Available online at www.sciencedirect.com
ScienceDirect
Psychiatry Research 145 (2006) 119–126
PSYCHIATRY RESEARCH
www.elsevier.com/locate/psychres

Abnormal typicality of responses on a category fluency task in schizotypy

Michael Kiang [a,*], Marta Kutas [a,b]

[a] Department of Cognitive Science, University of California, San Diego, Mail Code 0515, 9500 Gilman Dr., La Jolla, CA 92093-0515, USA
[b] Department of Neuroscience, University of California, San Diego, Mail Code 0662, 9500 Gilman Dr., La Jolla, CA 92093-0662, USA

Received 11 August 2005; received in revised form 14 November 2005; accepted 28 December 2005

Abstract

Existing hypotheses about semantic processing in schizophrenia and schizotypy suggest that both conditions are associated with a less than normal difference in the degree to which some concept activates the mental representation of other concepts that are strongly versus weakly related to it in meaning. To seek further evidence for this, we examined response typicality on the Category Fluency Test (CFT) as a function of schizotypy. Individuals from a non-clinical population verbally generated as many exemplars as they could in 1 min for each of four categories (fruits, four-footed animals, articles of clothing, vehicles). Participants subsequently completed the Schizotypal Personality Questionnaire (SPQ). SPQ score was not significantly correlated with the total number of responses generated for any of the categories. Individuals with higher (as opposed to lower) SPQ scores, however, generated more atypical members of the fruit category both in their initial responses and overall (as indexed by the average ratio of each response's ordinal position to its position in population typicality norms). These results support the hypothesis that semantic memory organization in non-clinical individuals with higher schizotypy is functionally altered.

Keywords: Schizotypal personality; Category fluency; Semantic processing; Language; Schizophrenia; Neuropsychological tests; Typicality

1. Introduction

Schizotypal personality traits qualitatively resemble the defining symptoms of schizophrenia but are quantitatively less severe. Thus, the schizophrenic symptoms of delusions, hallucinations, frank disorganization, and negative symptoms have counterparts in the schizotypal traits of ideas of reference, unusual perceptual experiences, odd speech and behavior, and social isolation, respectively. The degree to which individuals in the general population exhibit schizotypal traits varies on a continuum (Kendler et al., 1991), and is thought to reflect the total loading on multiple genetic and environmental factors that also can contribute to schizophrenia (Siever and Davis, 2004; Jang et al., 2005). In support of this view, schizotypy in non-clinical samples has been found to be associated with a higher prevalence of various psychophysiological markers that characterize schizophrenia patients (Klein et al., 1998; Della Casa et al., 1999; Kimble et al., 2000; Lubow and De la Casa, 2002; Ettinger et al., 2005; Kiang and Kutas, 2005).

Odd speech in schizotypy includes "distinctive or peculiar" language that "may have meaning only to" the

* Corresponding author. Tel.: +1 858 534 2440; fax: +1 858 534 1128.
E-mail address: mkiang@cogsci.ucsd.edu (M. Kiang).

0165-1781/$ - see front matter © 2006 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.psychres.2005.12.010

speaker, "and may often need interpretation" (Sadock and Sadock, 2003). In research settings it can be quantified by a clinician's interview-based rating, or by the individual's self-rating on a questionnaire such as the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991).

The propensity toward unusual language production in schizotypy is also measurable by appropriate psychological and neuropsychological tests. In free word-association tests, for example, individuals are presented with a word and asked to generate the first other word that comes to mind. In a non-clinical population, high scorers on the Perceptual Aberration-Magical Ideation scale generated more unusual responses and fewer common responses, compared to controls, on free word-association (Miller and Chapman, 1983). Scores on the Eysenck Psychoticism Scale were also found to be correlated with the proportion of unusual word-association responses, at least in men (Ward et al., 1991), or with the proportion of unique responses (Merten, 1993). These results parallel the common finding that schizophrenia patients produce a greater proportion of unusual or unique responses compared to controls on word-association tests (Janowsky et al., 1977; Shakow, 1980; Johnson and Shean, 1993).

These results from word-association tests appear consistent with the view that schizophrenia, and perhaps by extension schizotypy, may be associated with abnormalities in how concepts activate one another in semantic memory. Such hypotheses assume a model of semantic memory in which concepts are represented as nodes in a network, and associations between concepts (e.g., between an object and its features) as links among these nodes (Collins and Loftus, 1975; Neely, 1977; Anderson and Pirolli, 1984). Whenever a concept node is activated, as by its corresponding word stimulus, this activation is thought to spread through the network to associated nodes. The degree to which one concept activates another and facilitates its processing—e.g. making it more likely to be generated as a word associate—is presumed to be related to the strength of the links between them.

According to one hypothesis, unusual associations in schizophrenia result from an abnormally broad spread of activation in the semantic network, such that activation of the mental representation of an item (i.e. word or picture) not only leads to a normal degree of activation for the representation of items strongly related to it, but also to a greater than normal degree of activation for that of items weakly related to it (Spitzer, 1997). As a consequence, more items would become activated in semantic memory, and the difference in resulting activation between strongly and weakly related items would be less than normal. This, in turn, could increase the likelihood that weakly related items would be produced in a word-association test. According to an alternative hypothesis that also could account for the production of unusual associations in schizophrenia, there is decreased gain control in prefrontal neural networks presumed to be involved in maintaining representations of context in working memory (Cohen and Servan-Schreiber, 1992). In this model, decreased gain proportionally reduces the degree of activation or inhibition of all the neurons typically comprising such representations. If we view a given item as a contextual stimulus represented in working memory by a particular pattern of neural activation, then decreased gain in this representation might in turn lead to decreased activation of semantically related items as well as to decreased inhibition (i.e. increased activation) of semantically unrelated items, and hence to production of a greater number of unusual responses in a word-association test.

There is in fact support for both the above hypotheses from behavioral priming and N400 event-related brain potential data in schizophrenia (reviewed in Minzenberg et al. 2002). The evidence implicates a broader spread of activation at shorter time intervals (<250 ms) after a stimulus, and poor use of context at longer intervals. There are also data pointing to similar abnormalities in association with schizotypy (Moritz et al., 1999; Niznikiewicz et al., 1999; Kimble et al., 2000; Niznikiewicz et al., 2002; Niznikiewicz et al., 2004; Kiang and Kutas, 2005).

The Category Fluency Test (CFT) (Spreen and Strauss, 1998) is another neuropsychological test, with some similarities to the word-association test, that also offers a window into the functional organization of semantic memory (Aloia et al., 1996; Paulsen et al., 1996; Troyer et al., 1998; Rossell et al., 1999; Sumiyoshi et al., 2001) and thus might likewise be a sensitive measure of unusual language production in schizophrenia and schizotypy. In this test, individuals are given the name of a semantic category (e.g. fruits, animals, tools), and asked to produce as many exemplars of it as possible within a given time period. The total number of responses generated, or fluency, on the CFT has been found to be lower in schizophrenia patients than in controls (Allen and Frith, 1983; Allen et al., 1993; Aloia et al., 1996; Paulsen et al., 1996; Rossell et al., 1999; Sumiyoshi et al., 2001; Giovannetti et al., 2003). To our knowledge, however, prior work has not examined whether the *typicality* of CFT responses also varies as a function of schizophrenia or schizotypy.

The typicality of a category exemplar is defined as its relative frequency of production by individuals asked to name members of the category of which it is a member (McCloskey and Glucksberg, 1978; Stuss et al., 1988). Population norms for the typicality of exemplars for various categories have been collected in this way (Shapiro and Palermo, 1970; Hunt and Hodge, 1971; McEvoy and Nelson, 1982; Yoon et al., 2004). For example, according to these norms *apple* is a more typical fruit than *mango* (at least in the United States). This measure of typicality is also correlated with individuals' ratings of how typical the exemplar is of the category (Mervis et al., 1976), and with the featural overlap between the exemplar and either the set of other category exemplars or the category concept itself (Rosch and Mervis, 1975; Hampton and Gardiner, 1983). Within the network model of semantic memory, higher typicality is thought to reflect greater total strength of the links between the category and the exemplar (McCloskey and Glucksberg, 1978).

The primary aim of the present study was to examine the typicality of CFT responses as a function of schizotypy in a non-clinical sample. We hypothesized that individuals with higher schizotypy would produce more atypical responses. This would be consistent with the view that individuals with higher vs. lower schizotypy, when presented with a semantic stimulus (i.e., the category), experience a less than normal difference in the degree of activation enjoyed by strongly versus weakly related items (i.e., high- and low-typicality exemplars, respectively). This in turn would reduce the likelihood that they would produce high-typicality exemplars while increasing the likelihood that they would produce low-typicality exemplars. This outcome would be consistent with either the hypothesis of Cohen and Servan-Schreiber (1992) or that of Spitzer (1997), and would provide additional evidence that schizotypy in the general population modulates how concepts activate one another in semantic memory in a manner similar to that seen in schizophrenia.

A secondary aim of the study was to examine the correlation between schizotypy and total number of responses on the CFT. If decreased category fluency in schizophrenia reflects deficits that also vary on a continuum of severity across the general population in proportion to the degree of genetic susceptibility to schizophrenia, then in a non-clinical sample we might also expect individuals with higher schizotypy to exhibit lower fluency—that is, to generate fewer category members—than those with lower schizotypy.

We administered the CFT for four categories—fruits, four-footed animals, articles of clothing and vehicles. We chose these categories so that both living things and human artifacts would be represented. These two classes of categories have been postulated to have different characteristics, based on studies of neurological patients with class-specific deficits (McRae and Cree, 2002). We also chose these categories because they were among those included in the recent typicality norms for young Americans by Yoon et al. (2004), and thus could serve as norms for our participant sample. As a measure of the typicality of the first response generated by an individual for a given category, we used the "response probability" of that exemplar in the Yoon et al. (2004) norms. In that study, subjects' responses were viewed as drawn from an underlying multinomial distribution in which each exemplar has a particular frequency, and the response probability was an estimate of this frequency, based on a rank-order logit model. Additionally, we calculated a typicality index for the entire set of responses given for each participant in each category, by averaging, over all responses, the ordinal position of each response with its position in the response probability ranking from the population norms. Participants subsequently completed the SPQ. For each category, we hypothesized that higher SPQ score would be correlated with lower typicality of the first response and of the entire response set, and with a lower total number of responses.

2. Methods

2.1. Participants

Sixty native English speakers [34 female, 18 to 35 years of age, mean age 20.9, S.D.=3.5] were recruited from the University of California (San Diego) campus. Most were undergraduates. Participants gave written informed consent and were compensated with course credit or cash. The study procedure was approved by the Human Research Protections Program of the University of California (San Diego).

2.2. Assessments

For the CFT, each of the 60 participants was asked to verbally generate as many names of fruits as possible in 1 min. Thirty-four of these participants [16 female, 18 to 34 years of age, mean age 20.8, S.D.=3.6] were also asked to verbally generate as many names of four-footed animals, articles of clothing, and vehicles as they could in 1 min each.

Participants subsequently completed the Peabody Picture Vocabulary Test (PPVT) (Dunn and Dunn,

1997) for an estimate of vocabulary, followed by the SPQ for an estimate of schizotypy. The SPQ is a self-report scale with 74 dichotomous-choice (Yes or No) questions. The maximum possible total score is thus 74; maximum possible scores for its three factors (Disorganized, Cognitive-Perceptual, and Interpersonal) (Raine et al., 1994) are Disorganized: 16; Cognitive-Perceptual: 33; and Interpersonal: 33.

2.3. Analysis of CFT responses

The total number of responses produced by each participant for each category was recorded.

For each category, as a measure of the typicality of each participant's first response, its "response probability" was obtained from the category production norms for young Americans compiled by Yoon et al. (2004). In that study, responses were viewed as drawn from a multinomial distribution in which each response has an innate frequency, and the response probability was an estimate of this frequency. For example, response probabilities for fruit ranged from 41.8% for *apple* to 0.1% for *coconut*. Higher response probabilities thus correspond to higher typicality.

In addition, as a measure of overall typicality of the participant's response set for a particular category, a typicality index t was calculated:

$$t = \frac{\sum_{i=1}^{n} [f_i/\mathrm{i}]}{n}$$

where n = the total number of responses, i = the ordinal position of each response, and f = its position in the ranking of exemplars by response probability in the Yoon et al. (2004) norms (e.g., for fruit, f ranged from 1 for *apple*, to 30 for each of 13 different exemplars—such as *coconut* and *prune*—with a response probability of 0.1). If a given response did not occur in the norms, it was assigned a rank one greater than the total number of items occurring for that category in the norms. In other words, t represents the mean, over all responses, of the ratio of each response's rank in the norms to the position in which it was produced by the individual, with lower values of t corresponding to higher typicality. If an individual's responses exactly matched the response probability rankings, beginning with the first-ranked exemplar, t would have the minimum possible value of 1—for example, for fruit, this could occur if the individual produced the response set "*apple*, *orange*, *banana*, *pear*, *grape*, *strawberry*," which, in that order, are the first six exemplars in the norms ranked by response probability. If, on the other hand, the individual produced these same six exemplars but in reverse order, t would equal 1.86. The typicality index would be even lower if the individual said "*peach*, *kiwi*, *mango*, *pineapple*, *watermelon*, *plum*," which are the seventh through twelfth exemplars in the norms (t=3.45).

2.4. Statistical analyses

To examine correlations between pairs of variables, Pearson product moment correlation co-efficients r were computed with two-tailed significance levels, if both variables passed the Kolmogorov–Smirnov test for normality (α=0.05). For all four categories, response probability of the first response was not normally distributed, because these responses were more likely to be exemplars with higher response probability; therefore, for correlations involving this variable, Spearman's ρ was computed, with two-tailed significance levels.

3. Results

3.1. Overall assessment scores

Table 1 shows descriptive statistics for assessment scores for the study sample. In the CFT, no participants gave any inappropriate responses (i.e., items that could

Table 1
Means, standard deviations and ranges of assessment scores for the study sample (n=60, except n=34 for CFT data for four-footed animals, articles of clothing, and vehicles)

	Mean	S.D.	Range
SPQ total	16.6	12.7	1–60
Cognitive-Perceptual factor	5.8	4.8	0–19
Disorganized factor	4.7	3.9	0–14
Interpersonal factor	6.3	4.8	0–17
PPVT	188.2	5.8	170–196
CFT			
Number of responses produced			
Fruit	15.6	3.7	6–22
Four-footed animals	16.1	4.5	8–29
Articles of clothing	19.4	3.4	12–27
Vehicles	14.5	3.6	8–23
Response probability (%) of first response			
Fruit	24.9	17.5	0–41.8
Four-footed animals	21.6	18.5	0.3–47.2
Articles of clothing	9.2	10.8	0–32.2
Vehicles	33.1	27.9	0.1–57.5
Typicality index t			
Fruit	2.1	0.6	1.3–3.9
Four-footed animals	3.0	1.1	1.5–6.1
Articles of clothing	3.0	1.2	1.4–8.1
Vehicles	4.3	1.4	1.9–7.0

Table 2
Correlations of SPQ scores with response probability of the first CFT response (by category), with two-tailed test of significance

	Fruit		Four-footed animals		Articles of clothing		Vehicles	
	ρ	P	ρ	P	ρ	P	ρ	P
SPQ total	−0.36	0.006*	0.02	0.92	−0.20	0.26	0.27	0.13
Cognitive-Perceptual factor	−0.28	0.03*	0.02	0.90	−0.23	0.19	0.22	0.20
Disorganized factor	−0.37	0.004*	0.07	0.71	−0.22	0.22	0.13	0.48
Interpersonal factor	−0.30	0.02*	0.02	0.90	−0.23	0.19	0.22	0.20

*$P<0.05$.

not be considered a member of the category). Overall, the distribution of the first responses produced by participants for each category appeared consistent with the response probabilities from the Yoon et al. (2004) norms, suggesting that the presumed underlying response distribution was similar between their study population and ours. For example, the most common first response for fruit was *apple*, produced by 30 of 60 participants, a proportion similar to its response probability of 41.8% in the norms. Likewise, 14 of 60 first responses (23%) for fruit were exemplars whose response probability in the norms was 4% or less, consistent with the fact that the summed response probability of these exemplars in the norms was 24%.

There appeared to be substantial variability between individuals in overall typicality of responses. For example, for fruit, one participant (with a total SPQ score of 6) produced the relatively high-typicality response set [*apple*, *orange*, *banana*, *pear*, *peach*, *plum*, *pineapple*, *mango*, *strawberry*, *cantaloupe*, *melon*, *grapefruit*, *grapes*, *tangerine*], while another (SPQ=23) produced the low-typicality response set [*cherimoya*, *banana*, *apple*, *orange*, *tangerine*, *grape*, *passionfruit*, *kiwi*, *jackfruit*, *lime*, *lemon*, *cherry*, *strawberry*, *persimmon*, *cantaloupe*, *Persian melon*, *plum*, *nectarine*, *peach*, *avocado*].

There was no significant correlation between total SPQ score and vocabulary as measured by the PPVT [$r=0.19$, $P=0.15$].

3.2. Correlations between CFT measures and SPQ scores

None of the correlations between SPQ scores (either total or factor scores) and the number of responses on the CFT for different categories approached significance ($P>0.20$ for all correlations).

Correlations between SPQ scores and response probabilities of first responses, and between SPQ scores and the typicality index t for the overall response set, are shown in Tables 2 and 3, respectively. For fruit, total SPQ score and all three factor scores were significantly correlated with lower response probability of the first response, and total SPQ score and the Disorganized and Interpersonal factor scores were significantly correlated with higher t values—suggesting that higher schizotypy was associated with lower response typicality of both the first response and the overall response set. In contrast, neither the response probability of the first response nor t was correlated with SPQ total or factor scores for any of the other three categories assessed.

One possible explanation for this contrast between the pattern of results for fruit and for the other categories might have been that the subset of participants who completed the CFT for the other categories somehow differed from the overall sample, such that they exhibited no significant correlation between SPQ scores and typicality even for the fruit category. This possibility was ruled out, however, by the finding that even for just these 34 participants, t for fruit was significantly correlated with total SPQ score ($r=0.42$, $P=0.01$) and with the Disorganized ($r=0.39$, $P=0.02$), Interpersonal ($r=0.39$, $P=0.02$), and Cognitive-Perceptual ($r=0.39$, $P=0.02$) scores, and response probability of first response was significantly correlated with total SPQ score ($\rho=-0.38$, $P=0.03$), and with the Cognitive-Perceptual ($\rho=-0.48$, $P=0.004$) score.

In order to test the post hoc hypothesis that the contrasting pattern of results seen for fruit compared to

Table 3
Correlations of SPQ scores with typicality index t of CFT responses (by category), with two-tailed test of significance

	Fruit		Four-footed animals		Articles of clothing		Vehicles	
	r	P	r	P	r	P	r	P
SPQ total	0.35	0.006*	0.12	0.48	0.07	0.72	−0.03	0.87
Cognitive-Perceptual factor	0.24	0.07	0.13	0.47	0.07	0.68	−0.08	0.64
Disorganized factor	0.37	0.004*	0.11	0.55	0.04	0.83	0.12	0.51
Interpersonal factor	0.33	0.01*	0.12	0.50	0.07	0.70	−0.10	0.58

*$P<0.05$.

the other categories might be associated with lower individual variability in response typicality for fruit, we compared the variances of the typicality index t for all pairs of categories, using Levene's test for equality of variance. Variance was indeed smaller for fruit than for either four-footed animals [$F=13.96$, $df=(1,92)$, $P=0.0003$], articles of clothing [$F=6.71$, $df=(1,92)$, $P=0.01$], or vehicles [$F=35.11$, $df=(1,92)$, $P<0.0001$], while it did not differ significantly among the latter three categories.

4. Discussion

In this study, we assessed the hypothesis that schizotypy, like schizophrenia, may be characterized by abnormal activation of items in semantic memory, by examining the total number and typicality of the items generated in a 1 min category fluency task. We calculated the number of responses and the typicality of the initial response as well as that of the entire set of an individual's responses for four categories—fruits, four-footed animals, articles of clothing and vehicles. In contrast to what is generally observed with schizophrenia, we found no correlation between schizotypy and the total number of responses generated for any of the four categories assessed. However, individuals from our non-clinical population who scored high on schizotypy were in fact more likely to generate more atypical exemplars of the fruit category; i.e., schizotypy was reliably associated with decreased response typicality of both the first response and the overall response set for the fruit category, though not for any of the other categories.

This association between higher schizotypy and lower response typicality for the fruit category fits a model in which schizotypy and schizophrenia share abnormalities in how concepts in semantic memory activate one another. In particular, the results suggest that schizotypy is associated with less of a difference in the degree to which a meaningful stimulus (such as a category name) activates concepts (such as category members) that are strongly and weakly meaningfully related to it. This is consistent with both the hypothesis of Spitzer (1997)—in which activation spreads more broadly to weakly related items—and that of Cohen and Servan-Schreiber (1992)—in which the gain function that determines the activation of related items is decreased.

One question raised by our results is why an association between schizotypy and typicality was obtained only for fruit and not for the other categories. Although dissociations between semantic processing of living things and human artifacts have been reported in other neuropsychiatric disorders (McRae and Cree, 2002), this distinction cannot explain our findings, given that we observed a similar lack of association between schizotypy and typicality for four-footed animals as for articles of clothing and vehicles. There are, however, reasons to believe that the category of fruits does differ from that of the other categories examined. In particular, data from category norming studies suggest that there is less inter-individual variability not only in the set of responses generated, but also in the order in which they are generated, for the fruit category relative to most other categories. First, people as a whole offer fewer different exemplar names in response to the fruit category than for four-footed animals (Battig and Montague, 1969; Yoon et al., 2004), articles of clothing (Battig and Montague, 1969; Hunt and Hodge, 1971; Yoon et al., 2004), or vehicles (Battig and Montague, 1969; Ruts et al., 2004; Yoon et al., 2004). Second, in a study conducted in Dutch (Ruts et al., 2004), fruit ranked first out of 13 categories, including vehicles and various classes of animals, on the negative correlation between exemplar generation frequency and mean rank position of generation, suggesting that different participants tended to generate the same exemplar fruits in similar ordinal positions. Third, Yoon et al. (2004) measured the similarity in response probabilities for category exemplars among four subpopulations—younger and older adults, in China and the United States—and found that fruit was among only 13 out of 105 categories with "roughly equivalent category responses across all four culture-by-age groups". By contrast, this was not the case for the category of four-footed animals, articles of clothing, or vehicles. Finally, we too found that the variance in the typicality index was significantly lower for the fruit category than for any of the other three categories, whose variances were similar to each other. Lower variability in response probability for the fruit category, compared to other categories, probably reflects relatively homogeneous experience with members of the category despite distinctly different cultural (e.g., regional, ethnic, gender, age) backgrounds. Given that our participants also differed to some extent in subcultural background both from one another and from the population sampled by Yoon et al. (2004), a lower baseline variability in response probability for the fruit category could have rendered variation due to schizotypy more detectable by increasing the signal-to-noise ratio between these factors.

By showing that individuals scoring higher on the SPQ produce more atypical responses on a category production task, our results further support the convergent validity of the SPQ as a metric for the propensity to

produce unusual speech. Our results also suggest that response typicality particularly for the fruit category on the CFT may be useful as a sensitive, quantitative, objective, and rapidly administered measure of unusual speech.

Contrary to what was hypothesized on the basis of the literature on schizophrenia per se, schizotypy was not correlated with the number of CFT responses. This contrasts with the decreased category fluency (i.e., fewer items generated) typically observed in schizophrenia patients, which has been hypothesized to reflect an inability to generate semantically related response clusters due to degradation of normal links in the semantic network (Aloia et al., 1996; Paulsen et al., 1996; Rossell et al., 1999; Sumiyoshi et al., 2001), or an inability to switch clusters due to compromised executive function mechanisms (Giovannetti et al., 2003). Siever and Davis (2004) have proposed that the capacity to activate other frontal regions in compensation for certain prefrontal deficits determine whether individuals with a genetic susceptibility to schizophrenia are in fact spared the disease. The normal category fluency that we observed even in individuals with higher schizotypy scores might reflect such compensatory mechanisms. Alternatively, decreased category fluency in schizophrenia but not schizotypy could mean that in schizophrenia this decrease reflects secondary effects of psychotropic medication, acute psychosis, or social deterioration rather than primary deficits in semantic memory and/or executive functions.

Future studies can confirm whether schizophrenia, like schizotypy, is associated with decreased typicality of category fluency responses. If so, this would be evidence for at least somewhat distinct processes leading to decreased typicality of responses and decreased number of responses, with the former reflecting an underlying abnormality common to schizotypy and schizophrenia, and the latter being specifically associated with the development of schizophrenia.

In summary, we found that higher schizotypy was associated with decreased typicality of responses for the fruit category on a category fluency task, both for initial responses and for the overall response set. The results support the view that schizotypy, like schizophrenia, is associated with less of a difference in the degree to which a meaningful stimulus activates concepts in semantic memory that are strongly and weakly related to it.

Acknowledgments

This study was supported by grants HD22614 and AG08313 to M. Kutas from the National Institutes of Health. M. Kiang is supported by a Postdoctoral Fellowship from the Canadian Institutes of Health Research, Ottawa, ON. We thank Jim Mintz and Virginia de Sa for helpful discussion on statistical methods.

References

Allen, H.A., Frith, C.D., 1983. Selective retrieval and free emission of category exemplars in schizophrenia. British Journal of Psychology 74 (Pt 4), 481–490.

Allen, H.A., Liddle, P.F., Frith, C.D., 1993. Negative features, retrieval processes and verbal fluency in schizophrenia. British Journal of Psychiatry 163, 769–775.

Aloia, M.S., Gourovitch, M.L., Weinberger, D.R., Goldberg, T.E., 1996. An investigation of semantic space in patients with schizophrenia. Journal of the International Neuropsychological Society 2, 267–273.

Anderson, J.R., Pirolli, P.L., 1984. Spread of activation. Journal of Experimental Psychology: Learning, Memory and Cognition 10, 791–798.

Battig, W.F., Montague, W.E., 1969. Category norms for verbal items in 56 categories: a replication and extension of the Connecticut category norms. Journal of Experimental Psychology Monographs 80, 1–45.

Cohen, J.D., Servan-Schreiber, D., 1992. Context, cortex, and dopamine: a connectionist approach to behavior and biology in schizophrenia. Psychological Review 99, 45–77.

Collins, A.M., Loftus, E.F., 1975. A spreading-activation theory of semantic processing. Psychological Review 82, 407–428.

Della Casa, V., Hofer, I., Weiner, I., Feldon, J., 1999. Effects of smoking status and schizotypy on latent inhibition. Journal of Psychopharmacology 13, 45–57.

Dunn, L.M., Dunn, L.M., 1997. Peabody Picture Vocabulary Test, 3rd ed. American Guidance Service, Circle Pines, MN.

Ettinger, U., Kumari, V., Crawford, T.J., Flak, V., Sharma, T., Davis, R.E., Corr, P.J., 2005. Saccadic eye movements, schizotypy, and the role of neuroticism. Biological Psychology 68, 61–78.

Giovannetti, T., Goldstein, R.Z., Schullery, M., Barr, W.B., Bilder, R.M., 2003. Category fluency in first-episode schizophrenia. Journal of the International Neuropsychological Society 9, 384–393.

Hampton, J.A., Gardiner, M.M., 1983. Measures of internal category structure: a correlational analysis of normative data. British Journal of Psychology 74, 491–516.

Hunt, K.P., Hodge, M.H., 1971. Category-item frequency and category-name meaningfulness (m′): taxonomic norms for 84 categories. Psychonomic Monograph Supplements 4, 97–121.

Jang, K.L., Woodward, T.S., Lang, D., Honer, W.G., Livesley, W.J., 2005. The genetic and environmental basis of the relationship between schizotypy and personality: a twin study. Journal of Nervous and Mental Disease 193, 153–159.

Janowsky, D.S., Huey, L., Storms, L., Judd, L.L., 1977. Methylphenidate hydrochloride effects on psychological tests in acute schizophrenic and nonpsychotic patients. Archives of General Psychiatry 34, 189–194.

Johnson, D.E., Shean, G.D., 1993. Word associations and schizophrenic symptoms. Journal of Psychiatry Research 27, 69–77.

Kendler, K.S., Ochs, A.L., Gorman, A.M., Hewitt, J.K., Ross, D.E., Mirsky, A.F., 1991. The structure of schizotypy: a pilot multitrait twin study. Psychiatry Research 36, 19–36.

Kiang, M., Kutas, M., 2005. Association of schizotypy with semantic processing differences: an event-related brain potential study. Schizophrenia Research 77, 329–342.

Kimble, M., Lyons, M., O'Donnell, B., Nestor, P., Niznikiewicz, M., Toomey, R., 2000. The effect of family status and schizotypy on electrophysiologic measures of attention and semantic processing. Biological Psychiatry 47, 402–412.

Klein, C., Andresen, B., Berg, P., Kruger, H., Rockstroh, B., 1998. Topography of CNV and PINV in schizotypal personality. Psychophysiology 35, 272–282.

Lubow, R.E., De la Casa, G., 2002. Latent inhibition as a function of schizotypality and gender: implications for schizophrenia. Biological Psychology 59, 69–86.

McCloskey, M.E., Glucksberg, S., 1978. Natural categories: well defined or fuzzy sets. Memory and Cognition 6, 462–472.

McEvoy, C.L., Nelson, D.L., 1982. Category name and instance norms for 106 categories of various sizes. American Journal of Psychology 95, 581–634.

McRae, K., Cree, G.S., 2002. Factors underlying category-specific semantic deficits. In: Forde, E.M.E., Humphreys, G. (Eds.), Category-Specificity in Mind and Brain. Psychology Press, East Sussex, UK.

Merten, T., 1993. Word association responses and psychoticism. Personality and Individual Differences 14, 837–839.

Mervis, C.B., Catlin, J., Rosch, E., 1976. Relationships among goodness-of-example, category norms, and word frequencies. Bulletin of the Psychonomics 283–284.

Miller, E.N., Chapman, L.J., 1983. Continued word association in hypothetically psychosis-prone college students. Journal of Abnormal Psychology 92, 468–478.

Minzenberg, M.J., Ober, B.A., Vinogradov, S., 2002. Semantic priming in schizophrenia: a review and synthesis. Journal of the International Neuropsychological Society 8, 699–720.

Moritz, S., Andresen, B., Domin, F., Martin, T., Probsthein, E., Kretschmer, G., Krausz, M., Naber, D., Spitzer, M., 1999. Increased automatic spreading activation in healthy subjects with elevated scores in a scale assessing schizophrenic language disturbances. Psychological Medicine 29, 161–170.

Neely, J., 1977. Semantic priming and retrieval from lexical memory: roles of inhibitionless spreading activation and limited-capacity attention. Journal of Experimental Psychology 106, 226–254.

Niznikiewicz, M.A., Voglmaier, M., Shenton, M.E., Seidman, L.J., Dickey, C.C., Rhoads, R., Teh, E., McCarley, R.W., 1999. Electrophysiological correlates of language processing in schizotypal personality disorder. American Journal of Psychiatry 156, 1052–1058.

Niznikiewicz, M.A., Shenton, M.E., Voglmaier, M., Nestor, P.G., Dickey, C.C., Frumin, M., Seidman, L.J., Allen, C.G., McCarley, R.W., 2002. Semantic dysfunction in women with schizotypal personality disorder. American Journal of Psychiatry 159, 1767–1774.

Niznikiewicz, M.A., Friedman, M., Shenton, M.E., Voglmaier, M., Nestor, P.G., Frumin, M., Seidman, L., Sutton, J., McCarley, R.W., 2004. Processing sentence context in women with schizotypal personality disorder: an ERP study. Psychophysiology 41, 367–371.

Paulsen, J.S., Romero, R., Chan, A., Davis, A.V., Heaton, R.K., Jeste, D.V., 1996. Impairment of the semantic network in schizophrenia. Psychiatry Research 63, 109–121.

Raine, A., 1991. The SPQ: a scale for the assessment of schizotypal personality based on DSM-III-R criteria. Schizophrenia Bulletin 17, 555–564.

Raine, A., Reynolds, C., Lencz, T., Scerbo, A., Triphon, N., Kim, D., 1994. Cognitive-perceptual, interpersonal, and disorganized features of schizotypal personality. Schizophrenia Bulletin 20, 191–201.

Rosch, E., Mervis, C.B., 1975. Family resemblances: studies in the internal structure of categories. Cognitive Psychology 7, 573–605.

Rossell, S.L., Rabe-Hesketh, S.S., Shapleske, J.S., David, A.S., 1999. Is semantic fluency differentially impaired in schizophrenic patients with delusions? Journal of Clinical and Experimental Neuropsychology 21, 629–642.

Ruts, W., De Deyne, S., Ameel, E., Vanpaemel, W., Verbeemen, T., Storms, G., 2004. Dutch norm data for 13 semantic categories and 338 exemplars. Behavior Research Methods, Instruments, and Computers 36, 506–515.

Sadock, B.J., Sadock, V.A., 2003. Kaplan and Sadock's Synopsis of Psychiatry: Behavioral Sciences, Clinical Psychiatry. Lippincott Williams & Wilkins, Philadelphia.

Shakow, D., 1980. Kent-Rosanoff Association and its implications for segmental set theory. Schizophrenia Bulletin 6, 676–685.

Shapiro, S.I., Palermo, D.S., 1970. Conceptual organization and class membership: normative data for representatives of 100 categories. Psychonomic Monograph Supplements 3, 107–127.

Siever, L.J., Davis, K.L., 2004. The pathophysiology of schizophrenia disorders: perspectives from the spectrum. American Journal of Psychiatry 161, 398–413.

Spitzer, M., 1997. A cognitive neuroscience view of schizophrenic thought disorder. Schizophrenia Bulletin 23, 29–50.

Spreen, O., Strauss, E., 1998. A Compendium of Neuropsychological Tests, 2nd ed. Oxford University Press, New York.

Stuss, D.T., Picton, T.W., Cerri, A.M., 1988. Electrophysiological manifestations of typicality judgment. Brain and Language 33, 260–272.

Sumiyoshi, C., Matsui, M., Sumiyoshi, T., Yamashita, I., Sumiyoshi, S., Kurachi, M., 2001. Semantic structure in schizophrenia as assessed by the Category Fluency Test: effect of verbal intelligence and age of onset. Psychiatry Research 105, 187–199.

Troyer, A.K., Moscovitch, M., Winocur, G., Leach, L., Freedman, M., 1998. Clustering and switching on verbal fluency tests in Alzheimer's and Parkinson's disease. Journal of the International Neuropsychological Society 4, 137–143.

Ward, P.B., McConaghy, N., Cates, S.V., 1991. Word association and measures of psychosis proneness in university students. Personality and Individual Differences 12, 473–480.

Yoon, C., Feinberg, F., Hu, P., Gutchess, A.H., Hedden, T., Chen, H.M., Jing, Q., Cui, Y., Park, D.C., 2004. Category norms as a function of culture and age: comparisons of item responses to 105 categories by American and Chinese adults. Psychology and Aging 19, 379–393.