6. Robinson DG, Woerner MG, Alvir JMJ, Geisler S, Koreen A, Sheitman B, Chakos M, Mayerhoff D, Bilder R, Goldman R, Lieberman JA: Predictors of treatment response from a first episode of schizophrenia or schizoaffective disorder. Am J Psychiatry 1999; 156:544–549
7. Spitzer RL, Endicott J: Schedule for Affective Disorders and Schizophrenia—Change Version, 3rd ed. New York, New York State Psychiatric Institute, Biometrics Research, 1978
8. Cannon-Spoor H, Potkin G, Wyatt J: Measurement of premorbid adjustment in chronic schizophrenia. Schizophr Bull 1982; 8: 470–484
9. Simpson GM, Angus JWS: A rating scale for extrapyramidal side effects. Acta Psychiatr Scand Suppl 1970; 212:11–19
10. Roberts G: The origins of delusion. Br J Psychiatry 1992; 161: 298–308
11. Berner P, Gabriel E, Kieffer W, Schanda H: "Paranoid psychoses": new aspects of classification and prognosis coming from the Vienna Research Group. Psychopathology 1986; 19:16–29
12. David AS: Auditory hallucinations: phenomenology, neuropsychology and neuroimaging update. Acta Psychiatr Scand Suppl 1999; 395:95–104
13. Barta PE, Pearlson GD, Powers RE, Richards SS, Tune LE: Auditory hallucinations and smaller superior temporal gyral volume in schizophrenia. Am J Psychiatry 1990; 147:1457–1462
14. Flaum M, O'Leary DS, Swayze VW II, Miller DD, Arndt S, Andreasen NC: Symptom dimensions and brain morphology in schizophrenia and related psychotic disorders. J Psychiatr Res 1995; 29:261–276
15. Levitan C, Ward PB, Catts SV: Superior temporal gyral volumes and laterality correlates of auditory hallucinations in schizophrenia. Biol Psychiatry 1999; 46:955–962
16. Rajarethinam RP, DeQuardo JR, Nalepa R, Tandon R: Superior temporal gyrus in schizophrenia: a volumetric magnetic resonance imaging study. Schizophr Res 2000; 41:303–312
17. Milev P, Ho BC, Arndt S, Nopoulos P, Andreasen NC: Initial magnetic resonance imaging volumetric brain measurements and outcome in schizophrenia: a prospective longitudinal study with 5-year follow-up. Biol Psychiatry 2003; 54:608–615
18. Onitsuka T, Shenton ME, Salisbury DF, Dickey CC, Kasai K, Toner SK, Frumin M, Kikinis R, Jolesz FA, McCarley RW: Middle and inferior temporal gyrus gray matter volume abnormalities in chronic schizophrenia: an MRI study. Am J Psychiatry 2004; 161:1603–1611
19. Szeszko PR, Bilder RM, Lencz T, Pollack S, Alvir JM, Ashtari M, Wu H, Lieberman JA: Investigation of frontal lobe subregions in first-episode schizophrenia. Psychiatry Res 1999; 90:1–15
20. Prasad KM, Rohm BR, Keshavan MS: Parahippocampal gyrus in first episode psychotic disorders: a structural magnetic resonance imaging study. Prog Neuropsychopharmacol Biol Psychiatry 2004; 28:651–658
21. Breier A, Schreiber JL, Dyer J, Pickar D: National Institute of Mental Health longitudinal study of chronic schizophrenia: prognosis and predictors of outcome. Arch Gen Psychiatry 1991; 48:239–246; correction, 48:642

Brief Report

Cognitive Control and Semantics in Schizophrenia: An Integrated Approach

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Objective: The authors tested whether decisions about incongruencies in the representation and processing of semantic knowledge, thought to be related to cognitive control, are selectively impaired in schizophrenia.

Method: Twenty-four patients with schizophrenia and 24 healthy comparison subjects determined the relative size of paired stimuli as they are in the real world. Stimuli were words or images. Real-world "distance" (size difference between stimuli) was manipulated within pairs, as was "congruency" between real-world and presentation size.

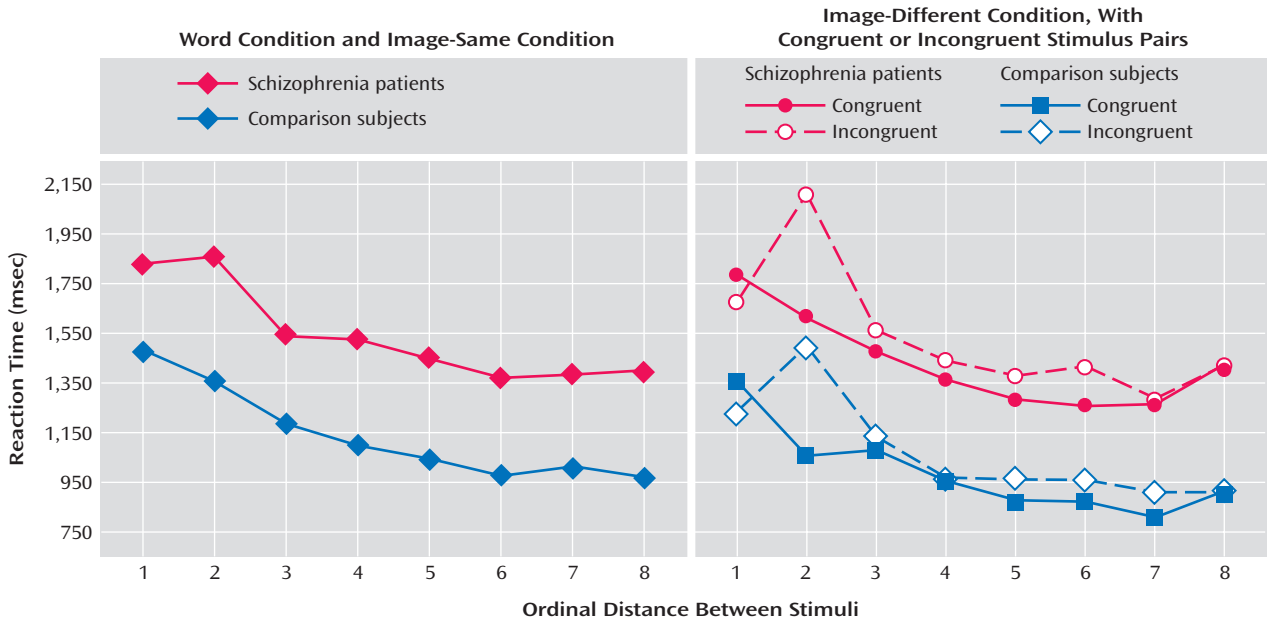
Results: Although patients were slower overall, both groups exhibited similar effects of "distance" and "congruency"; the task was easier when the real-world size difference between stimuli was greater and when stimuli were congruent in presentation and real-world size.

Conclusions: Some aspects of the representation of semantic knowledge are preserved in schizophrenia, and patients use this information to control cognition in the same manner as healthy individuals.

(Am J Psychiatry 2005; 162:1969–1971)

Information-processing problems comprise core deficits in schizophrenia. Observations of semantic memory impairments in these patients (1) do not conclusively pinpoint where these problems occur (e.g., at representation or retrieval). We examined this issue using 1) the "distance" effect: judgments about stimuli further apart in size are easier to make than about those whose sizes are more similar (2); and 2) the "congruency" effect: processing congruent information is more efficient than processing incongruent information (e.g., a Stroop paradigm). Con-

FIGURE 1. Median Reaction Time of Schizophrenia Patients and Comparison Subjects to Word Condition, Image-Same Condition, and Image-Different Condition, With Congruent and Incongruent Stimulus Pairs, as a Function of Ordinal Distance Between Stimuli



gruency effect findings have been inconsistent in schizophrenia (3).

We capitalized on the distance and congruency effects by employing a framework within which we could specify the nature of anomalies in knowledge representation and processing. If knowledge organization is unsystematic in patients, responses will not be lawful, as predicted by the distance effect, and problems in cognitive control will result in greater interference from incongruent stimuli. Also, since decisions involving words are harder than images (words first require a conversion to their visual analogs [4]), a combination of general slowing and an extra processing step should disproportionately slow patients' responses to words.

Method

Twenty-four patients (20 men; mean age=32.5 years, SD=10.5) with a DSM-IV diagnosis of schizophrenia or schizoaffective disorder and 24 normal healthy volunteers (10 men; mean age=31.3 years, SD=8.9) participated in the study. After the procedure had been fully explained, written informed consent was obtained before testing.

The patients were taking neuroleptic medication (mean illness duration=9.8 years, SD=7.7). Intellectual function was assessed with the Wide-Range Achievement Test—Revised (WRAT-R) reading section (5) and a short form of the WAIS-R (6). The patients were matched with the comparison subjects for age ($p>0.50$) and WRAT-R score ($p>0.10$) but had lower WAIS-R scores (mean=89.0, SD=9.1, and mean=110.7, SD=9.0, respectively) ($t=8.26$, $df=46$, $p<0.00001$).

We compiled a set of line drawings (7) and words whose relative size was determined by 20 healthy volunteers in a pilot study. The participants in the present experiment decided as quickly and accurately as possible, by pressing one of two buttons, the relative size of two stimuli displayed on a computer monitor, either words ("word" condition) or images ("image-same" and "image-different" conditions). The prompt was, "Is the stimulus on the bottom larger or smaller in the real world than the stimulus on the top?" In the image-different condition, the images were congruent if real-world size and presentation size were consistent (small "bee," large "sailboat") and incongruent if the two dimensions were not consistent (large "bee," small "sailboat"). Each trial consisted of the appearance of an asterisk (for 1,000 msec), then a blank screen (for 250 msec), then the stimulus pair, which remained until a response was given (or for a maximum of 6,000 msec). Before the next trial, there was another blank screen (for 250 msec).

The magnitude of the real-world distance (size difference) between the two stimuli was systematically varied. Each stimulus was rank ordered from smallest to largest, with the ordinal distance of a stimulus pair defined as the difference in ranking. Each distance between stimuli (1 through 8) was tested 16 times per condition, for a total of 128 trials.

In the image-same condition, the stimuli were images drawn to be equivalent in physical size (visual vertical and horizontal angles=6.30°). In the image-different condition, the stimuli were two images depicted in different sizes: small (visual vertical and horizontal angles=5.15°) and large (visual vertical and horizontal angles=11.42°). Half the trials were congruent. In the word condition, the stimuli were two words.

Data were analyzed with repeated-measures analysis of variance. Only correct responses were included in the reaction time analyses. Median and average reaction times yielded equivalent results; thus only median reaction times are reported.

Results

First, examination of the word and image-same conditions revealed a distance effect; a larger size difference correlated with faster judgments ($F=79.14$, $df=7, 308$, $p<0.001$). Although the patients were slower than the comparison subjects (mean=1,544 msec, SD=195, versus mean=1,141 msec, SD=189) ($F=17.98$, $df=1, 44$, $p<0.001$), there was no

group-by-distance interaction (F=1.38, df=7, 308, p>0.10) (Figure 1).

Second, congruent information was processed more rapidly than incongruent information (image-different condition) (mean=1,211 msec, SD=290, versus mean=1,304 msec, SD=333) (F=12.91, df=1, 44, p<0.001). As in the word and image-same conditions, there were significant effects of distance (F=53.35, df=7, 308, p<0.00001) and group (F=19.69, df=1, 44, p<0.0001) (mean=1,486 msec, SD=227, versus mean=1,029 msec, SD=190, for patients and comparison subjects, respectively) but no significant interactions (group-by-congruency: F=0.18, df=1, 44, p>0.50; group-by-distance: F=1.42, df=7, 308, p>0.10; group-by-congruency-by-distance: F=0.24, df=7, 308, p>0.50) (Figure 1). This lack of a group-by-congruency interaction was *not* attributable to the patients' overall slowness (additional analyses with percentage change is available from the authors).

Third, words were processed slower than images (mean=1,558 msec, SD=378, versus mean=1,127 msec, SD=196) (F=182.27, df=1, 44, p<0.001). Of interest, there was a group-by-condition (words, images) interaction because patients were disproportionately slow when making decisions about words (F=37.36, df=1, 44, p<0.001).

Accuracy data for all three conditions were consistent with reaction times. Some results were nearly significant.

Discussion

This study capitalized on robust "distance" and "congruency" effects. Each condition produced the expected outcomes: slower responses for judgments involving a smaller size difference, incongruent trials, and decisions about words as compared to images. This pattern was similar in both groups, implying that patients display normal knowledge representation and manipulation in a task requiring cognitive control.

The preserved distance effect in patients indicates successful accessing of distance, a critical semantic feature. Although distance is only one feature in the semantic system, there is no particular reason to assume feature-specific deficits in schizophrenia. Our interpretation of this normal knowledge representation is consistent with previous studies (8) (but see reference 1).

The congruency effect has been explored frequently in schizophrenia by using either the Stroop (3) or flanker paradigms with inconsistent results, likely because of methodological differences. Although the current stimuli are quite different from those in traditional paradigms, we nonetheless found highly significant congruency effects, implying that semantic judgment can provide considerable conflict.

In terms of brain regions, the anterior cingulate cortex is reliably engaged in tasks requiring conflict monitoring (9). In semantic tasks, the selection between conflicting responses has been found to activate the left inferior frontal gyrus (10). To our knowledge, semantic tasks focusing on conflict have not been applied to functional neuroimaging paradigms in schizophrenia, although it has been shown that the neurodevelopment, morphometry, and function of the anterior cingulate cortex are abnormal in schizophrenia (11).

Finally, the patients were disproportionately slow when processing words as compared to images, possibly attributable to extra slowing at each information-processing stage rather than being stimulus specific.

Our data provide evidence that some aspects of semantic knowledge are represented normally in schizophrenia and, crucially, that patients can exert cognitive control over this information in a systematic and lawful manner to "override" incongruent information. These findings usefully constrain theories about the way patients with schizophrenia understand and manipulate semantic information to make sense of the world.

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References

1. McKay AP, McKenna PJ, Bentham P, Mortimer AM, Holbery A, Hodges JR: Semantic memory is impaired in schizophrenia. Biol Psychiatry 1996; 39:929–937
2. Dehaene S: The Number Sense: How the Mind Creates Mathematics. New York, Oxford University Press, 1999
3. Barch DM, Carter CS, Hachten PC, Usher M, Cohen JD: The "benefits" of distractibility: mechanisms underlying increased Stroop effects in schizophrenia. Schizophr Bull 1999; 25:749–762
4. Moyer RS: Comparing objects in memory: evidence suggesting an internal psychophysics. Percept Psychophys 1973; 13:180–184
5. Jastak S, Wilkinson GS: The Wide Range Achievement Test, Revised. Wilmington, Del, Jastak Associates, 1984
6. Wechsler D: Manual for the Wechsler Adult Intelligence Scale—Revised. San Antonio, Tex, Psychological Corp, 1981
7. Snodgrass JG, Vanderwart M: A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. J Exp Psychol [Hum Learn] 1980; 6:174–215
8. Elvevåg B, Heit E, Storms G, Goldberg T: Category content and structure in schizophrenia: an evaluation using the instantiation principle. Neuropsychology 2005; 19:371–380
9. van Veen V, Carter CS: The anterior cingulate as a conflict monitor: fMRI and ERP studies. Physiol Behav 2002; 77:477–482
10. Thompson-Schill SL, D'Esposito M, Aguirre GK, Farah MJ: Role of left inferior prefrontal cortex in retrieval of semantic knowledge: a reevaluation. Proc Natl Acad Sci USA 1997; 94:14792–14797
11. Laurens KR, Ngan ET, Bates AT, Kiehl KA, Liddle PF: Rostral anterior cingulate cortex dysfunction during error processing in schizophrenia. Brain 2003; 126:610–622