PATTERNS OF CHANGE IN SEMANTIC CLUSTERING IN

SCHIZOPHRENIA SPECTRUM DISORDERS: WHAT CAN

IT TELL US ABOUT THE NATURE OF

CLUSTERING DEFICITS

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Semantic clustering has been used as a measure of learning strategies in a number of clinical populations and has been found to be deficient in individuals with Schizophrenia, but less attention has been paid to the dynamic use of this strategy over the course of fixed-order learning trials. In the current study, we examined this pattern of clustering use over trials in a sample of individuals with Schizophrenia, and explored whether the addition of this dynamic information would help us to better predict specific executive deficits. Results suggested that a decrease in semantic clustering across trials was associated with some executive deficits in the predicted manner. Nonetheless, the overall semantic clustering index generally proved more effective for the purposes, suggesting that in this population, the addition of dynamic information in strategy use is not likely to add considerably to clinical prediction and understanding.

ACKNOWLEDGMENTS

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CHAPTER 1

INTRODUCTION

The study of verbal memory has a long history in
Psychology dating back to Ebbinghaus's famous studies on
memorization of series of meaningless word lists
(Hothersall, 1995). Today, this long line of research is
drawn upon in the neuropsychological assessment of
individuals, the development of measures to tap brain-
behavior relationships, and in the description of cognitive
impairments across various populations. In addition to
research on recall and recognition, there have been
attempts to further break down the components of memory
processes. One area of interest has been the use of
learning strategies. More specifically, studies have
addressed how organizational strategies may be used to
increase recall. This latter area is the focus of the
current proposal.

One type of organizational strategy is semantic
clustering, or organizing related words together in memory.
The strategy of organizing semantically-related words in
this manner was shown to be used by healthy individuals and

was related to total recall (Sakoda, 1959; Tulving, 1962). Based on this earlier research, investigators began looking at differences between clinical groups in the tendency to organize information using a semantic clustering strategy. Decreased semantic clustering was found in a wide variety of clinical groups including individuals with Mental Retardation (Gerjouy & Spitz, 1966), Attention Deficit Hyperactivity Disorder (August, 1987), Nonverbal Learning Disability (Fisher & Deluca, 1997), Parkinson's Disease (Buytenhuijs, et al., 1994; Massman, Delis, Butters, Levin, & Salmon, 1990), head injuries (Gershberg & Shimamura, 1995; Levin, et al., 1996; Levin & Goldstein, 1986; Stallings, Boake, & Sherer, 1995; Villardita, 1987), Schizophrenia (Heinrichs, 1994; Paulsen et al, 1995), Schizotypal Personality Disorder (Volgmaier,Seidman, Salisbury, & McCarley, 1994; Volgmaier, Seidman, Salisbury, & McCarley, 1997), Alzheimer's Disease (Simon, Leach, Winocur, & Moscovitch, 1994), and HIV (Peavy, et al., 1994).

Most of the research in this area has measured total semantic clustering across a series of fixed learning trials rather than breaking down the pattern of organization within each trial. That is, while an overall

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measure of semantic clustering in learning was obtained, changes in the use of this strategy over repeated learning trials was not assessed. Nevertheless, it is possible that an increased understanding of memory processes may be obtained by breaking this clustering variable down further.

One goal of this study was to investigate variable patterns of semantic organization across a series of fixed verbal recall trials in a group of individuals with schizophrenia spectrum disorders (Schizophrenia and Schizoaffective disorders) and to analyze whether the pattern of changes in use of this strategy across trials in this population is associated with other neuropsychological variables. A second goal was to investigate the relationship between patterns of semantic organization across trials and degree of benefit from later cueing. The rationale and literature review that follows, is organized according to breadth and temporal development of the important concepts. It begins with early research on semantic clustering and word-list learning, in general, before the issue of changes in recall over trials is discussed. Cued-recall will then be addressed and followed by a brief review of research on the schizophrenia

spectrum, addressing issues relevant to the current study. Finally, the proposed study will be described in detail.

Early Research on Semantic Clustering

A large amount of research in the mid 20th century began to accumulate about the role of semantic organization in recall. It was determined, for example, that the degree of semantic similarity of an entire list of words can reduce overall recall (Baddeley, 1966); perhaps by decreasing distinctiveness among the stimuli. In contrast, the addition of semantic similarity that provides order can increase recall (Puff, 1970). This is created by providing multiple semantically-related groups of words within the list. For example, a list may consist of 12 words, containing 4 words from three semantic categories (e.g.,furniture, plants, and animals). The effects of this type of semantic organization (by providing shorter groups of words to recall) can be seen in a study by Miller (1965). This study compared recall on lists of 12 words that were either all semantically-related, contained two groups of six semantically-related words, or three groups of 4 semantically related words. Recall was lowest for the former list and highest on the latter, demonstrating how

memory can be aided by the addition of semantic structure in the free recall stimuli.

It is clear that individuals will remember more words from a list that has been semantically-grouped by the examiner (Miller, 1965). Even without such explicit grouping, however, individuals often use and benefit from implicit semantic structure within a free recall list. There is a tendency in healthy individuals to self-organize words according to semantic groupings during free recall when words are presented in mixed order by the examiner (Tulving, 1962). That is, when asked to recall a list of words that are randomly organized but have an inherent semantic organization, individuals will show a tendency to cluster semantically-related words together in terms of their order of recall. This tendency to organize order of recall by semantic groups is referred to as semantic clustering (Bousfield, 1953).

The tendency for individuals to self-organize information through semantic clustering has been considered a measure of their ability to spontaneously use an effective learning strategy (Delis, Kramer, Kaplan, & Ober, 1987). Indeed, it appears to be effective, in that semantic clustering during free recall has been shown to be an

advantageous learning strategy and there is a consistent

correlation between amount of semantic clustering and total

recall in healthy adults (Sakoda, 1959; Tulving, 1962).

Providing cues to encourage semantic organization during

recall can also lead to improved performance. The use of

semantic cueing during recall (i.e., providing the category

names and asking examinees to recall the words in each of

the categories separately) has even been shown to increase

the recall of "non-intentional learners" (those not told

that they will be asked to recall the material) to the

level of recall found in "intentional learners" (Postman,

Adams, & Bohm, 1956), perhaps suggesting that the provision

of recall cues may assist those failing to actively

organize the material during the learning phase.

Tulving (1968) differentiated between primary and

secondary organization in this type of learning situation.

The former referred to that organization which was inherent

within the learning situation and the latter referred to

organization which required the learner to draw on

experiences previous to the learning situation. Semantic

clustering was considered by Tulving (1968) to be a process

of secondary organization, in that individuals must draw on

previous experience and knowledge about the words when organizing them.

Semantic clustering, in requiring general information about the words rather than memory specific to a time and place, may also be related to semantic memory (Baddely, 1990; Tulving, 1972, 1983). Some support for the relationship between semantic clustering and amount of prior experience (or semantic knowledge of the words) is found in studies demonstrating that individuals tend to use more semantic clustering with lists of high-frequency than low-frequency words (Cofer, Bruce, & Reicher, 1966; Rabinowitz, 1991). Thus, semantic clustering may vary with familiarity of the stimuli. This may also explain why the correlation between semantic clustering and total recall is less likely to be found in studies of children's recall (Bjorklud & Jacobs, 1985; Frankel & Rollins, 1985). It may be that the decreased semantic knowledge in children affects their degree of benefit from such a strategy. If so, it is possible that lower education, overall intelligence, or impaired semantic memory could impact the relationship between semantic clustering and performance in older individuals, as well.

In contrast to semantic organization, individuals may also choose a strategy of recalling a list of words in the order in which they are presented. This strategy is referred to as serial clustering and would be considered a process of primary organization (Tulving, 1968), because it draws directly upon experience with the words at the time of stimulus presentation rather than involving past experience with the words. In that serial clustering also relies on contextual and temporal information present during learning acquisition, it could also be considered more closely related to episodic memory (Baddeley, 1990; Tulving, 1972, 1983).

When lists with inherent semantic groupings are provided, the use of a serial clustering strategy is generally less effective than the use of a semantic organizational strategy (Craik, 1981). In fact, in one early study it was found that the addition of instructions to recall the serial order of a list resulted in a reduction of overall recall (Postman, Adams, & Bohm, 1956). In sum, semantic clustering is a useful strategy when attempting to recall word lists with inherent organization. The strategy appears to require some degree of active

organization (when explicit cueing is not provided) and sufficient semantic knowledge of the words.

The effectiveness of a semantic clustering strategy is so well documented by research, that it is used as a measure of an individual's ability to use appropriate learning strategies (Delis, Kramer, Kaplan, & Ober, 1987). As noted above, semantic clustering is found to be deficient in a number of clinical populations. Semantic clustering has been used as a measure of both executive functioning (*cf*., Romans, et al., 1997) and semantic memory (*cf*., Levin, et al., 1996). Likely, some ability in both areas is required for individuals to spontaneously use the strategy and to fully benefit from the semantic structure. The use of a less-effective serial clustering strategy, for example, was associated with hypofrontality in a PET study of patients with Obsessive Compulsive Disorder (Hazlett, et al., 2000), which indirectly confirms a relationship to executive abilities. Another study, however, found that while recall measures effectively discriminated between those with significant or minimal executive dysfunction, a semantic clustering index did not aid in distinguishing the groups (Tremont, et al., 2000).

One common neuropsychological measure that allows for the assessment of serial and semantic clustering strategies is a fixed-order multi- trial task: the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1987). The California Verbal Learning Test (CVLT) was designed with a stimulus list of 16 words, which represent four "shopping" categories of four words apiece. The primary list is presented in a mixed order (so words from the same categories are never presented contiguous to one another on the list) and is presented in the same order across five learning trials. The words on these lists were specifically chosen to avoid those most highly representative of the category (Delis, et al., 1987). The test correlates with general measures of verbal memory (Crosson, Cooper, Lincoln, Bauer, & Velozo, 1993), as well as with intellectual abilities (Lezak, 1995).

Though the CVLT is a commonly used measure to assess the use of a semantic organization strategy in word-list recall, the issue had been raised regarding whether is was optimally-sensitive to semantic clustering (Elwood, 1995). Specifically, whether the use of fixed-order learning trials (rather than permuting word order across trials) on the CVLT may lead to a decrease in semantic clustering over

the course of trials. The assertion is that this could occur as the repeated serial order becomes a more prominent organizational cue for the individual learning the list, thus requiring more effort on the part of the learner to reorganize using a semantic strategy.

Indeed, some researchers have considered serial organization in multiple fixed-order trials to be a type of explicit cueing (Buytenhuijs, et al., 1994; Van Spaendonck, et al., 1996). In these studies, the researchers used the multiple fixed order format to compare explicit cueing and implicit cueing. While the serial organization was explicit, being part of the organization of the list over trials, the semantic relations in the lists were described as implicit because they are not specifically divulged to the examinee. It was further supposed that the explicit cueing (serial order) would be more salient and require less self-organization, while use of the implicit organizational aspects (semantic clustering) would not only require self- organization, but would require some degree of inhibition of the more salient serial organization. Before discussing changes in clustering over trials in clinical populations, I will turn to research on the relationship between organization and multiple trials in

healthy individuals. The main question to address is, does fixed-order presentation lead to decreased semantic clustering as a general rule?

Repeated Trials and Recall Organization

Early research on multitrial list-learning generally used permuted order across trials. That is, each time the word-list was repeated, the order was changed. Research using word-lists of this format has demonstrated that both recall and semantic clustering increases over trials (Bousfield, Berkowitz, & Whitmarsh, 1959; Bousfield & Cohen, 1953; Bousfield, Esterson, & Whitmarsh, 1958; Gershberg & Shimamura, 1995; Marshall, 1967; Robinson, 1966; Rosenberg, 1966; Shuell, 1969; Tulving, 1962). Even additional recall trials, without further presentations of the list, have been shown to increase the amount of semantic clustering in healthy individuals (Brand, 1956; Cofer, Bruce, & Reicher, 1966). Individuals with head injuries were also shown to demonstrate an increased use of semantic clustering across permuted trials (Gershberg & Shimamura, 1995), though they showed less increase over trials than did controls.

With repeated fixed-order trials of a non-categorical list, however, there is an increasing tendency in healthy individuals to recall the list in the order in which it was presented (Mandler & Dean, 1969). Thus, there is increased serial clustering over trials with lists of unrelated words. Does this effect generalize to word-lists with inherent categorical structure? Does serial clustering become more prominent than semantic clustering as trials progress, such that individuals will rely more on this less-efficient but more salient organizational strategy? If so, healthy individuals would decrease semantic clustering across trials of a fixed-order categorized list.

In general, the hypothesis above has not been supported. There have been several studies which show changes in semantic clustering across trials of the CVLT in various populations. In these studies, healthy control groups have shown increased semantic clustering over the course of learning trials (Lyons, et al., 1995; Simon, Leach, Winocur, & Moscovitch, 1994; Volgmaier, Seidman, Salisbry, & McCarley, 1997). To some extent, patterns of increased semantic clustering over CVLT trials have been found in a few clinically-related populations. At the same time, however, certain groups have displayed some

deficiency in semantic clustering. One study, for example, demonstrated increased semantic clustering across trials in relatives of individuals with schizophrenia (Lyons, et al., 1995) similar to that seen in control populations, but the relatives showed problems in later recall. Another study demonstrated that a group of patients diagnosed with Schizotypal Personality Disorder (SPD) showed increases in semantic organization across trials, though the extent of use of the learning strategy was generally suboptimal (Volgmaier, et al., 1997).

A dissociation between inability to semantically cluster and a tendency to respond to the explicit serial cuing of a fixed-order multitrial list was demonstrated in research on patient's with Parkinson's Disease (Buytenhuijs, et al., 1994; Van Spaendonck, et al., 1996). Specifically, these reseearchers demonstrated that these individuals used less semantic clustering on a multiple-trial, fixed-order learning task, despite evidence of intact ability to semantically cluster on the initial recall trial. Though the patient group made less use of the implicit semantic organization in the standard fixed-order condition, they used normal levels of semantic clustering when a permuted multitrial list was used (in order to avoid

the repeated presentation of serial order information).

This suggests that the initial decrement in semantic

clustering may have been at the level of a deficit in

executive attention rather than reflective of an inability

to make use of the semantic information.

Thus, at least for this group, the argument that

fixed- ordered trials may decrease semantic clustering even

in those who might otherwise be capable of using this

strategy was correct. One finding more directly relevant to

this argument was that although individuals with

Parkinson's disease in the aforementioned studies showed

decreased use of semantic clustering across trials

(Buytenhuijs, et. al, 1994; Van Spaendonck, et. al., 1996)

when a fixed ordered format was used, the opposite effect

(increased use of the semantic clustering strategy over

trials) was found when the list-order was permuted. These

findings are consistent with the idea that fixed-order

presentation may decrease semantic organization in at least

some individuals susceptible to the distraction of serial

order. Individuals with Parkinson's Disease may decrease

use of the more effective semantic grouping strategy

because of difficulty inhibiting the serial order

information (made salient through repetition). Similar

difficulties with inhibition have been found in individuals with Parkinson's Disease on a conceptually analogous Stroop interference task (Hanes, Andrewes, Smith & Pantelis, 1996; Henik, Singh, Beckley, & Rafal, 1993).

In sum, healthy individuals have a tendency to increase semantic clustering over the course of both permuted and fixed trials. With regard to clinical populations, a few studies suggest that use of semantic clustering may be somewhat deficient. Some patients may show the expected pattern of increased clustering, even if attenuated, while others may decrease their use of the strategy as trials progress. It is this latter pattern that is of interest for proposed study, as it suggests relatively intact initial encoding of the categorical information, despite decreasing use of the information to aid recall. Of further note, in the Van Spaendonck et al. study (1996), the researchers found that the normative pattern of increasing semantic categorization across trials was found in subjects with Parkinson's Disease when they were informed, prior to acquisition, about the categorical structure of the task (i.e., given the category names into which the list could be grouped). Thus, such cueing may also affect later degree and pattern of semantic

categorization in a group of individuals who would

otherwise be prone to decreased use of this strategy across

trials.

Cued Recall

In addition to free recall trials, some categorized

list-learning tasks, such as the CVLT, provide a cued-

recall condition where examinees are asked to recall the

words in each of the categories individually, thereby

explicitly providing the semantic organization for the

individual at recall (Delis, et al., 1997). The intent of

this procedure is to allow comparison of the cued and free

recall conditions, with the assumption that increased

performance on the cued condition is indicative of a

deficit at the level of recall rather than encoding (where

decreased performance would be expected under both recall

conditions). This pattern is supported by some studies

demonstrating the expected degree of improvement from

cueing in clinical populations thought to have retrieval

deficits versus populations with memory deficits at the

level of encoding or storage. For example, some studies

have found the predicted failure to improve with cueing in

patients with Korsokoff's syndrome (Cermak & Butters, 1972)

and Alzheimer's Disease (Massman, Delis, & Butters, 1993),
while others have confirmed the expected pattern of
improvement from cueing in patients with Huntington's
Disease (Albert, Butters, and Brandt, 1981).

Despite some support, the relationship between the
ability to benefit from cueing and the level at which the
memory deficit occurs (encoding versus retrieval) is not
always clear in the literature. For example, one study
failed to find improvement on cued recall in patients with
Huntington's Disease (Massman, Delis, & Butters, 1993).
Another study showed improvement from cueing in an encoding
deficit group but not a group determined to have retrieval
deficits (Crosson, Novack, Trenerry, & Craig, 1989). Thus,
there are some discrepancies in the literature regarding
the extent to which cueing during recall differentially
benefits individuals with retrieval deficits.

Although the distinction in performance between
encoding and retrieval deficit groups may be controversial,
the benefit of clustering cues (such as those provided
during cued-recall trials) for some groups, is well-
established. For example, recall cueing has been shown to
differentially improve the performance of head-injured
patients relative to controls (Crosson, Novack, Trenerry, &

Craig, 1988). In early research on this phenomenon Postman, Adams, & Bohm (1956) demonstrated that semantic recall-cueing could improve the performance of a group of non-intentional learners (individuals not told they will be later asked to recall the list) to the level of intentional learners. This latter finding suggests that the addition of recall cues may have mediated the effects of decreased processing effort during encoding that would be expected in the non-intentional group.

These studies are of interest for the current study in that cued recall might provide the greatest advantage to those who are capable of benefiting from information about semantic relatedness to aid recall, but have not fully utilized this information during initial recall trials. Non-intentional learners may be one example of such a group. They may have failed to actively re-organize the information during encoding, because no active learning strategy was called for. While decreased processing effort of unintentional learners may be one variable affecting active use of learning strategies, other factors may influence the tendency to use a semantic clustering strategy in individuals who otherwise may be capable of doing so. Fixed order trials enhance the saliency of serial

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order and may lead to reduced semantic clustering over trials in a subgroup of individuals particularly susceptible to this interference. To the extent that such individuals are capable of using the semantic structure (as evidenced by initial use of the strategy on the first trial) but have not made full use of it during the free recall trials, we might predict that they (like the unintentional learners) would be particularly likely to benefit when the semantic structure is made more salient during cued recall.

Not all individuals, however, are equally capable of using or benefiting from implicit semantic organization within a word list. As mentioned above, a study of individuals with Schizotypal Personality Disorder (Volgmaier, et al., 1997), for example, demonstrated a relatively lower use of semantic clustering on the CVLT in this group; though they also showed a tendency to increase use of the strategy over trials. In contrast to a pattern of decreased use of semantic cueing over trials, this pattern of performance suggests that the lower use of semantic clustering was not solely due to interference from the more salient serial cueing inherent in repeated fixed-order trials. If this were the case, relatively normal use

of the strategy on trial one would be expected (when serial order had not yet been repeated) and semantic clustering might be expected to decrease as the serial order became more salient with repetition. Instead, the overall decreased use of the strategy may suggest more general difficulties in initiating and benefitting from the semantic structure. If this is the case, making the semantic structure explicit should not improve recall. This hypothesis was, in fact, confirmed. The clinical group did have poorer recall performance after semantic cueing compared to controls, which the authors interpreted as potentially suggestive of a more general deficit in using the semantic information (in contrast with a purely organizational deficit). A similar pattern was seen in a study of relatives of individuals with schizophrenia (Lyons, et al., 1995), who showed overall lower use of semantic clustering compared to controls, with the expected increase in use of the strategy over trials but poorer recall performance after semantic cueing.

Schizophrenia Spectrum: Organization, encoding, and memory

The population chosen for the proposed study are individuals diagnosed within the schizophrenia spectrum

(Schizophrenia or Schizoaffective disorder) as defined by DSM-IV (APA, 1994). A large body of research has accumulated, which demonstrates a variety of cognitive deficits among individuals with Schizophrenia (Blanchard & Neale, 1994; Heinrichs & Zakzanis, 1998; Palmer et al., 1997; Saykin et al, 1991), which appear to be stable over time (Rund, 1998).

Despite the consistencies in the literature with regard to the presence of deficits in schizophrenia and their stability over time, there is considerable heterogeneity in the pattern of such deficits. Various studies have suggested that the neuropsychological deficits in this population may be generalized (Blanchard & Neale, 1994; Heinrichs & Zakzanis, 1998), with others finding evidence for selective deficits (Saykin et al., 1991). Not surprisingly, some research indicates that such deficits may even be relatively absent for a subgroup of patients (Goldstein & Shemansky, 1995; Palmer et al., 1997). Such heterogeneity can be problematic in attempting to describe a neuropsychological profile of schizophrenia, in general. However, this same variability may allow for identifying subgroups of patients, or differences among patients, that will have implications for treatment. For example,

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cognitive rehabilitation could be tailored to the needs and abilities of individuals, or of subgroups of patients who show a similar pattern of strengths and weaknesses.

Another advantage to studying cognitive deficits in schizophrenia, is in what can be learned by their potential relationship to symptoms. Here, differences in neuropsychological profiles may help to predict, or perhaps even help explain, the heterogeneity seen in the nature and course of the illness. Cognitive profiles have been linked to symptom clusters. For example, negative symptoms, positive symptoms, and disorganized symptoms may each predict different neuropsychological patterns (O'Leary et al., 2000).

Despite the heterogeneity of neuropsychological profiles noted above, there is a strong consensus that all patients (even those displaying a mostly unimpaired profile) show problems on tests of learning and memory (Goldstein, 1986; Heinrichs, & Zaksanis, 1998; Koh, 1987; Levin, Yurgelun- Todd, & Craft, 1989; Neale & Oltmanns, 1980). Notably, learning and memory problems in schizophrenia have also been shown to be associated with impairment in psychosocial functioning (Green, 1996, Green et al, 2000).

Although memory performance is fairly consistently impaired in studies of schizophrenia, there are mixed findings regarding the nature and severity of the deficits. While some suggest that memory and learning deficits in schizophrenia are disproportionate to other neuropsychological impairments and consistent with an amnestic syndrome (Gold, Randolph, Carpenter, Goldberg, & Weinberger, 1992; McKenna, Tamlyn, Lund, Mortimer, Hammond, & Baddeley, 1990; Saykin, et al., 1991; Tamlyn, McKenna, Mortimer, Lund, Hammond, & Baddeley, 1992), the relative prominence of memory deficit is controversial (Blanchard & Neale, 1994; Heinrichs & Zaksanis, 1998). A number of findings indicate that impairments differ from true amnestic disorders both in severity and pattern (Duffy & O'Carroll, 1994; Hawkins, Sullivan, & Choi, 1997; Hawkins, 1999).

There is divergence in the literature regarding the cognitive explanation for memory difficulties in schizophrenia; various studies suggest that the memory difficulties seen in individuals with schizophrenia may be related to impaired semantic memory (Duffy & O'Carroll, 1994), impaired organization (Calev, Venables, & Monk, 1983; Levin, Yurgelun-Todd, & Craft, 1989; Perlick,

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Stastny, Katz, Mayer, & Mattis, 1986), or attentional

impairments that disrupt encoding (Gjerde, 1983;

Nuechterlein & Dawson, 1984). The findings of impaired

memory performance coupled with the diversity of proposed

cognitive mechanisms, make this population particularly

interesting for studying the nature and consequences of

impaired learning strategies.

Of particular relevance to the current study,

individuals with schizophrenia have been found to use less

semantic clustering, in general, on list learning

(Heinrichs, 1994; Koh, Kayton, & Berry, 1973; Paulsen et

al, 1995), which is consistent with theories suggesting

either semantic memory or executive abilities deficits.

While past research has shown a relatively normal pattern

of increasing semantic clustering over trials in

individuals with Schizotypal Personality Disorder (SPD) and

in relatives of persons with schizophrenia (Lyons, et al.,

1995; Volgmaier, et al., 1997), changes in the use of

clustering over trials has not been fully investigated in

schizophrenia or schizoaffective disorder. There is no

basis, at this point, for proposing that these individuals,

as a group, would show a pattern of decreasing use of

clustering across fixed-order trials. In fact, the overall

lower use of the strategy in this population could result from difficulties such as deficits in attention, language processing, or general cognitive abilities that could presumably decrease ability to benefit from the strategy even if the semantic nature of the list were overt. However, to the extent that some individuals with schizophrenia have pronounced deficits in the executive functions, we may find a subgroup of individuals who show decreasing semantic clustering over trials similar to individuals with Parkinson's Disease. If differences do exist in the pattern of strategy-use across trials, analysis of these differences may help to refine hypotheses regarding possible mechanisms for the breakdown in organizational strategy and lead to the identification of a new variable useful for clinical interpretation. Of additional interest, is whether these differences are correlated with symptomatology.

Another possible factor that may affect pattern of performance on verbal learning tests among individuals with schizophrenia spectrum disorders is severity of illness. A good example of research in this area is that of Calev, Venables, and Monk (1983) whose work suggested that while both mild and more severe schizophrenics had recall

deficits, they differentially benefited from semantic encoding practice (training with a sorting task prior to acquisition). Those patients classified as mild were able to improve later recall under the trained condition, while individuals with greater symptom severity continued to display a recall deficit. The authors interpreted these findings as evidence that the more severe group may demonstrate a post-encoding deficit that is not present in the mildly disturbed group. Their findings suggest the need for caution against over-generalizing the results of research that suggests a purely organizational encoding deficit in schizophrenia (Koh, Kayton, & Schwartz, 1974; Lutz & Marsh, 1981; Traupmann 1980), but lent support to the hypothesis as it applies to more mildly disturbed individuals. Thus, at least among some individuals with schizophrenia, there is evidence to suggest the capacity to benefit from semantic organization in memory despite a failure to initiate the strategy and it is possible that extent of benefit varies with severity of psychiatric disturbance. Insofar as a decrease in semantic clustering across trials presupposes some initial use of the strategy and benefit from recall cueing requires that the learner is

capable of making use of the semantic organization, both could potentially be related to severity of illness.

One final symptom variable that may have relevance to the cognitive factors under consideration in this study, is predominance of positive or negative symptoms. The majority of findings suggest negative, but not positive, symptoms are associated with impaired frontal/executive functioning (Liddle, 1987; Liddle and Morris, 1991) and a variety of other neurocognitive measures (Brekke, Raine, & Thomson, 1995; Green & Walker, 1985; Mattson, Berk, & Lucas, 1997; Nuechterlein, Edell, Norris, & Dawson, 1986; Walker & Lewine, 1988). Nonetheless, a few studies have shown correlation between positive symptoms and measures in both attention and executive functions (Berman, et al, 1997; Bressi, et al, 1997; Parellada, Catarineu, Catafau, Bernardo, & Lomena, 2000; Zakzanis, 1998). Furthermore, new research also suggests that disorganized symptoms affect cognition in a unique manner (O'Leary et al, 2000).

Summary

There is a sizeable body of research showing lower levels of semantic clustering on the CVLT in a variety of patient populations. (Should I add something about it

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potentially representing either exec. Or semantic
abilities?) Although it is a useful measure of total
semantic clustering during learning trials, the semantic
clustering index does not allow for the analysis of changes
in semantic clustering across trials. Nonetheless, it is
possible that patterns of change in the use of semantic
clustering across trials may provide meaningful
information. This was demonstrated, for example, by studies
which suggest that a progressive decrease in the use of
this strategy across CVLT learning trials in patients with
Parkinson's disease (Buytenhuijs et al, 1994; Van
Spaendonck et al., 1996) was associated with failures in
inhibition (to the more salient serial order) rather than
deficient ability to use and benefit from semantic
clustering, in general. This particular finding suggests
that this pattern of clustering use might serve as a more
specific indicator of deficits in executive functioning
than does a general clustering index.

While there has been only a limited number of studies
assessing changes in semantic clustering over CVLT trials,
those that have looked at healthy controls suggest the
typical pattern is toward increased use of semantic
clustering as trials progress (Lyons et al., 1995; Simon et

al., 1994; Volgmaier et al., 1997). In contrast, individuals with SPD (Volgmaier et al., 1997) and relatives of individuals with schizophrenia (Lyons, et al., 1995) have been shown to demonstrate the expected pattern of increasing semantic clustering over trials, though not at levels comparable to healthy controls.

As with non-intentional learners (Postman, Adams, and Bohm, 1956) we might expect semantic cueing on categorized list tasks to be of most benefit to individuals who have intact capacity to benefit from semantic organization of the list, but have not fully utilized this strategy during free recall. Although most individuals show increased use of semantic clustering over repeated fixed trials, at least one clinical group has been shown to decrease the use of this strategy over trials due to the sensitivity to the increased salience of serial order. Such individuals would not be using semantic clustering strategy to their fullest capacity. Individuals who are using a semantic clustering strategy to their full capacity (whether that capacity is intact or impaired) might be expected to plateau or increase their use of this strategy across trials. Thus, it is predicted that the former groups would show greater benefit from semantic cueing during recall. Initial support

from this comes from the observation that groups found to decrease (Buytenhuijs et al, 1994; Van Spaendonck et al., 1996) or increase (Lyons et al., 1995; Volgmaier et al., 1997) semantic clustering over trials showed this expected pattern of relative benefit from semantic cueing at later recall.

Individuals with schizophrenia spectrum disorders are of interest in the current study because of consistent findings of poor performance on memory tasks (Gold, Randolph, Carpenter, Goldberg, & Weinberger, 1992; McKenna, Tamlyn, Lund, Mortimer, Hammond, & Baddeley, 1990; Saykin, et al., 1991; Tamlyn, McKenna, Mortimer, Lund, Hammond, & Baddeley, 1992), as well as documented deficits in the use of semantic organization in list recall (Heinrichs, 1994; Koh, Kayton, & Berry, 1973; Paulsen et al, 1995). Furthermore, explanations for list-learning difficulties in this group diverge with regard to the relative impact of deficits in memory, executive functioning, attention, or semantic/language.

Analysis of semantic clustering, changes in its use over fixed-order trials, and its relationship to cued recall may help to better understand varied cognitive factors underlying impaired recall performance in this

population. In addition, differences in the pattern of change in semantic clustering may help to identify subgroups of individuals with specific executive deficits.

Purpose

The primary intent of this study was to explore patterns of change in the use of clustering strategies over repeated trials in a sample of individuals with schizophrenia spectrum disorders. Decreased use of semantic clustering (with possible concomitant increase in reliance on serial clustering) has been associated with difficulties in inhibiting the more salient serial order of the stimuli. In this study, I explored whether such changes represent a more specific indicator of failures in executive functioning than is a broader semantic clustering index that measures overall use of the strategy across trails. In addition, I investigated whether such changes in use of clustering strategies across trials predicted ability to benefit from cueing in this group. If this pattern of changing strategy use is associated with difficulties inhibiting the salient cues, than those individuals who move away from a semantic clustering strategy as trials progress, would be expected to show the most benefit from

semantic cueing at recall. This could provide information about differences in encoding and retrieval relevant to rehabilitation.

Hypothesis 1: Subjects who have negative semantic clustering slopes will perform more poorly on the Stroop, relative to those with an increasing score (positive slope).

Hypothesis 2: After the effects of overall semantic clustering have been removed, semantic clustering slopes will be positively correlated with Stroop performance.

Hypothesis 3: Subjects who have positive serial clustering slopes will perform more poorly on the Stroop, relative to those with a decreasing score (negative slope).

Hypothesis 4: After the effects of overall serial clustering have been removed, semantic clustering slopes will be negatively correlated with Stroop performance.

Hypothesis 5: After the variance due to Reading and Vocabulary performance has been removed, slopes of serial clustering cannot be predicted by increased letter fluency raw score, increased alternating fluency raw score,

increased Stroop performance, and decreased WCST perseverative errors.

Hypothesis 6: After the variance due to Reading and Vocabulary performance has been removed, slopes of serial clustering cannot be predicted by a combination of scores on the following measures: letter fluency raw score, alternating fluency raw score, WCST perseverative errors, and Stroop.

Hypothesis 7: Individuals with negative semantic clustering slopes will benefit more from semantic cueing, as measured by the cued-uncued change scores.

Hypothesis 8: Slopes of semantic clustering will be negatively related to ability to benefit from cueing, as measured by the cued-uncued change scores.

Hypothesis 9: Individuals with positive serial clustering slopes will benefit more from semantic cueing, as measured by the cued-uncued change scores.

Hypothesis 10: Slopes of serial clustering over trials are not related to the ratio of cued to uncued short-delay recall.

Exploratory Analyses: I examined the relationships between the clustering variables (serial clustering, slope of serial clustering, direction of serial clustering, semantic clustering, slope of semantic clustering, and direction of semantic clustering) and the following clinical and demographic variables (age, education, gender, primary diagnosis, PANSS positive symptom scale, PANSS negative symptom scale, PANSS general psychopathology scale, GAF score, AIMs score, and chlorpromazine equivalent dosage). I also examined the relationships between each of the clustering variables and the following CVLT indices: total recall over learning trials, short-delay free recall, long-delay free recall, and recognition discriminability.

CHAPTER 2

METHOD

Overview

In this study I attempt to identify a subgroup of

individuals with schizophrenia spectrum disorders who

abandon the use of semantic clustering as trials progress on

a fixed-order, list learning task. I explore whether

patterns of change in clustering strategy over trials are

associated with other cognitive and symptom variables. Also,

I examine which factors predict benefit from semantic cueing

and whether deficits in executive functioning are relevant

for understanding semantic clustering strategies.

As part of their entry into studies on medication

effectiveness and adherence to medications, subjects

completed a neuropsychological research battery, which

includes the CVLT. The testing was administered by myself

and other individuals trained in the use of the instruments.

Data obtained for purposes of the current study were

recorded from test results and research records. Identifying

information and participants names were not collected in my

records, and participants were identified only by a code number on any materials gathered for the proposed study.

<u>Participants</u>

The sample consists of 151 adults who, at time of testing, were receiving services at one of the following public or private mental health services and facilities in Connecticut: Connecticut Mental Health Center, Yale Psychiatric Institute, Bridgeport Hospital, Bridgeport Community Mental Health, Hartford Hospital/Institute of Living, Cedarcrest Hospital, or Hospital of St. Raphael. Participants had completed a battery of diagnostic and neuropsychological measures for research projects examining medication effectiveness or adherence to medications. Subjects were excluded if their raw neuropsychological data were missing or unavailable ($\underline{N}$ = 6) or if they did not complete the CVLT ($\underline{N}$ = 7). Of the remaining participants, 26 were removed from the final sample for missing data on one or more of the primary variables (Stroop, WCST, COWAT, alternating fluency, Vocabulary, or Reading). All

participants had signed voluntary consents and were paid for their participation in the larger study from which the current data were culled.

All individuals met DSM-IV criteria for either schizophrenia ($\underline{N}$ = 90) or schizoaffective Disorder ($\underline{N}$ = 60), based on the Structured Clinical Interview for DSM- IV (First, Spitzer, Gibbon, & Williams, 1997), which was administered by a licensed psychologist or a trained research assistant. The diagnostic data was missing for one participant due to a lost file. Of those diagnosed with schizophrenia, 41 were diagnosed with Paranoid type, 19 with disorganized type, 25 with undifferentiated, and 1 with residual. No individuals in the sample carried a diagnosis of catatonic type schizophrenia. Data on schizophrenia subtype were not available for 4 of the individuals.

Participants entered into the study during an inpatient hospitalization and completed testing at the time of hospitalization. If a participant was unable to test at the time of hospitalization (if, for example, they were discharged before testing could be completed), an appointment was made for testing shortly after discharge. Amount of prior hospitalizations was not controlled nor

recorded. Most participants were receiving psychopharmacological medications and many were on multiple medications. Complete medication data was available for 120 participants. The mean chlorpromazine equivalent dose of neuroleptics was 695 mg and the range was 0 mg to 3800 mg.

Participants ranged in age from 18 to 69 ($\underline{m}$ = 36) and had a mean of 11 years of education, with a range of 3 to 19 years. With regard to handedness, 82% of the sample were right handed ($\underline{N}$ = 124), 14% were left-handed ($\underline{N}$ = 21), and 4% had some degree of mixed-handedness ($\underline{N}$ = 6), based on their responses to a handedness screen. The sample included 98 males (65%) and 53 females (35%). The majority of the sample were either African American ($\underline{N}$ = 53; 35%) or Caucasian ($\underline{N}$ = 63; 42%). Of the remaining participants, 13 were Hispanic (9%), three (2%) were Asian, two (1%) were classified as "other" for ethnicity, and 17 (11%) had no data recorded on ethnicity.

<u>Instruments</u>

<u>Verbal list-learning</u>. The California Verbal Learning Test (CVLT) (Delis, Kramer, Kaplan, & Ober, 1987) was used as the measure of categorized list learning and semantic clustering. This measure was administered according to the

standardized instructions provided in the test manual. The CVLT utilizes a categorized list presented as a "shopping" list, which includes four words in each of four "shopping" categories, for a total of 16 words. The list is read to the examinee in mixed order such that no two items from one category are presented sequentially. The items are read at the rate of one word per second and, after presentation of the list, the examinees are asked to repeat back all items that they can remember in any order. The list is repeated, in fixed order, over five learning trials. After the learning trials, a similar list with different items is presented for recall as a distractor. Immediately after recall of the second list, the examinee is asked to again recall items from the first list (short-delay free recall). For the cued trial, the examiner provides each of the category names, one at a time, and asks the examinee to recall all items from that category. After a 30 minute delay, during which other tasks are presented, free and cued recall trials are repeated. Finally, a recognition task is performed. Split-half reliabilities for items, categories, and total scores across trials range from r = .69 to r = .92, as reported in the test manual (Delis, Kramer, Kaplan,

& Ober, 1987). Total performance across the learning trials was reported to be significantly correlated with the Wechsler Memory Scale Memory Quotient ($\underline{r}$ = .66).

Because the CVLT is a categorized list, it allows for measurement of a semantic clustering score, a measure of the degree in which individuals have clustered words during recall according to semantic categories. For the purposes of the current study, in addition to the standard indices and scores calculated for this measure, a semantic clustering score will be computed for each of the five learning trials and for the short-delay free recall trial for each participant in order to allow for analysis of changes in semantic clustering across trials.

Stroop. The Stroop Color and Word Test uses stimuli from the Golden form (1978). Administration was altered from that in the manual, so that only the last of 3 trials was administered. In this, subjects were given 45 seconds to name the colors of ink used to print a series of words representing incongruent colors (i.e., the word red may be presented in blue ink). The score represents the number of items that the participant was able to correctly name within this time frame. If the subject made a mistake, the

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examiner would say "no" and the subject would have to

correct the error before moving on to the next item. Higher

scores represent better performance and less interference.

Typically, reading (which is considered a more automatic

process) is faster than color naming, and performance is

slowed in the interference condition during which the

examinee must inhibit the meaning of the printed word in

order to name the color of ink. The interference task may

be viewed as one of response inhibition, selective

attention, and concentration (Lezak, 1995).

   The Stroop task was chosen for the current study

because of its theoretical similarity to what is required in

the CVLT (Delis, Kramer, Kaplan, Ober, 1987) for a

participant to ignore repeated serial order in order to

organize their recall semantically. Both decreased semantic

organization on list-learning (Buytenhuijs et al, 1994; Van

Spaendonck et al., 1996) and impaired performance on Stroop

interference (Hanes, Andrewes, Smith, & Pantelis, 1996;

Henik, Singh, Beckley, & Rafal, 1993) have been found in

patients with Parkinson's disease.

   Controlled Oral Word Association Test (COWAT). (Benton

& Hamsher, 1989). In this task, participants were presented

with the letters F, A, and S, one at a time. They were instructed to name as many words as possible that begin with the letter presented and were informed that the words may not be proper nouns or repetitions of the same word with different endings (the examiner will provide examples of each). The examiner attempted to ensure that the participant understands the directions fully before beginning testing. They were then be presented with each of the letters and the examiner recorded all words named in 60 seconds. The test was scored according to number of correct words named for each letter. The COWAT was used as a measure of executive abilities, and is known to correlate with frontal functioning (Lezak, 1995).

Alternating Fluency. Participants were instructed to name as many animal names and color names as they could in 60 seconds. They were instructed to alternate between the animal and color words (first an animal name, then a color name, then an animal, etc.) and were only given credit for novel words named in correct alternating order. This is not a traditional neuropsychological measure and has no available norms. Similar fluency tasks (requiring categorical and/or phonemic alternation) have been shown to

be impaired in patient's Parkinson's disease and

Schizophrenia (Gourovitch, Goldberg, & Weinberger, 1996;

Hanes, Andrewes, & Pantelis, 1995). Furthermore, one study

found that individuals with Parkinson's disease were more

impaired at this task than on more traditional semantic and

phonemic fluency measures (Zec, et al., 1999).

Wisconsin Card Sorting Test. In this task, participants

must match a series of cards which vary according to three

attributes (there are 1-4 objects per card, with one of 4

colors, and one of 4 shapes) to a series of four key cards.

The examinee is given feedback about whether a response is

correct, but must discover the sorting principle for his or

herself. The rewarded sorting principle is changed without

warning after 10 successful trials. The test was

administered via a computer program. The task is considered

a measure of executive set-shifting ability (Lezak, 1995) as

the examinee must respond to changing feedback by switching

strategies as the rules change. The number of perseverative

errors (defined as sorting to a previously correct category

after error-feedback), will be used as the primary index.

Vocabulary. This measure is a subtest from the WAIS-III

(Wechsler, 1997) and requires the examinee to provide

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definitions of words. Stimuli are read aloud by the examiner

and also presented in written form on stimulus cards. This

task was used as a general measure of verbal intelligence.

Reading. The Reading subtest from the WRAT-R (Jastak &

Wilkinson, 1984) requires the participant to correctly

pronounce a list of words of increasing difficulty. Along

with the Vocabulary measure, this task was used as an

estimate of verbal abilities.

Positive and Negative Syndrome Scale (PANSS). The scale

was developed to assess positive and negative symptoms of

Schizophrenia (Kay, Fiszbein, & Opler, 1987). This scale was

completed by a trained rater and scores for each question

were based on observations during interview, and/or reports

from primary care workers and family (the rating form

specifies which of these sources are relevant for each

question). The rating form consists of 3 scales: a positive

symptom scale (7 items), a negative symptom scale (7 items),

and general psychopathology scale (14 items). The symptoms

on each of the scales are rated by the interviewer for

severity from 1 (indicating that the symptom is absent) to 7

(representing extreme severity), and specific descriptions

are given for these ratings on each symptom. Thus, possible

scores on the positive and negative scales range from 7 to 49, whereas scores on the general psychopathy scale range from 16 to 112. These scores were used during the exploratory analyses, to assess whether symptom variables influenced the key measures or relationships between them.

AIMS. The Abnormal Involuntary Movement Scale (Simpson & Angus, 1970) was administered to all participants. It is a rating scale designed to assess extrapyramidal side effects. Given the role of the extrapyramidal system in executive functioning, I included this measure as a potential source of variance in the measures of interest and as a possible confound to the relationships between key cognitive variables.

CHAPTER 3

RESULTS

<u>Variables</u>

The primary variables of interest were computed and
coded in the following manner.

<u>Semantic clustering</u>. The measure of semantic clustering
on each trial was calculated by the formula provided in the
CVLT manual (Delis et al., 1987), as an observed versus
expected semantic clustering ratio (observed semantic
clustering/expected semantic clustering) that adjusts the
clustering score for number of words recalled in each
category. The observed semantic clustering score for each
trial is calculated as the number of recalled items that
were immediately preceded by an item from the same category.
The expected semantic clustering score is calculated as
$[T_n(T_n - 1)]/ MX$, where T_n represents the number of words
correctly recalled from category n. In the formula, MX
represents the total number of words recalled in the trial,
and includes perseverations and intrusions as well as
correctly recalled words. The resulting ratio ensures that
the semantic clustering score is not dependent upon the

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individual's overall recall, but on the amount of semantic

organization present in recall order. Although various

formulae have been used to calculate semantic clustering

(Kazen & Otani, 1997; Shuell, 1969), this is the measure

typically used to obtain the CVLT semantic clustering index

and has been shown to not result in spurious correlations

with other key variables when tested in random data

(Schmidt, 1987). Semantic clustering ratios for individual

trials and an overall semantic clustering index are among

the variables calculated by the CVLT scoring software

(Delis, Kramer, Kaplan, & Ober, 1987).

Change in semantic clustering across trials. For each

participant, a slope was computed to represent rate of

change in observed versus expected semantic clustering

scores across the five learning trials. A second method was

used to determine the overall level of change in semantic

clustering; for each participant, a measure of change in

semantic clustering was computed by subtracting the semantic

clustering index at trial one from the semantic clustering

index at trial five. The resulting index is a difference

score in which 0 represents no change, a negative integer

represents decreased clustering, and increased clustering is

represented by a positive score. Individuals were then classified according to whether they decrease use of the strategy (change score less than 0), increase use of the strategy (change score greater than 0), or show no change in strategy use. The comparison of interest to the current study is between those who increase and those who decrease. Using the direction of semantic slopes as a grouping variable, 48 individuals showed decreasing semantic clustering, 91 showed increased semantic clustering, and 12 showed no change in use of semantic clustering. When difference scores were used as the grouping variable 41 individuals showed decreased semantic clustering, 85 showed increased clustering, and 25 showed no change. The classification strategy using slopes was chosen for analysis because fewer individuals were identified in the unchanged group, allowing a larger $\underline{N}$ for the analyses comparing those who increase and decrease in use of the strategy. After the statistics were completed, I ran similar statistics with classifications determined by raw difference in clustering strategy for comparative purposes. These analyses yielded similar results.

    Serial clustering. A measure of serial clustering on

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each trial was calculated, using the formula suggested by the CVLT manual (Delis et al., 1987), as an observed versus expected serial clustering ratio that adjusts for the degree to which serial clustering is expected by chance. The observed serial clustering score is measured by counting the number of times that two words, which appeared contiguously on the list, are also recalled contiguously by the subject. When the examinee correctly recall at least one word on a given trial, the expected serial clustering score is calculated as (.135 x #C.62) - .135, where #C represents the number of words correctly recalled. When no words are correctly recalled on a particular trial, the expected serial clustering score is equal to zero.

Change in serial clustering across trials. Rate of change in serial clustering scores was calculated as a slope of the serial clustering scores across the five trials. The overall level of change in serial clustering was also computed for each individual by subtracting the serial clustering index at trial one from the serial clustering index at trial five. The resulting index is a difference score in which 0 represents no change, a negative integer represents decreased clustering, and increased clustering is

represented by a positive score. Individuals were then

classified according to whether they decreases use of the

strategy (change score less than 0), increased use of the

strategy (change score greater than 0), or showed no change

in strategy use (change score equal to 0). The comparison of

interest is between those who increase or decrease their use

of the strategy over trials.

Using the direction of serial slopes as a grouping

variable, 70 individuals showed decreasing serial

clustering, 70 showed increased serial clustering, and 11

showed no change in use of serial clustering. When

difference scores were used as the grouping variable 47

individuals showed decreased serial clustering, 59 showed

increased clustering, and 45 showed no change. The primary

difference between the two classification strategies was in

the number of subjects classified as zero. The

classification strategy using slopes was chosen for analysis

because fewer individuals were identified in the unchanged

group, allowing a larger $\underline{N}$ for the analyses comparing those

who increase and decrease. After the statistics were

completed, I ran similar statistics with classifications

determined by raw difference in clustering strategy for

comparative purposes, and the results did not differ from those obtained when individuals were classified by direction of slopes.

Ability to benefit from semantic cueing. The primary measure of the ability to benefit from cueing was a change score, which was calculated for each individual by dividing the difference between the short-delay cued recall score (SDCREC) and short-delay free recall score (SDREC) by SDREC and multiplying by 100, yielding the following formula: ((SDCREC-SDREC)/ SDREC) x 100. For example, an individual who recalled 8 items on short-delay free recall and 16 items on short-delay cued recall would receive a score of 100, indicating that cued recall represented a 50% increase in words from free recall. Thus, a higher score indicates greater improvement from cueing, a negative score indicates a decrease in performance from uncued to cued conditions, and the score is not directly dependent upon overall performance. This type of change formula does not provide a score for individuals who recall no words at short delayed free recall. Those for whom both SDREC and SDCREC are zero, will be given scores of 0. Those with SDREC of 0, but who improve on cued recall, cannot appropriately be given a

percent change score.

      <u>Clinical and diagnostic variables</u>. When available, the following variables were obtained for each individual for sample description and further analysis: age, sex, education, time since first symptom, diagnosis (schizophrenia or schizoaffective disorder, and schizophrenia subtype), AIMs score, GAF, PANSS positive scale score, PANSS negative scale score, and PANSS general scale score. When complete medication data was available for a participant, a chlorpromazine equivalent neuroleptic dosage was calculated.

<u>Analysis</u>

      <u>Data screening</u>

      Prior to analyses, descriptive statistics were run for all variables. Variables were screened for missing data and outliers. Outliers were checked against original records for mistakes, and any errors were corrected. Of the 177 participants who had complete CVLT's, 26 were missing one of the other primary variables needed for hypothesis testing and were excluded from the final sample. This subsample with missing data did not significantly differ from the

remaining participants on any of the demographic,

neuropsychological, or symptom data. Therefore, it is not

likely that the removal of these 26 subjects from the sample

affected the results. Means, ranges, and standard deviations

are reported in tables 2 and 3 for the remaining 151

subjects.

Table 1: Descriptive statistics for primary variables.

Variable	Mean (SD)	Range
Semantic clustering	1.39 (.23)	0 to 3.3
Semantic slope	.269 (.74)	-3.75 to 1.86
Serial clustering	2.617 (2.11)	0 to 11.3
Serial slope	-0.63 (2.02)	-7.9 to 5.92
Benefit from Cueing	31.27 (61.45)	-50 to 400
Vocabulary	28.66 (14.89)	2 to 65
WRAT-R Reading	51.4 (17.57)	4 to 89
Stroop	28.66 (10.66)	5 to 62
COWAT	29.26 (11.93)	0 to 63
Alternating fluency	6.41 (2.71)	0 to 15
WCST perseverative errors	30.96 (20.22)	0 to 94

Table 2: <u>Descriptive statistics for symptom and demographic</u>

<u>variables</u>.

<u>Variable</u>	<u>Mean (SD)</u>	<u>Range</u>
Age	36.19 (10.24)	18 to 69
Education	11.3 (2.48)	3 to 19
GAF	28.92 (8.97)	10 to 55
PANSS positive	23.84 (5.70)	10 to 37
PANSS negative	23.13 (6.06)	8 to 41
PANSS general	44.99 (8.53)	21 to 63
AIMs	.762 (1.57)	0 to 8
Chlorpromazine equivalent (mg.)	694.76 (546.1)	0 to 3800

Frequencies for semantic and serial slope directions were evaluated for the sample. Although it was most common for subjects to increase their semantic clustering over trials ($\underline{N}$ = 91; 60% of sample), 48 subjects showed the decreasing pattern of semantic clustering (32%) of interest to the current study, and 12 patients (8%) had a slope score of 0, indicating no change in semantic clustering across

trials. Examination of the 12 patients with no change in semantic clustering, revealed that most of these ($\underline{N}$ = 10) had clustering scores of 0 for all trials, indicating that they failed to use this strategy at any time during the learning trials. With regard to the serial clustering slopes, an equal number had negative ($\underline{N}$ = 70, 46%) and positive slopes. That is, the same percent increased serial clustering over trials as decreased their use of this strategy across trials. An additional 11 subjects (7%) had a slope score of zero (indicating no overall change in use of the strategy across trials). Of the subjects who had serial slope scores of 0, 8 of these had serial clustering indices of 0 on all trials, and 3 obtained serial clustering indices only for trial 3.

All variables were also examined for normality and skew. A significance level of $\underline{p}$ = .01 was used to assess whether each variable differed from a normal distribution. In order to normalize the distributions to meet statistical assumptions, the following variables were transformed: serial clustering index (SERIAL), semantic clustering slope across trials (SEMSLP2), Wisconsin Card Sorting Test perserative errors (WIPERSER), raw Vocabulary scores

(VOCRAW), CVLT recognition discrimination (DISCRIM), benefit from cueing change scores (BENCUE), AIMs scores (TTIAIMS), GAF scores, and chlorpromazine equivalent dosages (CHLOREQ). Transformations were based on recommendations in Tabachnick and Fidell (1996). Kurtosis and skew for untranformed variables are listed in table 3, along with kurtosis and skew after transformation. Note that the transformed semantic slope scores were converted to negative in order to aid interpretation when comparing with serial slopes scores (such that high score still indicate larger slopes). For the DISCRIM and TTIAIMS variables, tranformation resulted in a reversal of the direction of interpretation (i.e., with the transformed variables, lower numbers on the AIMS variable and higher numbers on the CVLT discrimination variable are worse). Distributions for TTIAIMS and BENCUE could not be fully corrected with transformation, but the transformations shown below did improve the distribution. For the TTIAIMS variable, the distribution was too skewed to be corrected even by inverting the numbers. The DISCRIM variable was improved by a square root transformation, but a logarithmic transformation resulted in an over-correction and even further deviation from normality.

After initial data screening corrected or removed any
erroneous data points, one univariate outlier remained for
each of the clustering slope variables. Both were determined
to be correctly entered. Despite the outlier, the
distribution of SERSLP2 scores was evaluated to be normal.
The Semantic slope variable would have been transformed even
with the outlier excluded, and the transformed variable was
adequately normal in distribution when the outlying case was
included. I chose to retain these cases in the analyses.
When relevant, I have rerun statistics with the outliers
removed for comparative purposes and the results were not
significantly affected.

Table 3: <u>Kurtosis and skew for variables before and after</u>

<u>transformation</u>.

	skew (z)	Kurt (z)	Tranformation	skew (z)	kurt (z)
SERIAL	9.32	3.36	Log10	0.4	0.61
SEMSLP2	-3.75	3.5	Reflect & square root adjusted to negative to aid interpretation	-0.55	2.01
BENCUE	14.97	5.73	Square root of variable + 50	3.32	3.84
WIPERSER	7.21	2.29	Square root	2.17	1.24
VOCRAW	2.81	-1.05	Square root	0.16	-1.10
DISCRIM	-6.45	2.23	Reflect and square root	1.72	-.62
AIMs	13.44	4.43	inverse	-1.22	-5.21
GAF	3.28	.71	square root	1.14	0.00

A correlation matrix was examined for all primary
variables in order to determine whether potential sources of
multicollinearity exist. No correlations were high enough
to suggest multicollinearity (r > .90), but the large
correlation (r = .72) between WRAT-R reading (WRATRAW) and
the transformed vocabulary scores (SQVOCRAW) suggests that
these two variables may be redundant if used in the same

analysis. All other correlations were at or below $\underline{r}$ = .55.

Table 4 depicts the correlations between the executive and

verbal measures, with values presented for two-tailed

significance testing.

Table 4: <u>Correlations between executive and verbal measures</u>.

N=151 2-tailed **=.05 *=.10	STPRAW	SQWISPER	CLFWRDS	CATFCORR	SQVOCRAW
SQWISPER	-.2204 p=.007**				
CLFWRDS	.3619 p=.000**	-.1630 p=.046**			
CATFCORR	.4701 p=.000**	-.1428 p=.080*	.4707 p=.000**		
SQVOCRAW	.3425 p=.000**	-.1431 p=.080*	.5378 p=.000**	.4643 p=.000**	
WRATRAW	.3859 p=.000**	-.0941 p=.251	.5513 p=.000**	.3429 p=.000**	.7233 p=.000**

The transformed semantic clustering slopes (TRNSMLP)

were related in the expected direction to Stroop scores ($\underline{r}$ =

.138, $\underline{p}$ = .09 for a two-tailed test) and letter fluency

(CFLWRDS) scores ($\underline{r}$ = .144, $\underline{p}$ = .07), but were not

significantly correlated with WCST perseverations (SQWISPER)

or alternating fluency (CATFCORR) measures. The TRNSMLP

scores were correlated positively with WRATRAW scores ($\underline{r}$ =

.172, $\underline{p}$ = .035), but the relationship with the transformed

vocabulary scores (SQVOCRAW) was not significant ($\underline{r}$ = .100,

$\underline{p}$ = .221). The serial clustering slope (SERSLP2) was

negatively correlated with WRATRAW ($\underline{r}$ = -.161, $\underline{p}$ = .048),

but was not significantly related to any of the other

primary neuropsychological measures.

Table 5: correlations between clustering and

neuropsychological variables.

N=151 1-tailed *<.05	TRNSMSLP	SEMANT	SERSLP2	LGSERIAL
SEMANT	.1874 p=.012*			
SERSLP2	-.0345 p=.337	.0836 p=.154		
LGSERIAL	-.0851 p=.085	-.2610 p=.001*	.0122 p=.441	
SQBENCUE	-.0602 p=.235	-.0123 p=.442	.1187 p=.077	-.0229 p=.392
STPRAW	.1384 p=.045*	.2487 p=.001*	-.1281 p=.059	.0708 p=.194
SQWISPER	-.0264 p=.374	-.1168 p=.077	-.0557 p=.249	.0519 p=.264
CLFWRDS	.1442 p=.039*	.2248 p=.003*	-.0610 p=.229	.1461 p=.037*
CATFCORR	.0287 p=.364	.3133 p=.000*	.0016 p=.493	.0401 p=.313
SQVOCRAW	.1003 p=.111	.2424 p=.002*	-.0672 p=.206	-.0092 p=.456
WRATRAW	.1715 p=.018*	.2697 p=.001*	-.1609 p=.024*	.0657 p=.212

The overall semantic clustering index (SEMANT) correlated significantly with the Stroop (r = .249, p = .002), letter fluency (r = .225, p = .006), and alternating fluency (r = .313, p = .000). There was a non-significant

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negative trend between SEMANT and SQWISPER (r = -.117, p =

.153), and SEMANT was significantly correlated with both

SQVOCRAW (r = .242, p = .003) and WRATRAW (r = .27, p =

.001). The transformed serial clustering index (LGSERIAL)

had a positive trend with CLFWRDS, but was not significantly

correlated with any of the neuropsychological measures.

Correlations between the four clustering scores and between

each of these scores and the primary neuropsychological

tests are presented above, in table 5.

A correlation matrix was also run with the

untransformed variables for comparative purposes.

Examination of the two matrices, which included all primary

neuropsychological variables, revealed four cases in which a

correlation changed level of significance (at the .05

significance level for two tailed tests) from the

transformed to untransformed state. Three of these

correlations were only trivially different in size and were

significant in both untransformed and transformed states if

a significance level of .05 for a one-tailed test were used.

These included the following correlations: Semantic

clustering index (SEMANT) and semantic slope (SEMSLP2);

benefit from cueing (BENCUE) and alternating fluency

(CATFCOR); and letter fluency (CLFWRDS) and WISPER. The correlation between BENCUE and WISPER was significant when untransformed scores were used, but yielded a reduced correlation with the transformed scores. The correlations for these four sets of variables in their transformed and untransformed states are listed in table 6.

Table 6: <u>Correlations that differ for transformed and untransformed variables</u>.

# indicates transformed variables ** significant at .05 for two-tailed * significant at .05 for one-tailed	Untransformed	Transformed
SEMANT with SEMSLP2#	.1473 <u>p</u>=.071*	.1874 <u>p</u>=.021**
CLFWRDS with WISPER#	-.1402 <u>p</u>=.086*	-.1630 <u>p</u>=.046**
BENCUE# with CATFCOR	-.1720 <u>p</u>=.038**	-.1598 <u>p</u>=.054*
BENCUE# with WISPER#	.1642 <u>p</u>=.048**	.1211 <u>p</u>=.146

Trial means for serial and semantic clustering were examined. These are presented below in Tables 7 (semantic clustering) and 8 (serial clustering). The means for semantic clustering increased consistently across trials

(also evident in the positive mean semantic slope presented in Table 1). For the serial trials, a mean negative slope (see Table 1), suggests that most individuals tended to decrease across trials. Examination of the individual trial means, however, suggests an initial increase followed by a decrease, with the mean serial clustering score at trial 5 no lower than that at trial 1.

Table 7: Mean semantic clustering for each trial.

	Mean	SD
SEMCL1	.90	1.16
SEMCL2	1.20	1.19
SEMCL3	1.25	1.04
SEMCL4	1.40	1.12
SEMCL5	1.48	1.19

Table 8: Mean serial clustering for each trial

	Mean	SD
SERCL1	2.33	3.58
SERCL2	2.76	3.23
SERCL3	2.38	3.47
SERCL4	2.41	3.05
SERCL5	2.35	2.98

<u>Hypothesis 1</u>

The model predicts that subjects with negative semantic clustering slopes will perform more poorly on the Stroop than those with positive semantic clustering slopes. The twelve subjects with semantic slopes of 0 were removed from analysis, and a t-test was computed to compare the Stroop scores (STPRAW) between individuals who increase or decrease in their use of clustering across trials (those with positive or negative slopes, respectively), with alpha set at .05 for a one-tailed test. The Stroop scores of individuals with negative semantic slopes ($\underline{m}$=27.06, $\underline{SD}$ = 10.636) were lower than those of individuals with positive semantic slopes ($\underline{m}$ = 30.46, $\underline{SD}$ = 10.089). The difference was small, but statistically significant ($\underline{p}$ = .033). Results supported the research hypothesis.

To test whether the above relationship was confounded by overall semantic clustering index (SEMANT), a point-biserial partial correlation was computed between the direction of semantic slope (coded as a dichotomous variable) and STPRAW, with variance due to SEMANT removed. The resulting partial correlation was significant ($\underline{r}$ = .150, $\underline{p}$ = .039) and comparable in size to the simple correlation

between semantic clustering direction and STPRAW (r = .156, p = .033).

An additional analysis was run to assess whether differences occurred between those with increased and decreased semantic slopes on the following measures: WCST perseveration (SQWISPER), letter fluency (CLFWRDS), and alternating fluency (CATFCORR). A Multivariate analysis of variance (MANOVA) was computed using SPSS at a .05 level of significance for a two-tailed test. The overall F was not significant: F (1, 137) = .637, p = .593, nor were any of the univariate F-tests for individual measures. Hypothesis 2

The model predicts a significant positive correlation between TRNSMSLP and STPRAW after the effects of SEMANT have been removed. A SPSS partial correlation was used with TRNSMSLP and STPRAW as variables, controlling for SEMANT. A simple correlation between TRNSMSLP and STPRAW was significant at the .05 level for a one tailed test (r = .138, p = .045) as was the simple correlation between overall semantic clustering (SEMANT) and STPRAW (r = .249, p = .001). When the effects of SEMANT were removed, the correlation between TRNSMSLP and STPRAW did not reach

significance ($\underline{r}$ = .097, $\underline{p}$ = .12). The results failed to support the research hypothesis. When the correlations were rerun with the one potential outlier removed, the results were unchanged.

For comparative purposes, the relationship between SEMANT and STPRAW was evaluated after the effects of TRNSMSLP were removed. A partial correlation was run using SPSS, with SEMANT and STRPRAW as variables controlling for TRNSMSLP. A significant positive correlation remained after the effects of TRNSMSLP were removed ($\underline{r}$ = .229, $\underline{p}$ = .002).

Hypothesis 3

The model predicts that subjects with positive serial clustering slopes will perform more poorly on the Stroop than those with negative serial clustering slopes. The 11 subjects with serial slopes of 0 were removed from analysis, and a t-test was computed to compare the Stroop scores between individuals who increase or decrease in their use of serial clustering across trials (those with positive or negative slopes, respectively), with alpha set at .05 for a one-tailed test. Results failed to support the research hypothesis; the Stroop scores of individuals with negative

serial clustering slopes ($\underline{m}$ = 29.99) did not significantly

differ ($\underline{p}$ > .05) from those with positive serial clustering

slopes ($\underline{m}$ = 28.23).

An additional analysis was run to assess whether

differences occurred between those with increased and

decreased serial slopes on the following measures: WCST

perseveration (SQWISPER), letter fluency (CLFWRDS), and

alternating fluency (CATFCORR). A multivariate analysis of

variance (MANOVA) was computed using SPSS at a .05 level of

significance for a two-tailed test. The overall F was not

significant: $\underline{F}$ (1, 138) = .977, $\underline{p}$ = .406, nor were any of

the univariate F-tests for individual measures.

Hypothesis 4

The research model predicts that, after the effects of

overall serial clustering have been removed, serial

clustering slopes are negatively correlated with Stroop. To

test this hypothesis, SPSS partial correlation was used with

serial slope scores (SRSLP2) and STPRAW as the variable,

controlling for (LGSERIAL). The signficance level was set at

.05 for a one-tailed test. The simple correlation between

SERSLP2 and STPRAW was in the expected direction, but did

not reach a significant level ($\underline{r}$ = -.128, $\underline{p}$ = .059).

LGSERIAL and STPRAW were not significantly correlated ($\underline{r}$ = .071, $\underline{p}$ = .194). After the effects of SERIAL were removed, the negative trend remained between SERSLP2 and STPRAW, but still did not reach significant levels ($\underline{r}$ = .129, $\underline{p}$ = .057). The results failed to reject the null hypothesis.

For comparative purposes a partial correlation was run between LGSERIAL and STPRAW, controlling for the effects of SERSLP2. This did not substantially alter the relationship ($\underline{r}$ = .073), which was not in the expected direction and was not significant at the .05 level for a two-tailed test.

Hypothesis 5

The research model predicts that after variance due to Reading and Vocabulary scores has been removed, transformed slopes of semantic clustering (TRNSMSLP) will be predicted by increased performance on letter fluency, alternating fluency, and Stroop, and decreased WCST perseverative errors after transformation (SQWISPER). Because initial data screening revealed that the WRAT-R reading (WRATRAW) and Vocabulary raw scores (VOCRAW) may be statistically redundant ($\underline{r}$ > .70), A decision was made to retain only one

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of these scores for the analysis in order to avoid inflated

error terms associated with redundant variables. The reading

scores were chosen because they correlated more highly with

the TRNSMSLP scores (r = .172, p = .035) than did the VOCRAW

scores (r = .100, p = .221). In order to test the model, a

mixed sequential multiple regression was computed with

TRNSMSLP scores as the dependent variable and WRATRAW,

CLFWRDS, SQWISPER, and STPRAW the independent variables.

Using SPSS, WRATRAW was entered in the first step. In the

second step, the remaining variable were entered as a step-

wise regression with entry criteria set at .05 and variables

below .10 removed from the equation. The R was significantly

different from zero after step one when WRATRAW was entered;

R = .172, F (1, 149) = 4.515, p = .035. None of the 4

remaining dependent variables entered the equation at step

2, nor did they enter if a more liberal entry criteria of

.20 was set. One multivariate outlier was identified based

on Mahalanobis distances. Removal of this case from the

equation did not significantly effect the findings. Results

fail to support the research hypothesis.

For comparative purposes SPSS was used to calculate a

mixed sequential multiple regression, similar to the above,

but with SEMANT entered as the dependent variable. The R was significantly different from zero after step one, when WRATRAW was entered into the equation first; R = .270, F (1, 149) = 11.692, p = .001. After WRATRAW was forced into the equation, remaining variables were entered using the STEPWISE command. Only CATFCORR (alternating fluency) entered the equation, but STPRAW was also significant after step one (T = 2.007, $Sig\ T$ = .047). The R was significantly different from zero at this step. After these two variables were in the equation, R = .358, F (2, 148) = 10.864, p = .000. None of the remaining variables were significant after step 2. Table 9 displays correlations between the variables, R, R^2, and adjusted R^2 after both variables were entered; it also displays the unstandardized regression coefficients (B) and the standardized regression coefficients (β) for those variables in the equation.

Table 9: <u>Results of multiple regression with semantic</u>

<u>clustering index as criterion</u>.

	WRATRAW	CATFCOR	STPRAW	SQWSPER	CLFWRDS	<u>B</u>	β	<u>Sig T</u>
<u>WRATRAW</u>						.008	.184	.026
<u>CATFCOR</u>	.343					.068	.250	.003
<u>STPRAW</u>	.386	.470						
<u>SQWSPER</u>	-.094	-.143	-.220					
<u>CLFWRDS</u>	.551	.470	.362	-.163			<u>R</u> =	.358
<u>SEMANT</u>	.270	.313	.249	-.117	.225		<u>R</u>^{2} =	.128
						Adj	<u>R</u>^{2} =	.116

<u>Hypothesis 6</u>

The null hypothesis predicts that after variance due to
Reading and Vocabulary scores has been removed, slopes of
serial clustering (SERSLP2)cannot be predicted by some
combination of scores on the following variables: letter
fluency, alternating fluency, Stroop, and WCST
perseverations (SQWISPER). As with the previous analysis,
VOCRAW was not retained due to possible redundancy with the
WRATRAW variable, which correlated more highly with SERSLP2
($\underline{r}$ = -.161 vs. $\underline{r}$ = -.067). In order to test the model, a

mixed sequential multiple regression was computed with

SERSLP2 scores as the dependent variable and WRATRAW,

CLFWRDS, SQWISPER, and STPRAW as the independent variables.

Using SPSS REGRESSION, WRATRAW was entered in the first

step. In the second step, the remaining variable were

entered as a step-wise regression with entry criteria set at

.05 and variables below .10 removed from the equation. The R

was significantly different from zero after step one when

WRATRAW was entered; R = .161, F (1, 149) = 3.958, p = .049.

None of the 4 remaining dependent variables entered the

equation at step 2, nor did they enter if a more liberal

entry criteria of .20 was set. One multivariate outlier was

identified by Mahalanobis distances. Removal of this case

from the equation did not significantly effect the findings.

Results fail to support the research hypothesis.

For comparative purposes SPSS REGRESSION was used to

calculate a mixed sequential multiple regression, similar to

the above, but with SERIAL entered as the dependent

variable. The R was not significantly different from zero

after step one, when WRATRAW was entered into the equation;

R = .066, F (1, 149) = .646, p = .423. After WRATRAW was

forced into the equation, remaining variables were entered

using the STEPWISE command. Only CLFWRDS (letter fluency)

entered the equation, but R was not significantly different

from zero at this step. After these two variables were in

the equation, $\underline{R}$ = .147, $\underline{F}$ (2, 148) = 1.64, $\underline{p}$ = .198.

Hypothesis 7

The model predicts that individuals with negative

semantic clustering slopes (those who decrease their use of

semantic clustering as learning trials progress) will

benefit more from semantic cueing than those with positive

semantic clustering slopes. To test this hypothesis, a t-

test was calculated to compare the transformed benefit from

cueing change scores (SQBENCUE) between individuals with

negative and positive semantic clustering slopes. The 5

cases for whom a benefit from cueing score could not be

calculated, were excluded from this analysis. The

significance level was set at .05 for a one-tailed analysis.

The mean SQBENCUE score for individuals with negative slopes

was 8.913 ($\underline{SD}$ = 3.199) and the mean SQBENCUE for those with

positive semantic clustering slopes was 8.451 ($\underline{SD}$ = 2.861).

The means for the two groups did not differ statistically ($\underline{p}$

= .197); results did not support the research hypothesis.

Because the above analysis required the exclusion of 5 cases who increased performance in the cued condition, a similar t-test was calculated to compare the two groups in their raw difference scores from uncued to cued conditions (SDCREC-SDREC). The results were similar. The mean raw difference score for the negative slope group was 1.583 ($\underline{SD}$ = 1.541) and the mean raw difference score for the positive slope group was 1.407 ($\underline{SD}$ = 1.966). The difference between the means was not statistically significant ($\underline{p}$ = .295).

Hypothesis 8

The research model predicts that slopes of semantic clustering will be negatively related to ability to benefit from cueing, as measured by the cued-uncued change scores. To test this hypothesis, a correlation was run between TRNSMSLP and the transformed benefit from cueing score (SQBENCUE). Five cases were excluded from this analysis because a benefit from cueing score could not be calculated. Alpha was set at .05 for a one-tailed test. The correlation coefficient was in the expected direction, but not significant ($\underline{r}$ = -.060, $\underline{p}$ = .235). Results did not support the research hypothesis.

A similar correlation was computed, with the benefit from cueing scores represented as raw differences to allow all subjects to be included in the analysis. This did not significantly effect the results (r = .029, p = .364).

The results of a correlation between the overall semantic clustering index (SEMANT) and SQBENCUE were examined for comparative purposes. The analysis did not suggest a significant relationship between the two variables at the .05 level of significance for a one-tailed test (r = -.012, p = .883).

Hypothesis 9

The research model predicts that individuals with positive serial clustering slopes (those who increased their use of serial clustering as trials progressed) will show more benefit from semantic cueing at short-delay recall than individuals with negative serial clustering slopes. The 5 cases for whom a benefit from cueing score could not be calculated were excluded from this analysis. In order to test this model, a t-test was calculated to compare SQBENCUE means for subjects with negative slopes (m = 8.460, SD = 3.487) and those with positive slopes (m = 8.763, SD =

2.515). Mean performance between the two groups did not

significantly differ ($\underline{p}$ = .281); results failed to support

the research hypothesis.

For comparative purposes, a similar analysis was run

using the raw difference scores to indicate benefit from

cueing. Results were not significantly different when all

subjects were included by using this measure. The mean raw

difference score for individuals with positive slopes was

1.2 ($\underline{SD}$ = 2.012) and the mean for those with negative slopes

was 1.7 ($\underline{SD}$ = 1.591). The difference between these groups

approached significance ($\underline{p}$ = .053).

<u>Hypothesis 10</u>

The research model predicts that slopes of serial

clustering over trials will not be related to the ratio of

cued to uncued short-delay recall. To test this hypothesis,

a correlation was computed between SERSLP2 and SQBENCUE,

with alpha set at .05 for a two-tailed test. The five cases

for whom a benefit from cueing score could not be calculated

were excluded from this analysis. There was a non-

significant positive trend between the two variables ($\underline{r}$ =

.119, $\underline{p}$ = .077). Results did not support the research

hypothesis.

For comparative purposes, a correlation between serial slopes and raw cued versus uncued difference scores was computed. Results were not significantly different from those above (r = .108, p = .094). The relationship between the transformed, overall serial clustering scores (LGSERIAL) and SQBENCUE was also examined for comparative purposes. No significant relationship was found between these two variables (r = -.023, p = .784).

Exploratory analyses:

In order to explore potential clinical correlates to the change in clustering variable, correlations were examined between TRNSMLP and a number of symptom and demographic variables: positive symptoms, negative symptoms, severity, transformed AIMs scores (a measure of involuntary movements), transformed chlorpromazine equivalent dosages, diagnosis (Schizophrenia versus Schizotypal Disorder), transformed age, gender, and education. At a significance level of .05 for a two-tailed test, only the transformed AIMs scores correlated significantly with TRNSMSLP (N = 143, r = .1947, p = .020). Though significant, this relationship

was not of sufficient size to suggest the need for concern about it seriously confounding other relationships.

For comparative purposes, the correlations were examined between overall semantic clustering index (SEMANT) and each of the symptom and demographic variables. SEMANT was not significantly correlated with the transformed AIMs variable ($\underline{N}$ = 143, $\underline{r}$ = .007, $\underline{p}$ = .932). This variable did correlate positively with education ($\underline{N}$ = 151, $\underline{r}$ = .212, $\underline{p}$ = .010). SEMANT was negatively correlated with PANSS negative symptom scale ($\underline{N}$ = 142, $\underline{r}$ = -.167, $\underline{p}$ = .046) and PANSS general psychopathology scale ($\underline{N}$ = 141, $\underline{r}$ = -.176, $\underline{p}$ = .038).

The serial clustering index and serial clustering slopes were not significantly correlated with any of the symptom and demographic variables at the .05 level of significance for a two-tailed test.

For exploratory purposes, correlations between the clustering scores and other CVLT memory indices were examined to consider any potentially confounding relationships. The memory indices included were: total recall across learning trials (CVLTRW), short-delay free recall (SDRECL), short-delay cued recall (SDCREC), long-

delay free recall (LDRECL), long-delay cued recall
(LDCURECL), tranformed recognition discrimination scores
(SQDISCRM), and transformed benefit from cueing scores
(SQBENCUE). None of the clustering variables significantly
correlated with the benefit from cueing variable (SQBENCUE).
Of the three semantic clustering variables (SEMANT,
TRNSMSLP, and the dichotomous direction of slope variable),
only SEMANT (the general semantic clustering index)
significantly correlated with any of the CVLT memory
indices. Of the serial clustering variables, only the
transformed overall serial clustering index (LGSERIAL) was
significantly correlated with any of the memory indices. The
correlations between the CVLT memory indices and the SEMANT
and LGSERIAL clustering variables are presented in table 10,
below. Note that the SQDISCRIM scores were inverted for
transformation, so the direction of the relationship is
reversed.

Table 10: <u>Correlations between the overall clustering</u>

<u>indices and the primary CVLT memory indices.</u>

	CVLTRW	SDRECL	SDCREC	LDRECL	LDCRECL	SQDISCRIM
SEMANT	.6103	.5974	.6310	.5642	.5950	-.4627
	p=.000	p=.000	p=.000	p=.000	p=.000	p=.000
LGSERIAL	-.1518	-.1996	-.1875	-.1295	-.1339	.1251
	p=.063	p=.014	p=.021	p=.113	p=.121	p=.126

CHAPTER 4

DISCUSSION

Past research suggests that a decreasing use of
clustering across learning trials in a fixed-order word list
learning task may occur in individuals with Parkinson's
disease, and may be associated with difficulties in
inhibiting the more salient serial order of the stimuli
(Buytenhuijs, et al., 1994; Van Spaendonck, et al., 1996).
Although the pattern of clustering use across learning
trials has not been explored as fully in individuals with
Schizophrenia, this group is known to show an overall
deficit in their use of the learning strategy, in general
(Heinrichs, 1994; Koh, Kayton, & Berry, 1973; Paulsen et
al., 1995). The use of semantic clustering is thought to be
related to executive abilities and, in fact, in one study of
individuals with schizophrenia, the use of the less-
effective serial ordering strategy was associated with
hypofrontality in PET imaging (Hazlett, et al., 2000).
Semantic clustering also requires, however, a store of
semantic knowledge and is associated with general
intelligence. The purpose of this study was to explore the

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relationships between clustering strategies and executive and language tasks. More specifically, I wanted to determine whether examination of the pattern of semantic clustering over trials could provide more specific information about the nature of an individual's difficulties in using the strategy. My research model suggests that a decreasing pattern of semantic clustering across trials could provide a more specific indicator of executive functioning than does the general clustering indices in common use. Of further interest was the relationship between clustering strategies (and their change over trials) and later benefit from recall cueing. It was predicted that individuals who decreased their use of semantic clustering as trials progress, would be most likely to benefit from cueing, if such individuals were initially capable of using the semantic organization but abandoned it due to the more salient serial order.

Examination of the mean semantic clustering for each trial and mean semantic clustering slope, suggested that this individuals in our sample tended to show an increase in their use of semantic clustering as trials progressed. Thus, as a group, the sample showed the normative pattern. The findings suggest that individuals with schizophrenia, as a

group, tend to be capable of utilizing the implicit semantic structure despite the explicit serial order made more salient by fixed-order presentation. This is inconsistent with the findings of Hazlett, et al. (2000). In the sample of individuals with schizophrenia in their study, the clinical population did not show the normative pattern of increasing clustering, but initially increased before decreasing in use of the strategy. Their study differed from this one in that the sample consisted of unmedicated patients. It is difficult to compare these two groups on overall use of clustering, as the semantic clustering index used for the two studies was computed in a different manner.

While the mean of serial clustering slopes was negative (suggesting a tendency in the group to decrease use of the strategy over trials), observation of the pattern of means for each group did not suggest a consistent trend toward decreased serial clustering. Trends may have been obscured, to some extent, by a large standard deviation in serial clustering means for each trial (suggesting substantial variability among the sample in use of the serial clustering strategy on a trial-by-trial basis). Nonetheless, these results are inconsistent with those of Hazlett, et al.

(2000), suggested a consistent increase in serial clustering over trials in a sample of unmedicated patients with Schizophrenia. This may suggest differences between medicated and unmedicated patients.

In this sample, the slopes of semantic clustering were positively correlated with the overall semantic clustering index, such that those who made greater overall use of the strategy also showed a greater increase over trials. The relationship was fairly small, however, and not at a level suggesting that the two variables were redundant. This is a predicted relationship insofar as those who can benefit from semantic clustering, under most circumstances, could be expected to use it increasingly as they become more familiar with the list.

Summary of findings in clustering use and executive abilities:

A review of the literature suggested that a greater degree of overall semantic clustering was associated with better performance on both verbal (such as WRAT-R reading and WAIS-III Vocabulary) and executive tasks. As such, semantic clustering may not serve as a specific indicator of

executive functioning. In this study, I examined the change in use of semantic clustering across trials to determine whether this information may serve as a more specific marker of executive functioning.

Results suggested that the overall semantic clustering index faired reasonably well as a predictor of executive abilities. As expected, it was positively correlated with 3 of the 4 executive tasks used in the main analyses, and with both of the verbal abilities tasks. Even after variance due to verbal abilities was removed, however, this measure continued to be positively correlated with alternating fluency and Stroop performance. Thus, despite its relationship to verbal abilities, the semantic clustering index also shares unique variance with some of the executive measures.

A decreasing pattern of semantic clustering across trials may reflect a failure of inhibition. By definition, it presumes some use of the strategy on trial one. Individuals with such a pattern may be initially capable of using the implicit semantic structure, but ultimately fail to continue with this strategy because they begin to respond to the more salient fixed serial order. As such, the

research model predicts that such a pattern could be a more

specific indicator of executive functioning than is the

overall clustering index. This model received only partial

support from the research findings. Analysis of change in

semantic clustering did not prove to be a robust and

specific indicator of executive functioning, nor did it

provide substantial information about executive functioning

beyond that accounted for by the overall index score. When

individuals were classified according to the direction of

change in semantic clustering (i.e., identified according to

increased or decreased use of the strategy), there was a

small difference between the groups in Stroop performance,

and this relationship remained when variance due to overall

semantic clustering was removed. This finding supports the

research model, but the difference found in Stroop

performance between the groups was small and would likely be

of limited clinical usefulness. Furthermore, the two groups

did not differ significantly on any of the remaining

executive measures. These findings do suggest an association

between failure in inhibition and direction of change in

semantic clustering. Nonetheless, the finding is not robust

enough to suggest that such deficits would fully account for

such a pattern, nor does it seem to be accounted for by

overall differences in semantic clustering. It may be that

lack of reliability could play a role. Data on the test-

retest reliability of a semantic clustering slope measure is

not available to examine this possibility.

   The rate of change in semantic clustering across trials

was positively correlated with Stroop performance, but the

relationship was attenuated when the effects of overall

semantic clustering were controlled for. In contrast, when

the effects of the change in semantic clustering scores were

removed, a positive correlation between the overall semantic

clustering score and Stroop performance remained. While the

rate of change was also positively correlated with one of

the remaining three executive indices, this relationship did

not remain after the variance due to verbal abilities was

removed. Thus, analysis of change in semantic clustering

does not appear to provide substantial information about

executive abilities, beyond that accounted for by its shared

relationship with verbal abilities and by the overall

semantic clustering index.

   Conceptually, difficulty in inhibiting the repeated

serial order of a word list could manifest, not just as an

abandonment of semantic clustering, but as increasing use of

serial clustering across trials. Thus, the relationship

between the serial clustering and executive measures was

also examined. Past literature would suggest that the

overall level of serial clustering and an increase in its

use over trials, might both correlate negatively with

executive measures. That is, individuals with greater serial

clustering or those who increase its use over trials, might

be expected to perform more poorly on executive measures.

Examination of the simple correlations between the two

serial clustering scores and the executive measures revealed

no significant correlations in the expected direction. The

serial clustering slope, but not the overall score, was

negatively correlated with WRAT-R reading. Neither measure

was correlated with WAIS-III Vocabulary, neither measure

related to the Stroop task when variance due to the other

was removed, and no relationship with executive abilities

emerged after controlling for the effects of verbal

abilities. To a limited extent, increased serial clustering

across trials (positive slope) appears to be related to

verbal abilities. Neither the overall serial clustering

index nor serial clustering slopes, however, appear to be

indicators of executive functioning.

The lack of associations between the overall serial clustering index and executive measures when general verbal abilities are controlled for, is particularly surprising given that there was a demonstrated relationship between the serial clustering index and semantic clustering index. That is, the two did negatively correlate, as expected; those who used more semantic clustering tended to use less serial clustering. So, despite their relationship, semantic clustering, but not serial clustering, was specifically associated with executive abilities. It may be that any relationship between serial clustering and executive abilities is mediated by semantic clustering. In other words, serial clustering is only associated with executive abilities insofar as high scores suggest less use of semantic clustering.

Summary of findings in clustering and benefit from cueing:

Hypotheses 7 to 10 predicted a relationship between clustering slopes and ability to benefit from cueing at recall. Previous researchers who studied changes in use semantic clustering (Buytenhuijs, et al., 1994; Van

Spaendonck, et al., 1996) demonstrated that decreasing use

of this organizational strategy (and/or a concomitant

increase in serial clustering) was seen among one group of

individuals who were capable of using the semantic

clustering strategy, but had difficulties inhibiting the

salient serial order as fixed-order trials progressed. This

was viewed as a deficit in inhibiting the salient serial

order, and could be related to a proposed difficulty in

directing attention to self-initiated processes when

confronted with salient external cues (Brown & Marsden,

1988). If a similar difficulty accounted for decreased

clustering in my sample, it was expected that such

individuals would show greater ability to benefit from

semantic cueing at recall. The results disconfirmed this

hypothesis. The ability to benefit from cueing could not be

predicted by serial or semantic clustering slopes, direction

of serial or semantic clustering slopes, nor by the overall

serial and semantic clustering indices.

Exploratory Analyses

    Examination of the relationships between the change in

semantic clustering scores (semantic clustering slopes) and

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each of the symptom and demographic variables, revealed a

significant relationship only with scores on a test of

involuntary motor movements (AIMS). This scale is a measure

of extrapyramidal symptoms, which can occur as side effects

from neuroleptic medications; similar movement abnormalities

have also been documented among neuroleptic naive patients.

Given the large number of correlations observed without

adjustment for multiple observations, this may have simply

been a chance finding. Nonetheless, this finding is

intriguing, given that past research suggested decreasing

semantic clustering across trials in an extrapyramidal

disorder -- ie., Parkinson's disease (Buytenhuijs, et al.,

1994; Van Spaendonck, et al., 1996). Furthermore, Berger and

colleagues (1999) found a relationship between symptoms and

changes in clustering strategies in individuals with

Parkinson's disease. These researchers found that an

increasing reliance on serial clustering over trials was

associated with greater hypokinesia/bradykinesia.

In my results, the change in semantic clustering

measure was not significantly related to chlorpromazine

equivalents (a rough estimate of the neuroleptic dosages,

obtained by converting dosages of various neuroleptics to

the dosage of chlorpromazine thought to be therapeutically equivalent), suggesting that any relationship between change in semantic clustering and abnormal involuntary movements was not simply mediated by medication dosage. Caution is warranted in interpreting this finding and replication in a separate sample of individuals with schizophrenia would be needed. However, if replication suggests that this correlation represents a true relationship between extrapyramidal dysfunction and decreasing semantic clustering across trials, it could serve as an interesting area for future research. Analysis of the changes in clustering across trials could potentially serve as a diagnostic marker, a means of subtyping, or even a means of identifying individuals who may be particularly susceptible to extrapyramidal side effects of neuroleptics.

The overall semantic clustering index did not correlate with involuntary motor movements, but was negatively associated with the general psychopathology and negative symptom scales on the PANSS. Past research suggests that higher negative symptom ratings are associated with impaired performance on verbal memory and verbal fluency tests (O'Leary et al., 2000). In this sample, the semantic

clustering index does correlate with the language and verbal

fluency measures, as well as with education; thus, it may be

that these abilities mediate the relationship between

semantic clustering and the symptom measures. In my sample,

the overall serial clustering index and serial clustering

slope did not significantly correlate with any of the

symptom or demographic variables.

In my exploratory analyses, I examined the

relationships between each of the clustering measures and a

number of CVLT memory indices. The overall semantic

clustering index significantly correlated with all of the

memory indices. Those who used more semantic clustering,

overall, did better on recall and recognition of the word

list. This is consistent with past research and such

findings form the basis for using a categorized list to

measure learning processes. It is notable that the

relationships between recall and clustering strategies

during learning trials remained even after the semantic

structure was made explicit by the examiner's prompts, which

provided external cueing. This suggests that, at least in

our sample of individuals with schizophrenia spectrum

disorders, the detrimental effects on recall from failures

to use semantic structure may have been at the level of encoding and could not be overcome through provision of external cueing at time of recall. The patients' problems in encoding may stem from a primary problem in attention, which is one of the hallmarks of schizophrenia. The failure to categorize apparently impaired the ability of the patients to learn the materials, not just to organize as an aid to recall. Furthermore, individuals who failed to use the semantic clustering strategy during recall, continued to perform poorly even when tested in a recognition format.

The overall serial clustering index was negatively correlated with short-delay free and cued recall, suggesting that those who used more serial clustering had poorer performance in the initial recall after distraction. Insofar as past research has demonstrated the serial clustering strategy to be less effective for categorized lists, this finding is not surprising. The serial clustering slope did not correlate with any of the other memory indices.

In contrast to the pure memory indices, which correlated with the semantic clustering index and to a lesser extent with the serial clustering index, the benefit from cueing measure was not significantly related to any of

the clustering variables. The research model predicted that it would not be related to the general clustering index, but would negatively correlate with the semantic clustering slopes if decreasing clustering was related to failures in inhibiting the salient serial order. However, the limited relationship between semantic clustering slopes and executive functioning tasks suggests that such failures in inhibition do not fully account for decreased clustering in this sample.

Limitations and delimitations of the study

The present study is limited in its generalizability by the nature of the sample, which consists of individuals with schizophrenia spectrum disorders who were recruited as inpatients. The relationships between neuropsychological variables in this sample may not generalize to a healthy population, nor to other clinical populations. Individuals with schizophrenia may not show a predictable pattern of association between neuropsychological measures. This idea is supported by the work of Tekell and colleagues (1999), which showed that an association between executive functioning and attentional performance was not evident for

a group of schizophrenia patients, but was apparent for healthy controls and other clinical populations. Similarly, the failure to find significant relationships between patterns of serial or semantic clustering and executive functioning in individuals with schizophrenia, says little about whether such patterns are present in healthy individuals or in other patient populations.

Such relationships could be obscured, also, by general impairments often seen in samples of individuals with schizophrenia. In this sample, for example, the mean performance on WAIS-III Vocabulary was one standard deviation below the normative mean, as was WRAT reading performance. This is not inconsistent with previous findings in samples of patients with schizophrenia (Heinrichs & Zakzanis, 1998), but does suggest the findings may not be extrapolated to groups without such generalized cognitive impairment.

Another potentially limiting variable in the current study is the motivation of the participants. Individuals were paid to participate in the study and it is not known whether or to what extent full motivation to perform at their best was achieved. That the test administrators were

experienced in helping to maintain motivation and discontinue testing when necessary, may have reduced the effects of poor motivation. Nonetheless, an individual participating as part of a paid research study certainly may have less incentive than one who is testing purely for clinical purposes. Unless or until these results are replicated on a sample tested on a purely clinical bases, it is not known to what extent they would generalize.

Similarly, the measures for this study were part of a neuropsychological battery that took approximately two hours to administer. The examiners did break the testing up into multiple sessions when necessary and the symptom measures were completed on a different day. Nonetheless, fatigue could be an issue and it must be considered a potential limitation to the generalizability of these findings.

The study is limited by its non-experimental design. The inclusion of a permuted-order task for comparative purposes, for example, could have helped to distinguish those individuals who failed to use the semantic clustering strategy solely because of the fixed-order presentation of the list. As it is, I could not be certain that those who decreased clustering over trials did so only for this

purpose.

Another limitation to the study is its cross sectional design. A longitudinal study would have allowed me to compare individuals' clustering strategies over time, and would have allowed for determining whether different patterns of clustering over trials were stable. As it is, the reliability of clustering slopes is unknown and a low reliability may have resulted in significant error in the measure, thereby reducing the degree to which this measure could correlate with other variables.

With the exception of the alternating fluency task, the measures chosen for this study were conventional neuropsychological measures commonly used in clinical evaluations. This has the advantage of improving generalizability. It is possible that tasks more specific to a particular functional domain or anatomical correlate could have yielded different results. This limits the implications of the findings from the perspective of cognitive neuropsychology, but allows for greater extension into clinical practice.

Implications

    Clinical implications. In general, these results do not

lend support to the prediction that examination of

clustering changes over trials will provide substantial

information beyond that obtained by the overall semantic

clustering index. In a sample of individuals with

schizophrenia spectrum disorders, a measure of change in

semantic clustering over trials was associated with

executive tasks, but the association was no longer

significant when the effects of overall semantic clustering

or general verbal abilities were removed. When individuals

were classified according to whether they increased or

decreased in their use of semantic clustering, the two

groups differed on Stroop performance even after the effects

of overall clustering had been removed, but the differences

were small and not likely to be clinically useful. A

measure of change in serial clustering, did not

significantly predict performance on the executive tasks.

    In contrast, the study does lend support to the

potential usefulness of the overall semantic clustering

index. This measure was significantly associated with three

of the four executive tasks and the relationship remained

even after the effects of verbal abilities were removed. In individuals with schizophrenia, the overall semantic clustering index appears to be associated with both verbal and executive abilities, and to share unique variance with the latter. This supports the practice of using the index as a measure of executive functioning as it relates to verbal learning.

Past research has indicated that an analysis of clustering slopes could prove useful for identifying individuals with specific difficulties in their ability to inhibit the salient serial order of a fixed-order list. This did not prove to be the case in a sample of individuals with schizophrenia spectrum disorders. As such, at least with this population, clinicians would benefit little in their understanding of a patient's executive abilities by computing clustering change scores.

None of the clustering variables appeared to be associated with the ability to benefit from cueing. Instead, the general semantic clustering index was strongly associated with recall performance in both cued and uncued conditions, as well as during recognition testing. This is a notable finding in that it suggests that the failure in

these patients to use category clustering was associated with encoding deficits that could not be overcome even when external organization was provided by the examiner. Thus, rather than simply reflecting a failure to organize information in a way that benefits recall, this organizational or semantic failure appeared to impact the initial acquisition of the information. While it is tempting to assume that prompting can differentially improve performance among individuals whose learning is effected by decreased organization, this does not appear to be the case among individuals with schizophrenia spectrum disorders. Instead, amount of semantic clustering in this population appears to be unrelated to benefit from cueing.

The finding of a relationship between change in semantic clustering over trials and scores on a scale of involuntary movements, was interesting. It was the discovery of decreasing semantic clustering across trials in patients with a Parkinson's disease (an extrapyramidal disorder) that originally drew my interest into studying the patterns of change in use of the strategy. That the change in semantic clustering variable was associated with a measure of extrapyramidal symptoms in this sample, suggests a potential

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diagnostic marker or a potential marker of susceptibility to extrapyramidal side effects.

Directions for future research. In this study, the change in semantic clustering over trials did not appear to be a strong predictor of executive abilities beyond that accounted for by overall semantic clustering or by verbal abilities. Further research on the relationship between these functions in normal controls and other clinical populations would help to determine whether this pattern of findings is unique to schizophrenia. If the decreasing pattern of semantic clustering is pathological, the number of individuals showing such a pattern may be minimal and lead to difficulties with restricted range. Nonetheless, such work would be useful for comparative purposes.

Because previous work had suggested that patients with Parkinson's disease may tend to show a decreasing pattern of semantic clustering over trials, this population is of particular interest. A similar study, to the current one, in a sample of individuals with Parkinson's disease would be useful in determining whether within group differences in the use of these strategies are associated with performance on tasks of inhibition. If only a subset of patients

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decrease their semantic clustering over trials, these can be compared to those who do not show such a pattern on measures of inhibition such as Stroop and Lurian go/no-go tasks. If a sizeable portion of the sample decreases their use of the semantic clustering strategy over trials, then this could be used as a continuous variable to determine whether degree of decrease is associated with degree of impairment on the inhibition tasks. Positive findings would lend support to the work of Buytenhuijs, et al. (1994) and Van Spaendonck, et al. (1996) suggesting that such a pattern is consistent with greater interference from salient external stimuli.

If within group associations, through studies such as those discussed above, are found between differing clustering patterns and tasks of inhibition among individuals with Parkinson's disease or normal controls, then extension of such research into other clinical populations may be valuable. If the aforementioned studies do not yield associations between these variables, it is unlikely that future research in this particular direction will be fruitful.

A related area of potential research in individuals with schizophrenia, is a comparison of performance on

permuted and fixed order lists. If a subgroup of individuals with schizophrenia show differential improvement in the former condition, it would be interesting to see whether such patient are more likely to show a decreasing use of semantic clustering across trials, benefit more from semantic cueing in fixed-order condition, or show more impaired performance on tests of inhibition.

In studying the relationships between executive abilities and learning strategies, one area of potential interest is the release of proactive interference. Proactive interference occurs when examinees must recall words from a new list that are derived from the same semantic categories provided on a previously learned list. Under such conditions, recall will decrease with each new list of shared-category words. When a new list is then presented, which contains words of a different semantic category, recall will improve; a phenomenon known as release from proactive interference. This phenomenon has been alternately attributed to either deficits in benefiting from semantic organization (Squire, 1982) or to deficits in set-shifting (Tweedy, et al., 1982). Our study would suggest that semantic organization and set shifting are related,

nonetheless, this would be a fruitful area for future

research. It would be interesting to examine the

associations between overall clustering, change in

clustering across trials, separate executive measures, and

release from proactive interference.

Whatever the future of research on changes in use of

clustering across trials, the current study does validate

the usefulness of an overall semantic clustering index. In

our sample, this index predicted both verbal abilities and

executive functioning, but also shared unique variance with

at least some of the executive measures. Greater use of the

less effective serial clustering strategy has been

associated with hypofrontality on PET imaging in a study of

individuals with schizophrenia (Hazlett, et al., 2000) and

the semantic clustering index is used by some as a measure

of executive abilities (cf., Romans et al., 1997). At the

same time, the semantic clustering index did have strong

associations with verbal abilities in our study. This is

consistent with its use, by some, as a measure of semantic

clustering (cf., Levin et al., 1996) and this incomplete

specificity may explain why it failed to differentiate

between those with severe and miminimal executive abilities

in the study by Tremont and colleagues (2000). The semantic clustering index, alone, does not appear to be a specific indicator of executive abilities. Nonetheless, it does appear to share unique variance with executive functions and future clinical research may help to determine an algorithm by which the executive and semantic components could be more clearly differentiated for diagnostic purpose. If the change in clustering does not serve this purpose (as it did not in this study), then other relationship may.

The association found, in the current study, between change in semantic clustering across trials and scores on an abnormal involuntary movement scale was relatively small and incidental to the primary purpose of the research. Nonetheless, it is an interesting finding. A simple study would suffice to see whether this correlation holds up in another sample of individuals with schizophrenia. Further elaborations could include controlling for medication dose and type of neuroleptic. If the finding is replicated, and the association between the change in clustering and extrapyramidal signs is not solely mediated by a shared relationship with medications, then a longitudinal study would be very interesting. Such a study could be best

incorporated into treatment research on initially

unmedicated schizophrenics. Patients would be tested on the

fixed-order word list and AIMS scales at baseline, and

repeated testing would be performed after treatment. A time

lag design could help determine whether the decreasing

semantic clustering occurred at the same time as the

extrapyramidal signs or predicted their later occurrence.

<u>Summary and Conclusions</u>

In this study, I focused on semantic and serial

clustering in the CVLT. I attempted to determine whether a

decreasing pattern of semantic clustering across trials

would serve as a more specific indicator of executive

abilities, than did the overall semantic clustering index.

Similarly, I looked at whether an increasing pattern of

serial clustering would do the same. Of additional interest,

was the relationship of these measures to the ability to

benefit from semantic cueing at recall.

The results of the study did not lend substantial

support to the utility of measuring change in clustering

across trials. Limited support was seen in the finding that

individuals who decreased in use of semantic clustering

across trials did do more poorly on a task of inhibition, a

relationship that was not mediated by overall semantic

clustering. Nonetheless, the differences between the two

groups were quite small, which reduces clinical utility. In

general, the semantic clustering index appeared more useful

than the analysis of change in clustering. This index did

predict several of the executive measures, and a

relationship remained after controlling for either verbal

abilities or the change in clustering scores. In this

sample, neither the serial clustering index, nor analysis of

change in serial clustering over trials, tended to be strong

predictors of executive abilities.

Contrary to the research hypothesis, ability to benefit

from cueing could not be predicted by change in semantic

clustering over trials, nor by any of the other primary

clustering measures. The semantic clustering index, however,

was strongly related to all of the memory indices, including

performance on cued recall and recognition. This suggests

that the failure to initiate a categorical organization of

the list impacts the initial encoding of the material,

rather than simply affecting recall organization.

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