had similar FA rates. Because the number of individuals per group was more evenly matched in the OB alone groups, analyses used this grouping. Fifteen participants were in the high group (Odd Beliefs > 2), 22 in the intermediate group (Odd Beliefs >0 and <=2), and 32 in the low group (Odd Beliefs = 0). The groups showed similar variance in lure accuracy (Levene test: p = .65), supporting the use of ANOVA.

2.2 Procedure

There were two lab sessions: a computer session and neuropsychology/questionnaire session. The order of these sessions was counterbalanced.

2.2.1 Computer task—Thirty lists were created from a database of words and their normative ratings, including associative strength (Nelson et al., 1998) to create a task based on the DRM paradigm. The task contained lists based on a target word, where words at the beginning of each list were highly associated with the target lure and decreased in associative strength toward the bottom of the list.

Presentation of each list of six words was preceded by ‘list #’. Five lists were displayed and followed by a 65-word recognition phase. In total, there were six blocks of five lists, thus 180 encoding words (6 words/list × 5 lists/block × 6 blocks). The words in each recognition round consisted of 6 previously-presented words from each of the lists, 6 words thematically-related to the presented list that had not been presented, and the lure. Thus, there were 390 words during the recognition phase (30 lists × (6 old words + 6 related new words + 1 lure)).

Stimulus presentation and collection of RTs were controlled by STIM software from James Long Co. Words consisting of white letters were presented (1500 ms) against a black background, followed by a white fixation cross (500 ms). Participants completed a practice period (one 15-word list followed by seven probe words).

2.2.2 Neuropsychological testing/questionnaires—Neuropsychological tests assessed executive function, conventional intelligence, verbal memory, and creativity. As outlined above, executive function was assessed as a potential mediator of the use of semantic information. Three fluency tasks that are often used as indices of executive function were used: letter fluency, category fluency and design fluency. Because creativity and conventional intelligence are often correlated (Sternberg & O’Hara, 1999), conventional intelligence [indexed by Vocabulary and Block Design from the Wechsler Adult Intelligence Scale (WAIS)] was assessed to determine whether it contributed to results. Verbal memory [indexed by The California Verbal Learning Test (CVLT)] was assessed to distinguish general memory function from other skills needed for the DRM task. Performance measures of creativity were the Remote Associates Test and the Utility Test (UT; Wilson, Merrifield & Guildford, 1969). The self-report measure of creativity was the Creative Experiences Questionnaire (CEQ; Merckelbach et al., 2001).

Questionnaires indexed anxiety, current mood (anxious arousal, anxious apprehension and anhedonic depression) and negative schizotypy to rule out comorbid psychopathology: Mood and Anxiety Symptom Questionnaire (MASQ; Watson et al., 1995), Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990; Molina & Borkovec, 1994), Physical Anhedonia and Social Anhedonia (Chapman et al., 1976).

2.3 Data Analysis

The curvilinear relationship of positive schizotypy and the linear relationship of frontal executive function to lure accuracy were tested using curvilinear hierarchical regression. Odd Beliefs was entered as the schizotypy measure. Because Figural Fluency accounted for unique variance of lure accuracy in prior work (Fisher et al., 2007), it was entered as the executive function measure. Odd Beliefs was entered first, Odd Beliefs squared was entered next, and Figural Fluency was entered last to predict lure accuracy. The regression was repeated with Letter Fluency and Category Fluency to determine if the relationship would generalize to other executive function measures.

To further characterize the U-shape, a one-way ANOVA with three OB groups and lure accuracy as the dependent variable was computed. Planned contrasts comparing the high and low groups to the intermediate group on lure accuracy were conducted. Additional ANOVAs were computed to determine group differences on neuropsychology measures and questionnaires.

3. Results

The hypothesis that the relationship between lure accuracy and schizotypy would resemble the inverted-U shaped curve depicted in Figure 1 and that executive function would account for additional variance was supported. A hierarchical regression with Odd Beliefs as a curvilinear predictor and Figural Fluency as a linear predictor of lure accuracy confirmed the hypothesis that individuals near the midpoint of the U would make the most FAs. The overall model accounted for significant variance, $F(3, 63) = 3.45$, $p = .02$. Odd Beliefs was entered first as a linear predictor. It did not account for any variance ($\Delta R^2 = .00$, $p=.89$). However, Odd Beliefs squared entered second ($\Delta R^2 = .05$, $p=.07$) and Figural Fluency entered last ($\Delta R^2 = .09$, $p=.01$), accounted for meaningful variance. To determine whether these relationships generalize to other executive function measures, Letter Fluency and Category Fluency were substituted for Figural Fluency in separate regressions. The overall model with Letter Fluency accounted for significant variance, $F(3, 63) = 3.51$, $p = .02$ and Letter Fluency accounted for significant variance when added last ($\Delta R^2 = .09$, $p=.01$). The overall model with Category Fluency was not significant, $F(3,63) = 1.99$, $p = .13$ and Category Fluency did not account for variance when added last ($\Delta R^2 = .04$, $p=.12$).

Because Block Design and CVLT recall measures were also correlated with lure accuracy (Table 1), these measures were added to the model to determine the specificity of the executive function measures to the curvilinear relationship with Odd Beliefs. Only executive function measures (Letter Fluency and Figural Fluency) accounted for significant variance when added last, further demonstrating that only executive function measures in combination with Odd Beliefs predicted lure accuracy (Table 2).

Consistent with results of the regression, the High Odd Beliefs (hiOB), midOB, and loOB groups differed in lure accuracy ($F(2,64) =5.32$, $p=.02$), with hiOB, $t(64) = 4.47$, $p=.00003$, and loOB, $t(64) = 5.39$, $p<.00001$, more accurate than midOB. Effect sizes for these two comparisons were moderate to large (loOB vs midOB: d= .65; hiOB vs. midOB: d= .55; hiOB vs. loOB: d = − .12). In order to determine whether the tendency for midOB to make false alarms extended to other unpresented words, d′ was calculated. The overall test indicated a trend for a difference in d′ between the OB groups ($F(2, 64) = 2.87$, $p = .06$). Post-hoc LSD tests indicated that midOB was less able to discriminate between presented and unpresented words than the loOB ($p = .03$). To determine whether executive function and Odd Beliefs accounted for variance in overall discriminability, the curvilinear regression with OB, OB squared and Figural Fluency predicting d′ was calculated. The regression was not significant, $F(3, 63) = 1.76$, $p = .17$, indicating that the relationship between executive function and Odd Beliefs is specific to lure accuracy.

It was expected that individual differences in lure accuracy would be related to schizotypy, executive function, and creativity. Comparisons of the three OB groups indicated differences on positive schizotypy measures, Creative Experiences ($p = .05$) and Vocabulary (p=.007). According to Figure 1, individuals on the descending arm of the U would have high schizotypy scores and high lure accuracy, due to reduced semantic activation and/or increased monitoring skills. Indeed, posthoc LSD comparisons of the main effects listed above indicated that the hiOB group had higher scores on positive schizotypy measures compared to the other two groups: Perceptual Aberration (midOB: p=.009; loOB: p <.001), Magical Ideation (midOB: $p = .005$; loOB: p <.001), Ideas of Reference (loOB: p <.001); Unusual Perceptual Experiences (midOB: p=.018; loOB: p <.001), Odd Eccentric Behavior (loOB: $p = .012$). The High OB group also had higher scores on Creative Experiences than the loOB group (p =.02), indicating both high self-reported schizotypy and creativity. The midOB group differed only in having higher scores on Odd Speech than the loO B group (p = .007). The intermediate OB group also had lower vocabulary scores than the loOB group (p=.002) and a high rate of FAs to lures (see above) suggesting less efficient use of semantic information in this group. Lastly, the loOB group had lower scores on schizotypy measures than the other two groups (Eccentric Behavior: hiOB: p =.04, midOB: $p = .05$; Ideas of Reference: hiOB: p<.001, midOB: p <.001; SPQ total: hiOB: p<.001, midOB: p<.001), indicating a group with few schizotypal characteristics.

Mood and anxiety symptoms in each group were also investigated to determine any influences of comorbidity. Depression and anxiety did not differ between the OB groups, although there was a trend for the hiOB group to have higher anxious arousal scores (p = . 07) than the loOB group.

4. Discussion

The goals of this study were (1) to identify the relationship between schizotypy, creativity, and activation and monitoring of semantic information and (2) to determine whether this relationship is associated with measures of executive function. Confirming hypotheses, schizotypal symptoms and activation/monitoring of semantic information resembled an inverted U-shaped curve. Both positive schizotypy (Odd Beliefs) and executive function (Letter Fluency and Figural Fluency) were related to activation and monitoring of semantic information. In addition, individuals with high Creative Experiences scores also had high scores on Odd Beliefs, suggesting an overlap in these characteristics.

The curvilinear relationship between the use of semantic information and schizotypy was supported. HiOB and loOB groups had higher lure accuracy than the midOB group. Scores on questionnaire measures suggest that the hiOB group consisted of “creative” individuals with strong monitoring abilities. In comparison, the loOB group had low scores on psychopathology, indicating a “healthy/non-creative” group. This group did not differ from the hiOB group in lure accuracy, suggesting intact semantic monitoring abilities.

The midOB group had higher scores on Odd Speech and poorer vocabulary. These individuals also had an increased tendency to fall for lures than did the other two groups, suggesting that activation of semantic information was stronger than monitoring skills. One might suggest that this group would also have higher scores on divergent or convergent thinking, given the tendency to activate semantic associates. However, high scores on those tests also require strong executive function, which did not characterize this group. Instead, this group resembled individuals with thought disorder who have weak context-processing skills and weak ability to select information in the presence of competing information

(Kerns & Berenbaum, 2003). It is possible that this group represents individuals on the part of the curve (midOB group in Figure 1) in which executive function/monitoring starts to decrease, allowing activation of semantic associates.

Although this characterization of the intermediate group is inconsistent with evidence that patients with schizophrenia are *less* likely to make FAs to lures, few of those studies included patients with thought disorder or active positive symptoms. According to the present study, high scores on Odd Beliefs combined with decreased executive function leads to increased FA. Patients in prior studies may have displayed more negative than positive symptoms, which would be consistent with the right-most side of Figure 1, depicting fewer FAs. It is likely that symptom presentation may influence the type of strategy used, as patients experiencing delusions tend to make more FAs (Bhatt et al., 2010), consistent with the intermediate Odd Beliefs group in the present study.

One aspect of this study did not manifest as predicted. Category Fluency was not a significant predictor of lure accuracy in combination with Odd Beliefs. Of the three fluency measures, Category Fluency relies more on left temporal regions and less on frontal function (Baldo, Schwartz, Wilkins & Dronkers, 2010), which is required for the other two fluency tasks and for monitoring lures on the DRM. The difference in task requirements between the fluency tasks likely explains why category fluency was not a significant predictor of lure accuracy in the model with schizotypy.

In addition, both the “left-hemisphere” (Letter Fluency) and “right-hemisphere” (Figural Fluency) tests with Odd Beliefs were significant predictors of lure accuracy, which is not consistent with the association between hyperactivation of semantic associates and right-hemisphere function in schizotypy found in prior studies. Those studies used tasks that likely engaged the right-hemisphere to a greater extent (i.e., unlike the DRM) and/or used more sensitive methods (i.e., neuroimaging) to determine activation of brain regions. The results of this study do suggest that activation and use of remote ideas is associated with frontally-mediated executive function, but the specification of regional involvement remains to be determined with more sensitive techniques.

The present study supports the idea that activation of semantic information in creativity and schizotypy can be differentiated by executive function. Executive function plays a role in monitoring remote semantic information to create innovative output. As executive function decreases, less monitoring occurs and communication difficulties emerge. The present study is consistent with reports that creativity increases with schizotypy and decreases with severity of psychopathology (Nelson & Rawlings, 2010), but extends this relationship more specifically to the activation of semantic associates, a process important for verbal creativity and more directly related to communication difficulties in the schizophrenia-spectrum. Because creativity and schizotypy characteristics overlap, measurement of schizotypy would benefit from additional indices, especially assessments of executive function, in order to determine whether participants fit a “creative” or “schizotypal” profile.

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- Unusual use of semantic information is common in schizotypy and creativity
- We examined activation and monitoring of semantic information
- Activation and monitoring of semantic concepts are differentiated by executive function
- Executive function measures are useful for differentiating creativity and schizotypy

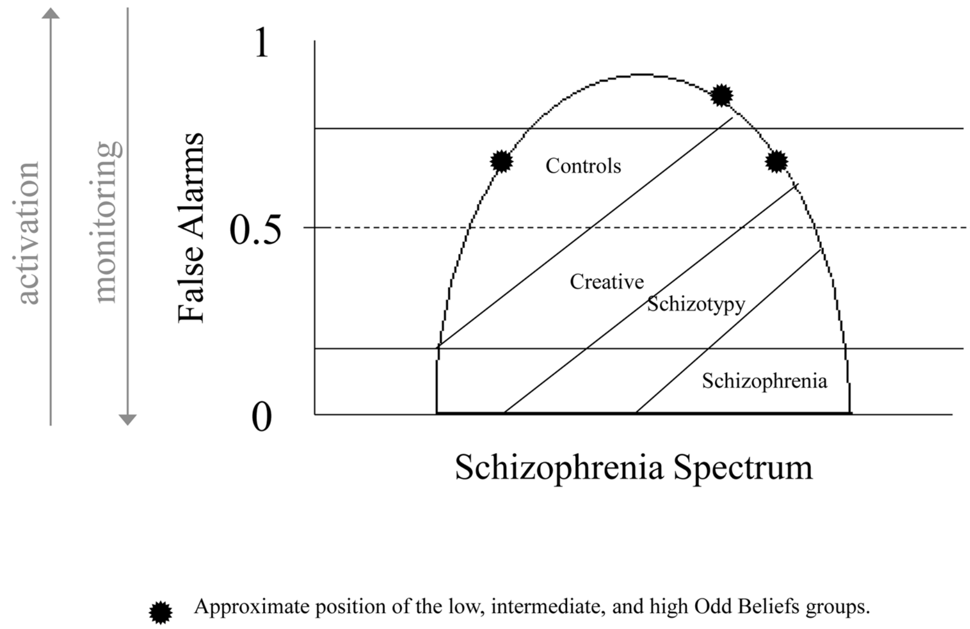

Figure 1.
The relationship between lure accuracy and schizotypy. False alarms to lures increase and decrease according to symptom severity and a corresponding balance between activation and frontal executive monitoring of semantic associates.

Table 1

Neuropsychology/Creativity Measures and Word Type Accuracy Correlations (N=67)

		Lures	Strong AP	Intermediate AP	Weak AP	Strong ANP	Intermediate ANP	Weak ANP
Executive function	Letter fluency	.34 **	.22	.18	.23	.22	.19	.17
	Category fluency (n=66)	.27 *	.12	.11	.13	.17	.19	.15
	Figural fluency	.36 **	−.13	−.15	−.04	.20	.13	.08
Conventional intelligence	Block Design	.25 *	.007	−.03	.03	.02	.07	.08
	Vocabulary	.20	.06	−.003	.07	.07	.08	.04
Memory	CVLT correct trials 1–5	.25 *	.04	.12	.07	.15	.09	.07
	CVLT SD free recall	.25 *	.10	.11	.06	.11	.05	.05
	CVLT SD cued recall	.29 *	.002	.08	.02	.004	.01	.009
	CVLT LD free recall	.32 **	.09	.15	.10	.15	.16	.16
	CVLT LD cued recall	.321 **	−.02	.04	.02	.02	.02	−.001
Creativity	CEQ	−.06	.12	.04	.05	−.06	−.03	−.06
	RAT	.15	.08	.10	.17	.08	.05	.05
	UT-U	.08	.02	−.06	.07	−.06	−.04	−.08
	UT-C	.12	−.08	−.16	.00	−.03	−.04	−.12

Note. AP = associates presented; ANP = associates not presented; CVLT = California Verbal Learning Test; CEQ = Creative Experiences Questionnaire; RAT = Remote Associates Test; UT-U = Utility Test, unique responses; UT-C = Utility test, number of changes; SD= short delay; LD = long delay

* $p < .05$,

** $p < .01$

Table 2

Hierarchical Curvilinear Regression Predicting Lure Accuracy

Predictors	R^2	•R^2	*F* or *t*	*p*
Full model	.30		2.41	.02
Odd Beliefs		.00	.02	.89
Odd Beliefs		.05	.69	.07
Executive function		.15		.006
---Letter fluency			2.03	.05
---Figural fluency			1.97	.05
Memory		.10		.15
---immediate recall			.38	.70
---SD free recall			−.09	.93
---SD cued recall			−1.2	.22
---LD free recall			.91	.37
---LD cued recall			1.17	.25
Conventional Intelligence (Block Design)		.00	−.14	.89

Note. CVLT = California Verbal Learning Test; SD = short delay; LD = long delay