THE MODIFIED FORM OF THE WISCONSIN CARD SORTING TEST: NORMATIVE DATA AND ANALYSIS OF PROBLEM-SOLVING SKILL IN CHILDREN

by

JOAN ELLEN MACHAMER
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[redacted]

We accept this thesis as conforming
to the required standard

[redacted]
Dr. R. Graves

[redacted]
Dr. M. Corcoran

[redacted]
Dr. O. Spreen

[redacted]
Dr. L. Ollila

[redacted]
Dr. P. Parry

Supervisor: Professor Roger Graves

ABSTRACT

Normative data was collected on the modified form of the Wisconsin Card Sorting Test (WCST) for children 6 to 9 years old. Thirty children at each age level (120 total) were administered the WCST, the Peabody Picture Vocabulary Test-Revised (PPVT-R), and the block design subtest of the WISC-R. A simple concept formation task was also administered to insure all the children had the concepts color, form and number. Developmental changes in flexibility and in problem solving skill were investigated. Performance on the WCST was also compared with intelligence and mental age scores on the PPVT and block design subtest.

The number of categories obtained and the total number of errors made on the WCST were significantly related to age. However, no particular type of error could be identified as decreasing significantly as the age of the subjects increased. Correlations between intelligence and WCST performance were low. Correlations between mental age scores and WCST performance were significant but only accounted for nine percent of the variance. Mental age scores on the PPVT and the block design subtest were equally correlated with WCST performance.

A new scoring system was devised for the modified form of the WCST. This, and related issues were discussed.

Examiners:

[redacted]
Dr. R. Graves

[redacted]
Dr. M. Corcoran

[redacted]
Dr. O. Spreen

[redacted]
Dr. L. Ollila

[redacted]
Dr. P. Parry

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DEDICATION

This is dedicated to JBD, for his patience.

INTRODUCTION

> Experimental psychological investigation when utilized clinically must be concerned not so much with whether a problem is solved as with the way in which it is solved. In other words, it calls for a careful qualitative analysis of the patient's activity, of the difficulties experienced, and of the mistakes made (Luria, 1966, p. 303).

When evaluating children's abilities to solve cognitive problems it is imperative to take into account developmental differences in the way in which the task is attempted, as well as the ability to find the solution. The purpose of the present study is to collect norms on a problem solving task appropriate for children and to examine some differences between age groups. Specifically, the study compares differences in flexibility and problem solving skill at four age levels. The relationship between intelligence and mental age with problem solving ability is examined. The following sections will present the rationale for norm collection and the test selection as well as review the literature pertaining to the areas described above.

RATIONALE FOR NORMATIVE DATA COLLECTION

The ability to solve problems is clearly a crucial component of a child's cognitive activity. Vygotsky (1962) claimed that the ability to attain the solution to a concept formation task is closely linked to language and the formation of higher psychological processes. He presented 22 wooden blocks to his subjects which varied on color, shape, height and size. A nonsense word was printed on the bottom of each block (lag, bik, mur or eev). The examiner turned over one of the blocks, allowed the subject to see the nonsense word, and asked him or her to choose the other blocks that belong with the exposed one. When the subject was finished the examiner turned over one of the incorrect blocks and displayed the different nonsense word. The subject was given other chances to group the blocks correctly. After each grouping the examiner turned over an incorrect block until the subject made a completely correct sort.

Vygotsky (1962) found that the ability to form the correct solution (or concept) improved as the age of the child increased. In his view, concept formation begins as a syncretic process wherein the child does not sort the blocks so much as simply puts them together into an unorganized pile.

The manifestations of this stage can also vary between randomly choosing blocks to form a group to choosing them on the basis of their spatial position in the original layout. Vygotsky calls the next stage "thinking in complexes" and is characterized by relating the blocks subjectively as well as by factual, concrete reasons. This sort of ordered relationship can take one of several forms but the reason why certain blocks are placed together is never abstract nor logical. The last step within this second stage is called the "pseudo-concept". Here, the child sorts the blocks as if he is sorting to a concept but in fact, he is only sorting to a concrete, visual likeness. The full development of concept formation ability is acquired when the simultaneous and parallel development of abstraction as well as the development of complex thinking are complete. By abstraction Vygotsky (1962) means the ability to abstract the relevant traits from the stimuli in order to form the overall concept. Vygotsky (1962) claims that it is the combination of abstraction and complex thinking in adolescence which culminates the process of cognitive development.

Piaget (1951) demonstrated the relevance of problem solving ability as a valid indicator of cognitive development. His work revealed stages of thought (e.g. sensori-motor, pre-operational, concrete-operational & formal operations) which were adequately gauged by children's skill in

solving logical problems. Inhelder & Piaget (1964) clarified the pattern of development in children's ability to logically classify stimuli. They isolated three stages in this development: graphic collections, non-graphic collections, and hierarchical classifications.

Graphic collections (the first stage) is the arrangement of stimuli into spatial patterns. The child (4 to 5 years old) in this stage typically does not use all the stimuli and often makes patterns of objects that form a figure. The second stage of classification, non-graphic collections, is characterized by groupings of objects that are similar to each other. This classification system often appears to be based on a logical system but closer examination reveals that it is a quasi-classification. Although children in this stage can group stimuli on the basis of similarity they fail to understand the principles of all and some. The third stage, hierarchical classification, occurs after age 7 years and is characteristic of logical groupings. Furthermore, children in this stage comprehend the relation between an all-encompassing category, like form, and its components (e.g. squares, circles and triangles).

One of the crucial differences between each of these levels of categorization is the ability to exhibit flexible sorting behavior. Inhelder & Piaget (1964) claim that the child's ability to solve the sorting problem improves as his

or her thought processes become increasingly logical and flexible. As they put it," . . . for every stage in the development of operational structures there must be a corresponding development in flexibility" (p. 196).

Inhelder & Piaget (1964) demonstrated that the child's ability to solve logical classification problems improves with age, is related to an increase in flexibility, and is a valid indicator of cognitive development.

Besides the fact that problem solving ability is related to age and stage of thought, it is also found to be deficient in brain-damaged, retarded and learning disabled children. For example, brain-damaged and retarded children's ability to attain concepts on concept acquisition tasks is inferior to that of normal controls (Bell, 1972, 1974; Denney, 1975; Reed et al, 1965; Strauss & Werner, 1942; Werner & Strauss, 1941). For example, Townes et al. (1978) compared 27 normal children with 27 brain-damaged children on the Category and Matching Pictures subtests of the Reitan-Indiana Battery. The children's ages ranged from 5 through 8 years. As predicted, the brain-damaged children's performance was inferior to the normal children's performance.

Flexibility is also a distinguishing factor on concept acquisition tasks between abnormal groups of children. McMurray (1954) found a difference in performance between 15 brain-injured children and 15 mentally retarded children on

a card sorting task. These children were chosen from a population of 2000 so that both groups matched each other as completely as possible. A modified form of the Wisconsin Card Sorting Test was administered. In this task the cards varied on color, form and number and the subjects had to discover the relevant sorting concept. After they made five consecutive correct responses the sorting concept was changed. Rigid behavior was gauged by the number of perseverative errors made on the test. McMurray (1954) found that brain-injured children made significantly more perseverative errors than the mentally retarded children.

Both flexibility and concept acquisition are deficient in brain-injured children. There is no doubt that neuropsychological assessment of these abilities is important.

There is now evidence that some learning disabled children have difficulty solving problems. Torgesen (1977) reviewed the research on the development of memory, attention, and learning, and proposed that many learning disabled children are unable to adapt to the requirements of a new task. They do not know how to go about learning the new material. Torgesen (1979) tested his proposal by questioning good readers and poor readers about memory and memory strategies. He found that the poor readers had significantly less knowledge about strategies like rehearsal, generating a plan to solve a memory problem and less ability to generate

different solutions tc memcry prcblems. Torgesen (1979) concluded that many children who are pccr readers may also not manage their intact capabilities efficiently.

Barringer & Ghclscn (1980) examined problem solving strategies in 80 normal and 80 reading disabled children in the fourth and fifth grades. The stimuli varied cn fcur dimensions (colcr, form, size and positicn). On some trials the subjects received feedback on their responses and cn other trials they did not. They fcund that the normal readers either performed well throughout the task cr imprcved with practice. The reading disabled children were less likely to switch their attention from a disconfirmed stimulus response to the cne that was correct. The learning disabled children made irrelevant hypotheses twice as often as normal readers. Barringer & Gholscn (1980) concluded that the reading disabled subjects had a processing deficit. Others have found evidence that some learning disabled children have difficulty with the problem solving process (Hall, 1980; Reid & Hreskc, 1981).

Thus, the ability to solve problems is deficient in some learning disabled childrer and in some brain-damaged children. Furthermore, the ability to solve prcblems is correlated with age and stage of thcught in normal children. Therefore, neuropsychological evaluation of prcblem solving ability is important and necessary for the adequate assessment of the developmental and cognitive status of children.

There is no standardized, easily administered test available to assess problem solving ability in children. Cognitive tasks like logical classification (Inhelder & Piaget, 1964) or Levine's (1966) discrimination task have not been standardized for clinical use. Furthermore, there is no normed, readily available neuropsychological test designed to assess children's skill in solving problems. The Halstead Category Test (Halstead,1947) does measure concept formation in a problem solving format but in order to administer it, equipment is required which is not easily transported. Although the WISC-R (Wechsler Intelligence Scale for Children-Revised) may provide an indirect indicator of problem solving competence, none of the subtests can be considered as pure, valid tests of this ability. Therefore, there is a great need for a normed, easily accessible test to assess the problem solving skills of children.

The Wisconsin Card Sorting Test

One test which has been recognized as a measure of adult problem solving ability is the Wisconsin Card Sorting Test (Grant & Berg, 1948; Berg, 1948). The Wisconsin Card Sorting Test (WCST) was originally devised by Grant & Berg in 1948, based on a Weigl type sorting task. Weigl's (1941)

test consisted of a group of cut-out forms (circle, square and triangle) colored red, green, blue or yellow. Weigl asked his subjects to sort these figures. After they had sorted them in one way he asked them to resort them. His test revealed a concrete or abstract sorting process as well as the ability to shift mental set.

The WCST consists of four stimulus cards, each with a different arrangement of number, color and form on it. The first card has one red triangle on it, the second has two green stars, the third has three yellow crosses and the fourth has four blue circles. The subject receives two packs of response cards, each with 64 cards in it. The cards have different combinations of color, form and number printed on them. The subject places each of his or her response cards below the stimulus she or he thinks it belongs to. After each placement, the experimenter tells the subject whether she or he is right or wrong. After the subject has made ten consecutive correct responses the sorting concept is changed without warning. The correct concepts to sort to in order are color, form, number, color, form, and number. The test is terminated when the subject has successfully solved all six categories or when he or she runs out of response cards (Grant & Berg, 1948).

The number of consecutive correct responses allowed before a category change was varied in some of the earlier

studies involving the WCST. Grant & Berg (1948) ran seven groups of subjects, each group receiving either 3, 4, 5, 6, 7, 8, or 10 reinforcing trials before a subset change. They found that as the number of reinforcing trials increased, the number of perseverative and nonperseverative errors decreased. Grant & Cost (1954) examined the effect of allowing subjects 5, 10, 20 or 40 positively reinforced trials before the category shift. They found that as the number of reinforced trials increased, the number of errors decreased. Furthermore, this improvement was gradual in the first three category changes but made no difference in the last three as long as there were at least 10 reinforcements before the shift. Therefore, ten consecutive correct responses before a category shift became a part of standard procedure of the test administration.

Other early studies performed on the WCST examined which category (color, form or number) was the hardest and which was the easiest to sort to. Grant, Jones & Tallantis (1949) hypothesized that form would be easiest, then color and then number. They based their hypothesis on the results of previous experimentation. For example, Brian & Goodenough (1929) studied dimension preference in 474 people between the ages of 2 and adulthood. They found that young children, under the age of 6 preferred color as a stimulus dimension. People 6 years and older preferred form to color.

These finding have been replicated many times (Melkman et al., 1981; Heidbreder, 1946, 1949; Suchman & Trabasso, 1966). Grant et. al. (1949) however, found that number was the easiest concept to sort and color was the most difficult. The authors suggested one reason for the unexpected finding was that each number of figures was ordered on the card in a consistently particular configuration. In a subsequent study one group of subjects was given the WCST with each number of figures matching a particular configuration, and another group was given the test with no systematic placement of figures on the cards (Grant, 1951). Grant found that it was easier to sort to the number concept when it always matched a particular configuration. In subsequent versions of the WCST the particular configuration was no longer varied systematically with the number of figures on the cards (Grant & Curran, 1952).

Mitler & Harris (1969) using a simplified WCST procedure, examined the effect of dimension preference on the attainment of color, form and number in 77 kindergarten, first and third grade children. First, the children sorted cards from the WCST. All but two of the subjects showed significant dimension preferences; 59 subjects preferred form, 9 number, and 7 color. Then the subjects had to solve for the concepts color, form and number using the same cards. The form dimension was the most easily solved, then color and

finally number. The third graders' performance on the WCST was significantly better than the kindergarten childrens' performance. The kindergartners had particular difficulty with the number concept. The means for the number of categories obtained on the WCST were: kindergartners, $\bar{X}$=1.78 (SD=1.22); first graders, $\bar{X}$=2.75, (SD=1.67); third graders, $\bar{X}$=3.33 (SD=1.79). The mean number of errors made were: Kindergartners, $\bar{X}$=47.67 (SD=9.34); first graders, $\bar{X}$=42.30 (SD=10.08); third graders, $\bar{X}$=35.00 (SD=11.63).

Mitler & Harris (1969) reasoned that the kindergartner's difficulty may have stemmed from their immediately prior experience of the dimension preference task. They ran a control group of third graders and kindergartners who received the WCST first before they participated in the dimension preference task. Significantly more control kindergarten subjects obtained the number concept than the experimental kindergarten subjects. Furthermore, only 47 percent of the control subjects exhibited dimension preferences, while 97 percent of the experimental group did. The effect of dimension preference on concept attainment was much more pronounced when the dimension task occurred first. Apparently, immediately prior experience can significantly affect concept attainment ability.

Clinicians and researchers have utilized the WCST to study different groups of people. For instance, Tarter &

Parsons (1971) found that alcoholics take more trials to reach criterion and make more errors than another group of patients and students. The researchers concluded that alcoholics do more poorly than normals because of an inability to sustain a systematic search when attempting to solve the test problem. In a later study, Tarter (1973) found that alcoholics, who admitted to alcoholism of less than 10 years, were impaired in set persistence on the WCST. Alcoholics of greater than 10 years duration were impaired in set persistence, set shifting, and error utilization on the WCST, when compared to normals. Milner (1964) found that patients with dorsolateral frontal lobe damage make more perseverative errors than do other brain damaged groups. A group of adults who scored high and a group who scored low on the Taylor Anxiety Scale were compared while performing the WCST and experiencing intermittent electric shock (Grant & Patel, 1957; Patel, Grant & Kuboyama, 1955). In general, these researchers concluded that very anxious subjects' conceptual ability was more susceptible to a stressful testing situation than those who scored low on the Taylor Scale. Fey (1951) compared schizophrenics' performance on the WCST with normal adults aged 18 to 34 years old. Schizophrenics performed poorly making more errors than normal subjects. However, Fey (1951) noticed that normal subjects, with no evidence or history of pathology can experience difficulty

with the WCST. She found that they fell at both extremes of the possible range of ability on the test. She suggested the difference between normal adults' and schizophrenics' performance is quantitative, not qualitative, and the normal population's performance should be studied more thoroughly.

A few studies have examined normal subjects' performance on the WCST. Loranger & Misiak (1960) administered this test along with several others to a group of 50 adults over the age of 70 years who had no neurological or opthalmolcgical deficits. They found the average number of categories completed was 1.86. The average number of total correct responses was 12.28. The amount of nonperseverative errors made by the elderly averaged 11.36 and the average number of perseverative errors was 12.19. An average of 2.4 unique errors were made by the subjects.

Yeudall & Battle (1978, unpublished study) collected norms on the WCST using 46 male children aged 9 to 14 years old. They found that the average 9 year old in their sample obtained 5 categories. Ten year olds averaged 4.8 completed subsets, 12 year olds completed an average 5.5 subsets, and 13 year olds completed an average 5.4 subsets. Both the 11 and 14 year olds completed 6.0 subsets.

It would appear that the test has never been systematically administered to normal children under the age of nine. Normative data on this population would be of use in a neu-

ropsychology clinic as well as provide information on the development of various behaviors. One reason why normative data have never been collected for young children may be the reported difficulty of the test, not only for groups of abnormal subjects but as well for some normal adults. For example, Berg (1948) split her group of normal young adults into three groups based on their performance on the test. Group A had superior performance, Group B subjects made more errors but their performance gradually improved as the test continued. However, Group C subjects made many errors throughout the whole test, demonstrating perseveration and expressing the belief that there was only one underlying concept to sort to. Thus, children may have been neglected because of the reported difficulty and frustration the test presents for some adults.

Mitler & Harris (1969) developed a modified form of the WCST in order to make it more appropriate for young children. In this form, the same four stimulus cards are used but the response card pack is reduced from 64 to 24 cards. Every card that can match a stimulus card on more than one attribute is removed. Thus, each of the remaining 24 cards can only match a stimulus card by color, form or number but not by any combination of these. This variation allows six consecutive correct responses before changing the concept. The number and order of the sorting concepts are

the same as the traditional version. This modification greatly reduces confusion about what the correct sorting concept is, while not destroying any other aspect of the test such as the need to shift mental set without warning. Nelson (1976) used this modification of the WCST in order to make it easier for her patients to complete the test. Nelson (1976) provided no norms for children. Although Mitler & Harris (1969) provide means and SD's at three age levels (kindergarten, first and third grades) they report that the dimension preference task administered immediately before the WCST influenced WCST performance, especially at the younger ages tested. Furthermore, Mitler & Harris (1969) only provide normative data for number of categories obtained and total errors made on the WCST. They do not provide means and SD's for each error score.

The modified version of the WCST is advantageous because like the standard version, it can be used to assess both flexibility (the ability to shift set, i.e. to stop using an inappropriate concept), and the ability to attain new concepts. These two aspects have been reported to be essential to the development of problem solving ability in logical classification tasks (Inhelder & Piaget, 1964) and in other cognitive research (Gholson et. al., 1973; Tumblin & Gholson, 1981). There is evidence that these areas are developing and changing in young children. A collection of

norms for children on the Mitler & Harris (1969) modification of the WCST, scored for both the ability to shift set and to attain concepts would be exceedingly valuable.

CONCEPT ATTAINMENT & FLEXIBILITY IN NORMAL CHILDREN

Definition of Terms

The terms concept formation and concept attainment have been used interchangeably when discussing children's problem solving tasks. However, Bruner et al. (1956) make a distinction between concept formation and concept attainment. They view concept formation as the first step of concept attainment; it is "the sorting of stimuli into meaningful categories in order to lessen diversity in the environment". Concept attainment "refers to the process of finding predictive defining attributes that distinguish exemplars from nonexemplars of the class one seeks to discriminate" (p. 22). Although this may be a useful distinction, it is, as Pikas (1966) points out, difficult to uphold in a real problem solving situation. For example, to hypothesize is often to form a concept, yet Bruner et al. (1956) consider it to be a part of the concept attainment process. Problem solving can involve both concept formation and concept attainment processes although it does not have to. For instance, the WCST is a concept attainment task because the subject's

task is to determine the identity of the correct concept based on information provided by the experimenter. However, the subject must also be able to form the concepts color, form and number (i.e. to comprehend that red, blue, yellow and green make up the concept color). Inability to do so might seriously hamper the subject's ability to attain the correct solution.

Flexibility and rigidity have been described as two poles of a continuum (Goins, 1962). Rigidity has been defined and examined in several different ways. One way is equivalent to "perseveration". The term perseveration was first used by Neisser in 1897 (Cattell, 1946) to denote continual, persistent repetition of an activity once it had begun. Goldstein (1943) differentiated between primary and secondary rigidity. He emphasized the presence of rigidity in pathological populations. Primary rigidity refers to an all encompassing einstellung which causes the patient to persist at a task for an abnormally long period. Only if a novel, strong stimulus occurs in the environment will the patient's perseverative activity be interrupted. Secondary rigidity occurs whenever the patient is presented with a task that is too difficult. Goldstein (1943) also pointed out that normal individuals will perseverate when they are required to perform above their capacity.

Perseveration has been distinguished from persistence (Ryans, 1938). Ryans (1938) explained that persistence was physical endurance and is related to one's general activity level. Perseveration can also be distinguished from einstellung. Einstellung (Warren, 1934) is a term which denotes mental set, a set which predisposes an individual to one type of conscious motor act.

Rigidity and flexibility have been operationally defined in many different ways in research performed on adults (Cattell, 1946; Cattell & Tiner, 1948; Guilford, 1967; Spearman, 1927). Many studies sought out rigidity or flexibility factors across tasks (Baer, 1964; Cattell, 1946; Cattell & Tiner, 1948; Chown, 1961; Forster et al., 1955; Frick et al., 1959; Guilford, 1967; Schaie, 1955). However, Regard (1981) recently concluded that it is better to discuss rigidity and flexibility in relation to a specific task because of the difficulty of finding any clear factor. On the WCST (modified and traditional version) rigidity or perseveration is operationally defined as a measure of inability to shift set.

Early Studies on Flexibility in Children

Concept attainment and flexibility in children have not always been scrutinized together. Many of the early studies only examined rigidity or perseveration in children without comparing it to concept attainment or any other problem solving process.

Some of the early studies claimed that perseveration increased as age increased. For example, Pinard (1932) found that perseveration on his tasks steadily increased as the children got older. He required the children to write letters and numbers in the typical way and then in some unusual manner (i.e. the children wrote "S's", and then they were asked to write reversed letters and then to alternate between the two. Perseveration was measured by subtracting the total number of letters and figures written (minus the errors made) in the last two minutes of the test from the total number of letters and figures written (minus the errors) in the first two minutes. He found that there was a steady increase in perseveration from age 8 years to age 12 years. However, Pinard (1932) admits that this increase in perseveration may have been influenced by the slower speed at which the younger children worked.

Lewin (1935) claimed that rigidity increased as the person gets older. For example, Lewin (1935) wrote," The

great material plasticity of the normal small child gives way, generally at least, to greater firmness. That with increasing age this development may lead finally to decided rigidity, lack of mobility, and inelasticity scarcely demands extensive demonstration" (p. 236). Kounin (1941), Lewin's student, also made the same claim about rigidity and its relation to age.

Luchins (1942) conducted a study utilizing water jar problems with children 8 to 12 years old in private and public schools. The subjects are asked to solve a series of problems. The first questions can only be solved by one solution. However, the last few questions can be solved by the old solution or a new, faster, more efficient one. The subject's einstellung, or predisposition to a mental set is thereby measured. He found that the older children showed greater einstellung effects than the younger children. He suggested that this finding may have been due to the older children's longer exposure to school where rote learning is stressed, a method which may foster einstellung in children.

Although Luchins' (1942) study found greater einstellung effects in older children it is important to evaluate this finding in light of its relation to perseveration in other cognitive tasks. Levitt (1956) examined the Water Jar Test's validity by critically examining all the studies that have been performed using it. He concluded that the test's

reliability is questionable and is not related to other cognitive tasks like the Wisconsin Card Sorting Test or the Vygotsky Test.

On the other hand, Werner's (1948) position was that rigidity decreases as the age of the child increases because as a child matures she or he becomes more differentiated and hierarchically organized. He claims that psychological function is hierarchically organized so that the person has a range in which to respond. Werner (1948) equates flexibility with stability. "The point is, briefly, that stability of behavior requires a flexibility of response in order to preserve the functional equilibrium of the organism in the face of mutable situations" (p. 55). What evidence is there for a greater amount of rigidity in the young child than in the older one?

Jones (1929) examined inertia or perseveration in children. He had them perform tasks like copying a passage and then recopying it without crossing the t's or dotting the i's. They also were required to write numbers in one way and then reverse the direction of movement in writing. He found a slight increase in the efficiency with which these tasks could be carried out as age increased. Jones suggested the possibility that perseveration decreases as age increases.

Cattell (1935) administered a battery of tests to children as young as age 6 to reveal the p or perseveration factor. The tasks included drawing triangles first upward and then downward in an alternative manner; writing the letter w and then writing it with reversed strokes; picking out red colors and then blue; and writing abc then ABC and finally aBc. Cattell found negligibly low correlations between these test results and concluded that there is little evidence of a general factor of perseveration in children. However, in examining the 10 to 14 year olds' p scores he concluded that perseveration decreased slightly as age increased. He also found that as children fatigued during the day perseveration increased. Thus, children perseverated more in the afternoon than in the morning.

These studies of the developmental progression of perseveration present a confusing picture. Part of the problem stems from the different working definitions of perseveration. For example, Pinard (1932) examined speed in performing habitual and nonhabitual tasks. Luchins (1942) examined einstellung, and Lewin (1935) discussed structural rigidity. Another inconsistency between these studies were the task demands.

Free-sort and Concept Attainment Tasks

Inhelder & Piaget (1964) examined the develcpment of flexibility and classification skills in children aged 3 to 9 years because as they put it," . . . for every stage in the development of operational structures there must be a corresponding development in flexibility" (p. 196). In the first task the subjects were given twc boxes in which to sort various stimuli. After they had sorted the first set of stimuli (flat green circles and crosses) they were given different stimuli (yellow stars, then large mauve rhombi and semi-circles and finally triangles and ovals in ccrrugated cardboard) making it necessary fcr them to resort the items each time new ones were introduced.

Inhelder & Piaget (1964) ccmpared the children's ability to reclassify stimuli with their ability to make logical groupings. They found that the 3 tc 4 year olds perseverated. By perseveration Inhelder & Piaget (1964) meant, "a systematic difficulty in altering a given arrangement to meet with an alternative criterion" (p.212). If they began by classifying stimuli by color then they continued tc do so. The only exception to this is when the young child forgets about the old criterion and begins a new one. Then items are put together because the child says they go well together; but they are not grouped according tc any plan but

simply mixed together. These young children show no hindsight while classifying stimuli. They lack," . . . the necessary flexibility in hindsight to change the criterion and offer an alternative construction" (p. 196).

The behavior of the 5 to 6 year olds is less perseverative. Inhelder & Piaget (1964) claim that this group of children may be able to create a new classification but prefer to stay with the old one. There is less forgetting of initial classifications and less mixed collections of stimuli. The children show more hindsight while regrouping the items.

The 7 to 8 year old children do not perseverate, nor do they forget how they had sorted the stimuli earlier. Their classifications are logical. These children show both hindsight and foresight while sorting and the authors claim this makes their classifications more flexible.

Therefore, on a simple sorting task, Inhelder & Piaget (1964) demonstrated that as age increases, so does the subject's flexibility and logical classification skills. Their next experiment involved a more difficult task, where all the stimuli were presented to the subjects at once. The stimuli varied on form (squares & circles), color (red and blue), and size (large and small). First the subjects were asked to describe the test items and then to sort them. After this was completed they asked them to make alternate

classifications up to a maximum of three. They administered this task to 60 children, 5 to 9 years old. They found that 75 percent of the 6 year olds were able to make two or three classifications, although the majority of them (47 percent) were only able to make two different sorts. However, a majority of 8 to 9 year olds (69 percent) were able to make three different classifications of the stimuli.

In a third experiment, stimuli were presented on cards which varied in shape (circle, square or triangle), color (red, blue or yellow) and size (large or small). The children were given envelopes and instructed to write on the envelopes what the contents inside would be. After the child completed this he or she was asked to reclassify the stimuli. If a second sorting criterion was discovered then the child was asked to sort in a third way. This task was administered to 86 children between the ages of 4 to 9 years. One or two immediate changes of criterion did not reach the level of 75 percent until age 8. Inhelder & Piaget (1964) explained that flexibility in resorting stimuli occurred in older children in this task because the stimuli were more complex. In the previous experiment the items only varied on two attributes.

Others have found a similar developmental progression in logical classification of stimuli and the ability to shift set on free-sorting tasks. For example, Thompson

(1941) administered the Weigl Color-Form Test to 60 first through sixth grade children. This task consists of cut-out figures that vary in color (red, green, yellow and blue) and in shape (triangle, circle and square). The subject is instructed to sort the figures and after this is completed, she or he is asked to sort the stimuli in new way. The ability to sort to the category color or form is indicative of logical classification ability. The ability to resort the stimuli to a new category is a measurement of flexibility. Thompson (1941) found that the older children (fourth, fifth and sixth graders) were significantly superior to the younger chldren (first, second and third graders) in the ability to logically sort to the color and form categories and in the ability to shift set. Reichard et al. (1944) found that the majority of 7 year old children and 75 percent of the 8 year olds could logically classify stimuli and resort it when asked to on the Weigl Color-Form Test. Heald & Marzolf (1954) found that 71 percent of the 6 year olds they studied could resort the stimuli on the Weigl Color-Form Test. The percentage of children capable of this flexibility steadily increased until age 10 where 100 percent of their subjects were able to resort the cut-out figures.

Kofsky & Osler (1967) examined the sorting behavior of 5, 8 and 11 year olds to determine their ability to logically classify stimuli and to shift set. In the first experi-

ment the children had to sort geometric figures that varied on color, form, number and size. After they had done this they were asked to sort the stimuli in another way. The 5 year olds preferred to sort to color most frequently while the 8 and 11 year olds preferred to sort by form. The 5 year olds were inferior to the older subjects in their ability to make logical groupings. When the subjects were required to shift set the older children could do this but the 5 year olds had difficulty. Kofsky & Osler (1967) reasoned this difficulty was either an inability to sort to a nonpreferred dimension or a problem in shifting set. In a second experiment, they asked the subjects to sort stimuli which varied only on preferred attributes (color and form). In this condition more 5 year olds were able to shift set, indicating that stimulus preference was one of the factors determining this ability. Yet even so, the 5 year olds were still significantly inferior in their ability to shift set when compared to the older chilren. Thus, the 8 and 11 year olds were more flexible and better able to make logical groupings in the free-sorting task than the 5 year olds.

These studies clearly demonstrate that on free-sorting tasks children's flexibility and logical classification skills develop together. The literature indicates that between the ages of 6 to 8 years old, children become able to shift set and to form logical groupings on free-sorting

tasks. However, this finding may not necessarily generalize to concept attainment tasks. Although the child is allowed to group stimuli as she or he will on the free-sort task, on concept attainment problems the child must determine what the correct sorting principle is from the information provided by the experimenter.

Only one study has been performed with children using a task like the the WCST, scored for both the ability to shift set as well as the ability to attain concepts. Rosenstein (1960) examined deaf and normal hearing 8, 10 and 12 year olds', performance on a modified form of the WCST (this modification was not like the Mitler & Harris (1969) version). In this task four stimulus cards which varied on color, form and number were mounted on a rack. Sixty slides, each which also varied on these dimensions were flashed on a screen and the subject plugged in a jack under the stimulus card he or she thought was the correct match for the slide. If the subject's choice was correct a light would come on. The subjects had to sort to three concepts (color, form and number) and after they made ten consecutive correct responses the sorting criterion was switched without warning. Rosenstein (1960) did not find a significant difference between deaf and normal hearing children. All of the children (regardless of age) on the average solved two concepts. There was no change apparent in ability to attain the concepts.

Rosenstein (1960) reasoned that the older subjects did not attain more concepts than the younger subjects because they thought the task was more complex than it was. Thus, the older subjects were using complex hypotheses which were incorrect. Rosenstein (1960) also examined the number of perseverative errors made by the different age groups. A perseverative error was defined as any response which would have been correct on the preceding category but was not now correct. The 8 year olds made an average of 7 perseverative errors. The 12 year olds made an average of 5 perseverative errors. Thus, there was a non-significant trend for a greater ability to shift set with increasing age.

The finding that older children did not attain more concepts than younger children has been reported before. Friedman (1965) did not find the expected direct relationship between concept attainment ability and age. He studied first through fifth grade children's performance on a concept learning task. Although the first through third graders' ability steadily increased, the fourth graders' performance dropped below the third graders. Friedman (1965) suggested that this depression in performance may have occurred because the fourth graders were just beginning to use hypotheses to help them solve the problem and were unable to use their new tool effectively. However, such performance is not characteristic. Most studies on concept attainment

ability have found steadily increasing ability with age (Kendler, 1979; Osler & Kofsky, 1965; Vygotsky, 1962).

Furthermore, it is possible that Rosenstein (1960) only found a slight decrease in perseverative errors as the age of the subjects increased because the subjects were beyond the age where rigid behavior is characteristically found. For instance, Osler & Kofsky (1965) studied the role of age and stimulus complexity on concept attainment problems in 4, 6 and 8 year olds. The concepts were color, form and size. The children had to determine the correct concept under conditions of 0, 1 or 2 irrelevant stimulus dimensions. They found significant age and stimulus complexity effects. The older children solved more complex concept attainment problems. They noted that there were differences in the kind of errors made by children who failed to reach criterion. Older children who failed the task did not respond persistently to one stimulus dimension. The younger children who did not reach criterion tended to perseverate on irrelevant stimulus dimensions. Failing 4 year olds frequently responded to a stimulus position. Irrelevant hypotheses were also found among the 4 and 6 year olds.

Similar behavior was noted on a later study by Osler & Kofsky (1966). In this experiment they examined concept attainment in kindergarten, third and sixth grade boys. Each child was randomly assigned a problem. The problems dif-

fered by the number of stimuli or the number of dimensions in the set to discriminate. Set A consisted of stimuli which varied on four binary dimensions; Set B contained stimuli from one binary dimension and one dimension that varied on eight levels; and Set C contained stimuli which varied on two binary dimensions. They found that the kindergarten children solved the Set C problem but had difficulty with Sets A and B. Third grade children, on the other hand, solved Sets B and C more easily than Set A. The sixth grade children solved all three kinds of problems equally well.

Osler & Kofsky (1966) explained that the kindergartners' performance improved when the number of stimuli decreased rather than when the number of dimensions was reduced because they were less likely to categorize stimuli by dimensions. The older children's performance was hampered when the number of stimulus dimensions increased because they were more likely to categorize. The sixth graders performed well on all problems because their ability to categorize was greater than what was required in the test. Osler & Kofsky (1966) noted that the tendency to perseverate decreased as age increased. Perseveration occurred when the children responded to position biases or irrelevant stimuli. Twenty out of the thirty kindergartners who failed their assigned problem perseverated. Four out of five failing sixth graders showed no perseveration.

Thus, Osler & Kofsky (1965, 1966) have determined that as children get older they are better able to solve complex concept attainment problems. The ability to change criteria when necessary appears to be a crucial component to successful problem solution. In both experiments (Osler & Kofsky, 1965, 1966) young children who failed to reach criterion perseverated.

Literature on the development of problem solving strategies also provides some relevant information on rigidity and flexibility in concept learning. Gholson et al. (1972) have performed a number of investigations on groups of kindergarten, second, fourth, sixth grade and college students. The focus of the study was not to determine the effect of age on the ability to solve a problem but instead to examine the age and the way in which a person attempts to solve a problem. They used stimuli which varied on four dimensions; form (square and circle), size (large and small), color (white and black) and position of line (line above or below other stimuli). They gave a subject a series of feedback trials as they attempted to solve the problem and then followed these with a series of blank-trial probes where the subject received no feedback on his or her stimulus choices. It was assumed that if the subject is using some sort of plan to find the solution then the behavior on the trials without feedback will convey the type of strategy.

Gholson et al. (1972) have identified two basic kinds of systems these age groups utilize while solving a problem. One system they call "strategies" which consists of three levels of efficient usage: Hypothesis Checking, Dimension Checking and, most efficiently, Focusing. These strategies all aid the subject in forming hypotheses, proceeding consistently, and optimally, in finding the correct solution. The authors called the other basic system "stereotypes", which consists of Stimulus Preference, Position Preference and Position Alternation responses. As the titles imply, the use of stereotypes is not a system of effective, progressive hypothesizing but instead refers to the use of a single, persistent hypothesis despite negative feedback.

The results of the Gholson et al. (1972) study demonstrated that the use of these systems is age related. Almost all of the Kindergarten children used sterectypes to try to solve the problems posed by the investigators. Second graders through sixth graders typically used strategies but almost never did anyone of this age range use Focusing, the most efficient method. Only college students exhibited the use of the Focusing strategy. Other researchers have found similar results (Gholson & Danziger, 1975; Rieber, 1969).

Schuefper & Gholson (1980) examined the develcpment of prediction hypotheses in the young child. They claimed that hypotheses do not emerge at once but are acquired gradually

A hypothesis is made up of several components ("win-stay" and "lose-shift") which are acquired separately and at different rates. Schuepfer & Gholson (1980) found that children under the age of 6 will often respond to the problem solving situation with the same action ("win-stay", "lose-stay"). Young children who make position-oriented responses will demonstrate position preference ("win-stay", "lose-stay") before they show position alternation responses ("win-shift", "lose-shift"). Furthermore, the parts of prediction hypotheses that are eventually consolidated are acquired at different rates. For instance, the child who is using prediction hypotheses and receives negative feedback will shift to another hypothesis before she or he will remain with the hypothesis if it receives positive feedback.

The hypothesis-testing literature (Gholson et al., 1972; Gholson, 1980; Gholson & Tumblin, 1981) provides further research on children's problem solving behaviors. The consistent finding that response sets or stereotypes give way to strategies is essentially a demonstration that rigidity in a concept attainment task changes to flexible behavior; behavior that is influenced by the information provided by the experimenter. It is assumed that the ability to solve the problem improves as more efficient methods of solving it develop with age.

On both free-sort and concept attainment tasks, children typically demonstrate an increase in the ability to logically classify stimuli (Heald & Marzolf, 1954; Inhelder & Piaget, 1964; Reichard et al., 1944; Thompson, 1941) and in the ability to attain the correct solution on a concept attainment task (Osler & Kofsky, 1965, 1966). The ability to flexibly resort stimuli to a new dimension also improves as the age of the subject increases (Heald & Marzolf, 1954; Inhelder & Piaget, 1964; Reichard et. al., 1944; Thompson, 1941). Furthermore, as children develop they are less likely to use rigid stereoypes and more likely to use strategies while solving a problem (Gholson et al., 1972). Older children make fewer perseverative errors on concept attainment tasks than do younger children (Osler & Kofsky, 1965, 1966). Therefore, on the modified form of the WCST (Mitler & Harris, 1969) one would expect that perseveration will decrease as the age of the subjects increase, and that children's ability to attain the concepts will improve as age increases.

INTELLIGENCE AND CONCEPT ATTAINMENT

A related area of theoretical interest is the relationship between intelligence and concept acquisition. Osler & Weiss (1962) presented a concept attainment task to children 6, 10 and 14 years old, who formed two intelligence groups. The task was explained either with general or with explicit instructions. They found that under general instructions, children with superior intelligence performed significantly better than those with average intelligence. However, this difference between groups disappeared under the explicit instruction condition because the children with average intelligence improved their performance. Osler & Weiss (1962) concluded that superior intelligence aids children in the problem-finding phase of the task and not in the actual problem solution.

Osler & Fivel (1961) also studied 6, 10 and 14 year old children's abilities on a concept attainment task. The children were divided into normal and high intelligence groups. The children had to solve one of three concepts; bird, animal or living thing. The authors found that intelligence was significantly related to number of trials to criterion and the percent of successful subjects. They also

reported significant rank order correlations between mental age and error scores.

Others have found no relationship between intelligence and concept attainment ability. For instance, Osler & Kofsky (1965) studied the effect of age and stimulus complexity on concept attainment. They found no relationship between the number of errors made on a concept attainment task and intelligence as assessed by the Peabody Picture Vocabulary Test (PPVT). They reasoned that this failure to find a relationship was due to the effects of the extensive pretraining given to the children. The pretraining was thought to obliterate the differences between the intelligence of the children on the concept attainment task.

Townes et al. (1978) administered the Category and Matching Pictures subtests of the Reitan-Indiana Battery and the Wechsler Intelligence Scale for Children (WISC) to normal and brain-damaged children. The expected positive relationship between verbal, performance and full scale IQ scores on the WISC and concept formation abilities was only found for the brain-damaged children. The brain-damaged children with higher IQ's were better able to solve the problems on the Matching Pictures and Category subtests. However, there was no relationship between normal children's intelligence and their concept formation ability. This finding should only be generalized with caution because the

sampling of normal subjects in the study resulted in a negative relationship between the verbal and performance scale scores on the WISC. Furthermore, 10 out of the 27 normal children had a difference of greater than one standard deviation between their verbal and performance IQ scores.

Fey (1951) administered the WCST and the Wechsler Adult Intelligence Scale (WAIS) to schizophrenics and normal adults. She compared the number of categories obtained on the WCST with the subjects' scores on the WAIS. The correlation between the two was nonsignificant in both the normal and schizophrenic groups. None of the subtests on the WAIS correlated significantly with the number of categories obtained on the WCST.

Others have examined the role of IQ and Mental Age (MA) on problem solving tasks. Harter (1967) examined the learning set performance of normal and retarded children at two levels of MA (5.5 and 8.5 years), three levels of IQ (65, 100, 130) and two motivational conditions (standard and social). She found that the acquisition of the solution was more rapid at both higher IQ and MA levels. She found that MA was related to the type of hypothesis behavior utilized on a problem solving task. Children with low MA used position perseveration and position alternation responses more often than those with high MA. Children with high MA were more flexible while solving the problems, utilizing "win-stay", "lose-shift" hypotheses.

Weisz (1977) tested children at three levels of IQ (70, 100, 130) and three levels of MA (5.5, 7.5 & 9.5 years). The task stimuli varied on color, shape, size and letter. Weisz (1977) found that IQ was not related to hypothesis behavior but MA was. Schuepfer & Gholson (1980) also examined the hypotheses of normal and retarded children on blank-trial probes. The children were divided into two MA levels (5.5 and 7.5) and two IQ levels (65 and 100). They also found that MA had significant effects on performance but IQ did not.

Although two studies (Osler & Fivel, 1961; Osler & Weiss, 1962) found intelligence to be related to concept attainment ability, the other studies have not (Fey, 1951; Osler & Kofsky, 1965; Townes et al., 1978). This discrepancy in findings may be due to the different tasks used. Osler & Fivel (1961) and Osler & Weiss (1962) had their subjects solve for the concepts bird, animal or living thing. While the others used task stimuli that varied on color, shape, number, position or size (Fey, 1951; Osler & Kofsky, 1965; Townes et al., 1978). On the other hand, MA appears to be consistently, significantly related to concept attainment ability (Harter, 1967; Schuepfer & Gholson, 1980; Weisz, 1977). However, none of these studies distinguished between verbal and nonverbal ability. Osler & Kofsky (1965) compared vocabulary (as assessed by the PPVT) with the number

of errors made on concept attainment task. They did not find a significant relationship between the two. It is unclear whether the finding resulted from the extensive pretraining given to the children or because vocabulary is not related to concept attainment. Yet, the role of language has been proposed to be crucial to concept acquisition.

Vygotsky (1962) claimed that the ability to form concepts is closely linked to language and to the formation of higher psychological processes. He asserted that language has a self-regulating component; language directs action. Sokolov (1969) expressed a similar opinion:

> thought is not only expressed in speech but is formed and carried out in it. Language not only gives names to objects, but permits the abstraction of their properties and relationships. Language also leads to their generalization in the form of concepts and their objectification in the form of words and other symbols. It is therefore concluded that abstract thinking is impossible without language . . . (p. 531-532).

On the other hand, Inhelder & Piaget (1964) claimed that language is necessary but not sufficient to the development of logical abilities. Sensori-motor schemata antedate logical abilities like classification. They claim that rudimentary classification skills (like perceiving similarities and differences) have been observed in children before they acquire language. Furthermore, they point out that when a child learns to speak he or she does not automatically incorporate the categorizations the words embody. For

instance, a child may use the word "dog" but that does not mean he or she understands the class of dogs. They point out that young children can perceive similarities and differences between objects before they can classify them.

The examination of young children's conceptual abilities before they develop language may shed light on this theoretical question. Researchers have ascertained that categorization ability can precede language. Nelson (1973) studied one and two year old's abilities to group objects. She found that the infants could group objects in a consistent manner based on functional characteristics of the stimuli, that is, based on typical actions by or on the objects presented. Rosch et al. (1976) also found that preschoolers can make basic categorizations (i.e. all cars, instead of transport vehicles; cars, trains, planes etc.) and their ability was not dependent upon being able to name the category. However, Rosch et al. (1976) did report that there were developmental changes in the ability to make superordinate categories. Thus, the ability to make basic categorizations is present in children before they acquire language and before they are able to name the category they can form.

Siegel (1978) has also presented evidence to contradict the claim that language is crucial to concept formation and identification. She tested children in the pre-operational stage of development. Children in this stage are not suc-

cessful at conservation, seriation, and other tasks. However, many of the tasks the child is required to perform are dependent upon verbal responses. Siegel(1978) reasoned that children in the pre-operational stage may be failing tasks because they do not adequately comprehend and use language, not because they cannot logically solve the problems. She developed a number of nonverbal Piagetian-like tasks and administered them to young children. The results from these tasks suggested that the pre-operational child has logical concepts that were not known.

Therefore, the results of these studies performed with very young children suggest that contrary to Vygotsky's (1962) premise, conceptual ability need not depend on language. Of course, the kinds of conceptual and logical abilities described in these studies have been rudimentary (i.e. all cars go together, etc.). It is possible language becomes important when the level of conceptualization is more advanced.

There is some evidence to support the role of language in more complex conceptual activities. Luria & Yudovich (1956) report the case of twins ; Yura and Liosha who developed their own language and who were retarded in other developmental aspects (i.e. they were unable to classify stimuli). The twins were separated and Yura was given training in speaking. His training consisted of dialogue conversa-

tions, verbal analysis of pictures, and telling stories. Liosha was given no verbal training. The twins abilities were then compared ten months later. Both of them were now able to classify stimuli. They could both choose objects that looked like each other and place them in groups. However, there were also differences between the twins ". . . as a result of the special training of the one." Yura demonstrated he could classify objects objectively while Liosha was limited to classification on the basis of perceptual similarities. These results were found when the twins classified pictures as well as toys. Thus, assuming language was the contributing factor, then Yura's classification skills were advanced because of it.

Furthermore, the use of language to direct action while solving a problem has been related to MA. Deutsch & Stein (1972) found that children who scored high on the PPVT produced significantly more private speech while working on the problem. IQ is positively related to task performance with children who verbalize during the process (Klein, 1964).

Thus, young children have rudimentary classification skills before they acquire language (Nelson, 1973; Rosch et al., 1976). In some cases, young children may fail logical tasks because of their yet inadequate grasp of language and not their inferior logical abilities (Siegel, 1978). Yet, it is possible that language becomes more crucial to concep-

tualization when the task becomes more difficult (Klein, 1964; Luria & Yudovich, 1956). Therefore, it would be of interest to compare verbal and nonverbal ability with performance on the modified form of the WCST. The modified form of the WCST requires more than rudimentary conceptualization ability. The children must discover what the correct sorting principle is based on feedback from the examiner. Also, they must know what the concepts color, form and number are. Thus, it is expected that verbal ability will be significantly related to performance on the WCST.

GOALS AND HYPOTHESES

A principal goal of this study is to provide normative data on the modified form of the WCST for first, second, third, and fourth grade children. In spite of 35 years of WCST use, such data have not previously been available.

A second goal is to examine changes in several aspects of performance on the WCST as a function of chronological age. It is hypothesized that as the age of the child increases, the number of categories obtained on the WCST will significantly increase, and total errors on the WCST will decrease. These two aspects of performance are measures of concept attainment ability and the results should show whether the skills and strategies underlying this ability are developing over the age range from 6 to 9.

Since ability to solve the problems on the WCST is predicted to improve as the age of the child increases, it becomes important to know more precisely what it is that improves. The modified form of the WCST can also provide a measure of the ability to shift set or flexibility in the problem solving process. A high perseverative error score indicates rigidity, while a low score indicates flexibility. Furthermore, the WCST can also assess another aspect of

problem solving skill. The nonperseverative and unique error scores measure the child's ability to generate solutions to the problem. A low score indicates good ability to solve the problem. It is predicted that the number of perseverative errors as well as the number of nonperseverative and unique errors will decrease as the age of the child increases.

A third goal is to compare aspects of performance on the WCST with two measures of mental age. Both measures are predicted to correlate significantly with performance on the WCST. However, verbal ability, as measured by the PPVT-R, is predicted to relate more strongly with WCST performance than does nonverbal ability as measured by the block design subtest of the WISC-R.

METHODS

SUBJECTS

Four groups of subjects, each representing one age group from 6 to 9 years of age were chosen. Thirty subjects per age group (a total of 120 children) were tested. Within each age group, 15 subjects were male and 15 subjects were female. The children were randomly chosen from elementary schools in the Victoria school district which agreed to participate in the study.

Five elementary schools participated. All the parents of the first through fourth grade students within these schools were sent "consent" letters (Appendix 1). Four groups of children whose parents agreed to let them participate were formed according to their age and to the grade they were in during Fall, 1981. Therefore, all 6 year old first graders formed one group, 7 year old second graders another, 8 year old third graders another, and 9 year old fourth graders formed the last group. Children in each grade who were younger or older than the required age were excluded. Children who did not learn English as a first language were excluded. There was no attempt to screen out learning disabled children. The subjects were randomly chosen from each group.

Test Selection

The WCST consists of four stimulus cards, each with a different arrangement of number, color and form on it. The first card has one red triangle, the second has two green stars, the third has three yellow crosses and the fourth has four blue circles. The subject receives 64 response cards each of which has a specific combination of one color (red, green, yellow or blue), one form (triangles, circles, stars or crosses), and one number, (one, two, three or four forms). The subject places each response card below the stimulus card she/he thinks it belongs to. After each placement, the experimenter tells the subject whether she/he is right or wrong. After the subject has made ten consecutive correct responses the sorting concept is changed without warning. The correct concepts to sort to in sequence are color, form, number, color, form and number. The test is terminated when the subject has successfully solved all six categories or when she/he runs out of response cards (Grant & Berg, 1948).

In the Mitler & Harris (1969) version of the WCST the response card pack is reduced to 24 cards. Every card that can match a stimulus card on more than one attribute is removed. Thus, each of the remaining 24 cards can only match a stimulus card by color, form or number but not by any com-

bination of these. In this version only six consecutive correct responses are required before the concept is changed.

The rationale for the selection of the modified form of the WCST was discussed in the first section of this paper. The selection was further influenced by a pilot study run on 16 children aged 5 to 11 years. It was found that the modified version allowed the 5 to 8 year olds (N=3) to obtain some of the categories (average was two subsets) while one 7 year old was administered the traditional version and was unable to obtain even one subset. The 10 and 11 year olds tested (N=7) with the traditional version performed at various levels (categories obtained ranged from three to six), while those 11 year olds given the Mitler & Harris version (N=2) performed with few errors and obtained all the categories. The results from this preliminary study indicated that the traditional version is probably too difficult for children 7 years old and younger. For this reason, it was necessary to use the Mitler & Harris (1969) modification when collecting norms for young children.

A questionnaire (Appendix 2) was devised in order to ascertain how well the children could verbalize what they did on the WCST. It was assumed that the children who participated in this study would obtain different numbers of subsets on the WCST. Therefore, when they were asked to

verbalize what they did, the number of categories they solved was taken into account. On the verbalization questionnaire each possible number of subsets that can be obtained (0-6) was considered separately, each having a different number of total possible correct responses. This distinction was made in order to avoid penalizing children who did not obtain all the categories on the WCST and hence were unable to verbalize all of them.

The questionnaire is divided into three parts. The first part consists of the first question which is the most open-ended, general query posed to the children. It serves as an indicator of what the child is able to verbalize in response to a general question. The total number of points that can be collected ranges from 2-12, depending on the number of categories sorted to on the test. The second kind of question is a "prompt" question. These are numbers 2-4 on the questionnaire. They serve to prod the child into remembering and verbalizing what she/he left out before in her/his explanation. Each correct response is given one point and the possible total can range form 1-5 points. The third kind of question is a direct prompt question. These queries (5-9) directly ask if the child sorted to color, form and number. A correct response is given a half point. Total possible points on this kind of question range from .5-3. The scoring was completed when the person verbalized

his test performance or when she/he finished the questionnaire.

A simple concept formation task was administered to each child to insure that every one had the concepts color, form and number. It consisted of three sets of ten cards. In the first set number and form were constant but the color was either red or blue. In the second set color and number were constant but the forms were either squares or circles. In the third set color and form were constant but there were either two or three triangles on the cards. Thus, only one dimension varied on each set. If the child sorted by color in the first set, by form in the second, and by number in the third, then it was assumed that the child had the concepts color, form and number.

The Peabody Picture Vocabulary Test-Revised (PPVT-R) was chosen as the measurement of verbal aptitude. This test assesses listening or receptive vocabulary. Furthermore, the PPVT-R provides both an intelligence score as well as one based on mental age. Therefore, it was deemed appropriate for the needs of the study.

The block design subtest of the WISC-R was chosen as the measurement of nonverbal ability because it assesses spatial skill (Bannatyne, 1971). Furthermore, it has been claimed to be sensitive to a unique ability that is separate from other subtests on the WISC-R; nonverbal concept formation ability (Glasser & Zimmerman, 1967).

Procedure

The WCST, PPVT-R, and the block design were presented to the children in a counterbalanced order. The simple concept formation task (or control task) and the questionnaire were always administered immediately after the WCST. There were six test presentation orders:

1. WCST/questionnaire, control; PPVT-R; block design
2. PPVT-R; block design; WCST/questionnaire, control
3. block design; WCST/questionnaire, control; PPVT-R
4. WCST/questionnaire, control; block design; PPVT-R
5. PPVT-R; WCST/questionnaire, control; block design
6. block design; PPVT-R; WCST/questionnaire, control

The test presentation orders 1-6, were presented in that order to consecutive subjects. The order repeated itself. A 4 (age groups) x 6 (test presentation orders) matrix was constructed. Five children in each age group received one of the test presentation orders. The cells of the matrix were filled in randomly. Thus, on any given testing day children from several different grades were tested. Children were only tested during the morning.

All of the subjects were seated at a table next to the examiner and told: "I want to know how children solve problems, so you are really helping me out by showing me how you solve them. There will be several different things to do.

You will be matching some pictures with words, there will be block designs to make and something to do with cards." Then the subject was tested in the particular order assigned to him or her. When the WCST was administered the instructions were as follows: "I want you to place each one of your cards below the stimulus card you think it belongs to. Put each card down I will tell you whether you are right or wrong. Use the clues I give you to help you figure out the right way to sort the cards." Masking tape was placed on the table in the shape of a sorting tray. The tape created boundaries between the stimulus cards and the sorting cards and between each sorting pile.

The standard instructions contained in the PPVT-R manual (Dunn & Dunn, 1981) and the WISC-R manual (Wechsler, 1974) were given to the children.

The subjects were tested in one session since a pilot study conducted on first graders (N=6) did not find any evidence of fatigue in a half hour testing session. Three of these pilot subjects were given the first test presentation order and three children received the last (number 6) test presentation order. Their results were compared and no appreciable difference was found.

The entire testing session took approximately 25-35 minutes for each child.

RESULTS

Means and standard deviations were collected on all components of the WCST in order to provide normative data. The components were: the number of points earned on the verbalization questionnaire, the number of categories obtained, total errors, perseverative errors, nonperseverative errors, unique errors, total correct, lose-stay errors, and lose-shift responses. After the first category was obtained the WCST was scored for perseverative, nonperseverative, and unique errors. A perseverative error was a response which was correct in the immediately preceding category. A nonperseverative error was an incorrect response which was not correct in the preceding category. A unique error was a response which was not based on color, form or number. If the first response after a category shift was an error it was not counted. The "total correct" score on the WCST refers to the number of correct responses made after all the six consecutive correct ones have been subtracted out. This score measures the amount of reinforcement the subject needs in order to obtain the solution.

During the course of the testing, it appeared that the perseverative error score was not measuring rigidity, or the inability to shift set, in the sample of children examined.

Typically, the child demcnstrated the ability to shift to new solutions but that did nct preclude the use of a response that was correct in the preceding category. Yet, these respcnses were scored as perseverative and were supposed to reflect inability to shift set. In crder to assess rigidity a new scoring system was used and the data were analysed using post-hoc procedures. Each trial was sccred as a "lose-stay" or "lose-shift" trial. On lose-stay trials the child repeated a response which had received negative feedback on the immediately preceding trial. On lcse-shift trials, the child changed his or her response after receiving negative feedback on the immediately preceding trial. Lose-stay trials were classified as rigid trials because the subject persisted with a response that had just been negated. Lose-shift trials were ccnsidered as flexible trials because the subject tried a new response after negative feedback. Nelson (1976) used "lose-stay" trials in her analysis of rigidity in brain-damaged patients.

Means and standard deviaticns are presented at each grade level in tables 1, for males, females and for both sexes combined. The boys' and girls' performance was similar except at the fourth grade level. An examinaticn of Table 1 reveals that the fourth grade boys in this sample were performing on a level similar to the first graders. The fourth grade boys cbtained twc categcries less than the girls, and made more errors.

TABLE 1

Normative Data on the Wisconsin Card Sorting Test

First Graders

	MALES		FEMALES		BOTH	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	2.40	1.18	2.53	1.06	2.47	1.11
Total Errors	43.40	8.89	41.60	9.85	42.50	9.27
Perseverative Errors	17.40	8.62	21.00	12.88	19.20	10.92
Nonperseverative Errors	10.93	4.80	10.80	5.10	10.87	4.87
Unique Errors	7.40	4.69	6.20	5.78	6.80	5.21
Correct Trials	10.40	4.79	11.60	7.11	11.00	5.99
Verbalization Score	1.47	1.33	1.70	1.36	1.58	1.33
Lose-stay Errors	16.27	9.76	15.60	13.50	15.93	11.58
Lose-shift Errors	28.67	6.27	28.53	11.69	28.60	9.22

Second Graders

	MALES		FEMALES		BOTH	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	2.07	1.58	3.13	1.81	2.60	1.75
Total Errors	45.47	12.37	39.87	13.42	42.67	12.99
Perseverative Errors	15.13	8.66	16.13	6.82	15.63	7.68
Nonperseverative Errors	11.60	7.53	12.20	5.47	11.90	6.47
Unique Errors	6.67	5.69	5.13	4.14	5.90	4.95
Correct Trials	10.53	6.91	8.67	4.22	9.60	5.70
Verbalization Score	2.43	2.40	2.70	2.09	2.57	2.22
Lose-stay Errors	18.20	15.83	17.20	15.97	17.70	15.63
Lose-shift Errors	28.93	11.03	25.13	9.18	27.03	10.16

Third Graders

	MALES		FEMALES		BOTH	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	3.53	2.10	3.87	1.77	3.70	1.91
Total Errors	33.80	15.46	33.20	13.95	33.50	14.47
Perseverative Errors	14.07	9.45	16.73	10.89	15.40	10.11
Nonperseverative Errors	9.20	6.36	10.40	5.39	9.80	5.83
Unique Errors	4.40	5.26	4.07	5.03	4.23	5.06
Correct Trials	9.67	6.39	7.80	5.94	8.73	6.14
Verbalization Score	3.10	2.49	3.30	2.75	3.20	2.58
Lose-stay Errors	10.27	8.34	13.60	8.87	11.93	8.63
Lose-shift Errors	26.67	10.41	23.13	6.57	24.90	8.74

Fourth Graders

	MALES		FEMALES		BOTH	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	2.67	1.63	4.20	1.86	3.43	1.89
Total Errors	40.87	10.87	28.33	16.92	34.60	15.36
Perseverative Errors	17.60	9.80	12.53	8.62	15.07	9.43
Nonperseverative Errors	10.93	5.56	10.47	6.09	10.70	5.74
Unique Errors	7.07	5.89	3.40	4.61	5.23	5.52
Correct Trials	10.93	6.46	7.33	6.35	9.13	6.56
Verbalization Score	2.03	1.74	3.60	2.41	2.82	2.21
Lose-stay Errors	12.40	7.86	9.27	6.46	10.83	7.25
Lose-shift Errors	31.13	9.11	23.20	9.31	27.17	9.91

As a measurement of reliability, half the subjects from each age group were randomly selected. Their means and standard deviations on each component of the WCST were compared to the other half of the subjects' scores. The split-half scores are presented by each age group in Table 2. A visual examination of the data revealed they are similar at almost every age level and WCST component. However, one half of the third graders obtained one more category on the WCST than did the other half and one half of the first graders made 10 perseverative errors more than did the other half.

TABLE 2

Split-Half Reliability on the Wisconsin Card Sorting Test

	First Graders				Second Graders			
	1st Half		2nd Half		1st Half		2nd Half	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	2.40	.91	2.53	1.30	2.53	1.92	2.67	1.63
Total Errors	43.07	8.95	41.93	9.86	42.13	13.49	43.20	12.93
Persev. Errors	24.13	11.79	14.27	7.48	15.47	7.91	15.80	7.71
Nonpersev. Errors	11.47	4.01	10.27	5.67	11.00	6.39	12.80	6.65
Unique Errors	7.20	5.33	6.40	5.23	6.07	5.59	5.73	4.41
Correct Trials	10.73	6.20	11.27	5.97	10.40	6.76	8.80	4.51
Verbaliz. Score	1.53	1.44	1.63	1.25	2.83	2.74	2.30	1.59
Lose-stay Errors	17.53	14.09	14.33	8.60	18.27	15.78	17.13	16.02
Lose-shift Errors	27.60	10.44	29.60	8.07	26.40	10.69	27.67	9.92

	Third Graders				Fourth Graders			
	1st Half		2nd Half		1st Half		2nd Half	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	3.20	1.93	4.20	1.82	3.50	1.91	3.47	1.96
Total Errors	37.20	13.25	29.80	15.13	35.64	16.80	33.67	14.98
Persev. Errors	15.20	7.81	15.60	12.27	17.21	8.78	13.13	10.19
Nonpersev. Errors	10.67	7.61	8.93	3.28	12.36	5.94	9.33	5.49
Unique Errors	4.47	4.99	4.00	5.29	5.21	4.51	4.80	6.39
Correct Trials	9.53	5.37	7.93	6.91	6.07	5.31	11.07	5.98
Verbaliz. Score	3.10	2.69	3.30	2.55	3.14	1.98	2.60	2.49
Lose-stay Errors	12.80	7.62	11.07	9.73	12.21	6.94	9.93	7.68
Lose-shift Errors	27.13	9.93	22.67	6.99	27.07	9.64	27.00	10.77

The norms collected in this study were also compared with the means and standard deviations (SD) collected in the Mitler & Harris (1969) study. Mitler & Harris (1969) provide data on kindergarten, first and third grade children for number of categories obtained and the total errors made on the WCST. First and third grade scores are compared with first and third grade scores in this study in Table 3. The means and SD's between the two samples are similar.

TABLE 3

Comparison of Normative Data

First Grade

	Mitler & Harris		Machamer	
	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	2.75	1.67	2.47	1.11
Total Errors	42.30	10.08	42.50	9.27

Third Grade

	Mitler & Harris		Machamer	
	$\bar{X}$	SD	$\bar{X}$	SD
Categories Obtained	3.33	1.79	3.70	1.91
Total Errors	35.00	11.63	33.50	14.47

All of the children in this study solved the simple concept formation task with no errors.

The subjects' scores on the block design subtest of the WISC-R and the PPVT-R were compared to the norms available for the Victoria elementary school population (Spreen & McAllister, 1981 unpublished study). In Victoria, the average scale score on the block design subtest for first and for third graders is 12. Victoria norms are not available for second and fourth graders. The children in this sample scored at a comparable level to the norm. The first graders' mean was 11.3; the second graders' was 11.9; the third graders' was 12.8; and the fourth graders was 12.6.

The average standard score in Victoria on the PPVT for first graders is 107, and for third graders is 114 (there are no norms available for second and fourth graders). In the present sample of first through fourth grade children the mean scores obtained were 104.5, 101.2, 104, and 108.2, respectively (see Table 4). The first grade children's average score was comparable to the norm. However, the third graders' average score fell at the 30th percentile level when compared to the normative data available for Victoria. A t-test revealed there was a significant difference between the third grade groups, $t(102)=3.125$, $p<.005$.

TABLE 4

Comparison of PPVT and block design scores

	Machamer				Spreen			
	PPVT		BD		PPVT		BD	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
First	104.5	14.3	11.3	3.1	107	16.5	12	2.7
Second	101.2	16.6	11.9	3.9				
Third	104.0	13.1	12.8	2.6	114	15.2	12	2.8
Fourth	108.2	10.1	12.6	2.6				

A multivariate analysis of variance was conducted on the data to determine if performance on the WCST improved significantly as age increased. The dependent variables were the number of categories obtained on the WCST and total errors made on the WCST. The overall multivariate test was significant ($F(6,228)=2.28$, $p<.037$). The individual univariate analyses revealed that the number of categories obtained on the WCST increased significantly as age increased ($F(3,116)=3.85$, $p<.011$), and total errors on the WCST decreased significantly as age increased ($F(3,116)=4.19$, $p<.007$) (see Figure 1).

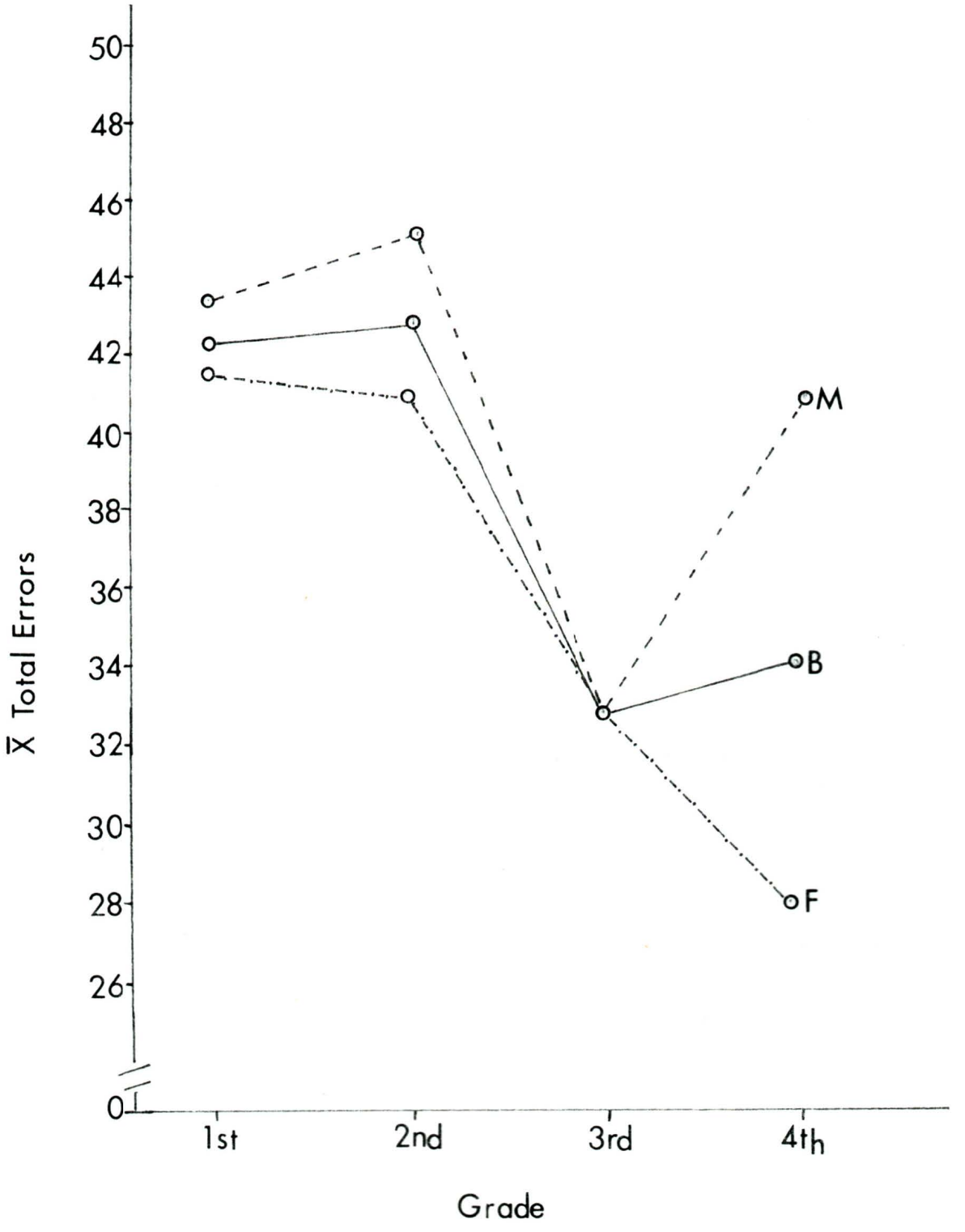

Figure 1: Grade by average total errors made on the WCST. M (males), B(both males and females), F (females)

Two one-way analyses of variance (age group with four levels) were conducted to determine if perseverative errors and nonperseverative plus unique errors decreased as the age of the subject increased. Perseverative errors did not decrease significantly as age increased ($F(3,116) = 1.2$, $p>.3$). Nonperseverative plus unique errors were not significantly different between age groups ($F(3,116)=1.17$ $p>.3$).

Two post-hoc, one-way (age group, with four levels) analyses of variance were conducted to discern if lose-stay trials decreased or lose-shift trials decreased significantly as age increased. For lose-stay responses there was a significant linear trend ($F(1,116)=5.267$, $p<.02$). Lose-shift responses did not show a linear trend with age ($F(1,116)=.684$, $p>.4$) (see Figure 2).

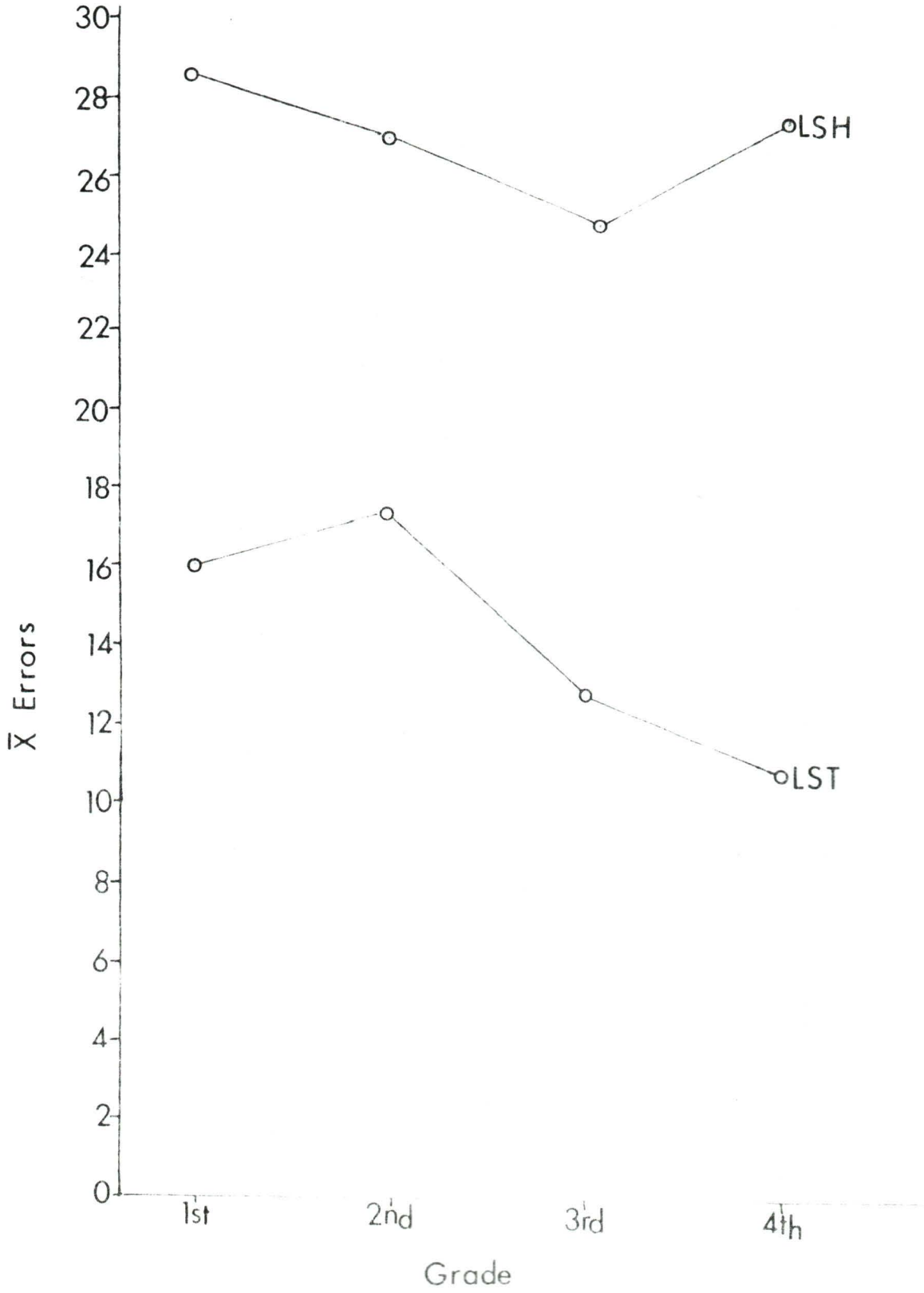

Figure 2: Average lose-stay (LST) and lose-shift (LSH) errors by grade

A post-hoc 4 x 6 (group by test presentation order) analysis of variance was run to determine if test presentation order had an effect on the number of categories obtained on the WCST. Neither the main effect of test presentation order ($F(8,96)=20.785$, $p>.5$) nor the group by order interaction was significant ($F(15,96)=1.443$, $p>.1$).

Post-hoc 2 x 4 (sex by group) analyses of variance were also run to see if the sexes differed significantly. For number of perseverative errors, neither sex ($F(1,112)=.098$, $p>.7$) nor the sex by group interaction was significant ($F(3,112)=1.231$, $p>.3$). For number of nonperseverative and unique errors neither sex ($F(1,112)=.707$, $p>.4$) nor the sex by group interaction was significant ($F(3,112)=.395$, $p>.7$). For number of categories, there was a significant sex effect ($F(1,112)=6.429$, $p<.013$) but there was not a significant sex by group interaction ($F(3,112)=1.155$, $p>.3$). For number of total errors there was a significant sex effect ($F(1,112)=4.693$, $p<.032$) but there was not a significant sex by group interaction ($F(3,112)=1.286$, $p>.2$). Differences between males and females were compared at each grade with t-tests for categories obtained and total errors made on the WCST. Since eight t-tests were performed the experimentwise error was inflated. In order to adjust for this, the alpha level was changed according to this formula: $1-(1-\alpha)^{1/t}$, "t" was the number of t-tests done. The adjusted alpha level

was equal to .006. None of the t-tests were significant at this level.

Pearson Product Moment Correlations were computed for the following variables: categories obtained on the WCST (categ), total errors on the WCST (terr), lose-stay score (lst), lose-shift score (lsh), mental age on the PPVT (map), mental age on the block design subtest of the WISC-R (mabd), scale score on the block design (igbd), and standard score on the PPVT (igp). The correlation matrix is presented in Table 5 The number of categories obtained on the WCST was most highly correlated with the mental age score on the PPVT (r=0.298), the mental age score on the block design subtest (r=0.272) and chronological age (r=0.251). Total errors made on the WCST was also most highly correlated with the mental age score on the PPVT (r= -0.307), the mental age score on the block design subtest (r= -0.291) and with chronological age (r= - 0.263). The total error score made on the WCST was about equally correlated with the mental age score on the PPVT (r=-.307) and with the mental age score on the block design subtest (r=-.291). The correlations between the number of categories obtained on the WCST and the standard score on the PPVT (r=0.175), and the scale score on the block design subtest (r=0.192) are low. Correlations between total errors on the WCST and the standard score on the PPVT (r=-0.185), and the scale score on the block design

subtest (r=-0.206) are also low. The highest correlation between performance on the WCST (total errors) is with mental age score on the PPVT (r= -0.307) which accounts for 9 percent of the variance.

TABLE 5

Pearson Correlation Coefficients

	Age	Categ	Terr	IQBD	IQP	MAP	LST	LSH	MABD
Age	1.000								
Categ	.251 P=.01	1.000							
Terr	-.263 P=.01	-.918 P=.01	1.000						
IQBD	.164 P=.04	.192 P=.02	-.206 P=.01	1.000					
IQP	.082 P=.19	.175 P=.03	-.185 P=.02	.208 P=.01	1.000				
MAP	.699 P=.01	.298 P=.01	-.307 P=.01	.268 P=.01	.757 P=.01	1.000			
LST	-.215 P=.01	-.466 P=.01	.663 P=.01	-.191 P=.02	-.164 P=.04	-.250 P=.01	1.000		
LSH	-.059 P=.26	-.567 P=.01	.465 P=.01	-.012 P=.45	-.021 P=.41	-.066 P=.24	-.346 P=.01	1.000	
MABD	.581 P=.01	.272 P=.01	-.291 P=.01	.868 P=.01	.222 P=.01	.545 P=.01	-.247 P=.01	-.050 P=.29	1.000

DISCUSSION

Normative data were collected for first through fourth grade children on a modified form of the WCST (Mitler & Harris, 1969). The predictions that the number of categories obtained on the WCST would increase, and total errors would decrease, as the age of the subjects increased were confirmed. The hypotheses that perseverative, and nonperseverative plus unique errors would decrease as age increased were not confirmed. Lose-stay errors decreased significantly with age but the expected decrease in lose-shift errors was not significant. As predicted, performance on the WCST (categories obtained and total errors made) was significantly correlated with both the mental age score on the PPVT-R and the mental age score on the block design subtest. However, the prediction that performance on the PPVT-R would be more closely related to performance on the WCST was not confirmed. Both measures were equally correlated with the WCST variables. The relationship between the mental age score on the PPVT-R and performance on the WCST only accounted for 9 percent of the variance.

Normative Data

The sample of children who participated in the study were representative of first and third graders in Victoria on their average score of the block design subtest of the WISC-R. Although the first grade children's average scores on the PPVT-R were similar to the mean, the third graders' average score was below the reported mean in Victoria. However, even if the third graders are not representative for PPVT-R performance, it is still quite possible that they are representative for the WCST since correlations between the standard score on the PPVT-R and the WCST were uniformly low.

The means and standard deviations (SD) Mitler & Harris (1969) obtained for first and third graders are similar to the means and SD's obtained in this study (see Table 3). Since the norms collected in this study match the means and SD's reported by Mitler & Harris (1969) and since the sample collected here is representative of the Victoria school population as judged by the block design subtest (and is not greatly discrepant as judged by the PPVT-R), it is probable that these norms are reliable.

The finding that females performed significantly better than males on the WCST was not predicted. Although the girls performed slightly better than the boys in the first

through fourth grades, most of the discrepancy between the sexes lies at the fourth grade level. The inferior performance of the boys is not due to the poor scores of a few members of the group. Two-thirds of the fourth grade boys solved three or less categories. Only one boy (out of 15) obtained all six categories. These results are in marked contrast to the fourth grade girls' results. Forty percent (6/15) of the girls solved all six categories on the WCST.

There is little support for the finding of sex differences in concept attainment in the literature. Pishkin (1972) found that third grade females performed significantly better than males on a concept identification task. However, this finding was not replicated in a later study (Pishkin & Willis, 1974). Other researchers have reported no difference between sexes and concept attainment (Heald & Marzolf, 1954; Osler & Kofsky, 1965; Wei, et al., 1971). Thus, it is improbable that a sex difference exists on the modified form of the WCST. In order to adequately determine the reliability of this finding another study would have to be conducted on a larger sample of children. If the finding was replicated in a study with a larger N, then one could be more confident that the result was not due to chance subject variability.

Performance Differences on the WCST

Differences between age groups

As the age of the subjects increased, performance on the WCST improved (i.e. the number of categories obtained increased and total errors decreased significantly), indicating that concept attainment ability is improving over the age range. This improvement did not appear to be related to a decrease in "rigidity" at least as measured by the perseverative error score (which did not decrease with age) and the nonperseverative plus unique error score (which did not decrease with age). Rigidity was expected to decrease with age because others have found that the ability to shift to a new sorting dimension improves with age (Heald & Marzolf, 1954; Inhelder & Piaget, 1964; Reichard et al., 1944) and the tendency to make perseverative errors decreases with age (Osler & Kofsky, 1965, 1966).

One reason for this finding may be that the perseverative error score did not measure "rigidity" or "inability to shift set" in young normal children. If this were the case it would still be possible that rigidity was, in fact, decreasing with age. The lose-stay score was created to attempt a different measurement of inflexible behavior on the

WCST. There was a significant linear trend in lose-stay errors. Thus, it may be that the lose-stay error score is a better measurement of rigidity than is the perseverative error score.

The modified form of the WCST did not reveal large qualitative changes in performance in normal children as age increased from 6 to 9. The pattern of error responses was remarkably similar across the age range tested. Perseverative errors (the repetition of a response that was correct in the preceding category) occur most often. Unique responses are rare and occur at the lowest rate. Nonperseverative errors occur more than unique errors and less than perseverative errors. The number of total errors made decreased significantly as the age of the child increased but clear differences in kind and pattern of errors could not be found with the present method.

The WCST may be insensitive to qualitative changes in performance because of the way the test is scored. The traditional measurement of rigidity on the WCST is the perseverative error score. Yet, as discussed earlier, the perseverative score did not appear to be sensitive to differences in "rigidity" observed informally. While the perseverative error score was not sensitive to developmental differences between the age groups, the lose-stay score did show differences between the age groups and thus it may be a

better measurement of rigidity. It may, therefore, be useful to incorporate the lose-stay error score into the WCST for further work with children.

Card sorts on the WCST are only scored color, form, number or unique responses when more detailed information about what the subject is doing may be needed. For example, a child may make a series of consecutive color responses and these would be scored as perseverative (if the child was working on the form category) or as lose-stay scores. However, the child may be systematically checking each dimension of the color category, i.e. making a blue color match, then a red one, then a yellow one, and then a green one. This information would be important to know. It is advisable to be aware of the actual components of the stimulus cards the child is sorting either by marking them down at the time of the testing or by reexamining the cards later. With these modifications in scoring procedure, the WCST may gain sensitivity in assessing qualitative differences in performance.

Differences between M.A. and I.Q. levels

Mental age scores on the PPVT-R and block design test are correlated more highly than chronological age with the

number of categories obtained and total errors made on the WCST. The correlations between MA (on the block design and the PPVT-R) and performance on the WCST are significant. The difference between the MA score on the PPVT-R and on the block design subtest is minimal. Therefore, this study does not provide evidence that performance on the WCST is related more to verbal ability than to nonverbal ability in normal children. This finding is not in accordance with Sokolov's (1969) statement that language is crucial to concept attainment ability. Nor is it consonant with the idea that language becomes more important to conceptualization when the task is complex. The finding that verbal and nonverbal abilities are equally correlated with WCST performance suggests that verbal ability is just as important as nonverbal ability in successful WCST performance. Therefore, this study's finding is more supportive of Inhelder & Piaget's (1964) claim that language is needed but is not sufficient for concept attainment.

The WCST did not correlate with intelligence as measured in this study for normal children. However, it might still be a valuable test to use for the assessment of the school age child. Further studies are needed which would compare the WCST performance to actual school performance. These studies should use improved scoring methods which are more sensitive to qualitative aspects of problem solving behavior.

The WCST may have good clinical usefulness because some of its scores are not strongly related to intelligence or mental age within the normal range. It could then become very obvious when a performance falls outside this range. Furthermore, there may be a greater relationship between the WCST and intelligence at the low end of the IQ scale. For example, Townes et al. (1978) found that intelligence was related to performance on the matching pictures and category subtests of the Reitan-Indiana battery in brain-damaged children. Those brain-damaged children with higher intelligence did better on the tasks than those with lower intelligence. While there was no clear relationship between intelligence and performance on the tasks for normal children, it is possible that such a relationship may exist for subnormal children.

A brain-damaged child or a child with learning disabilities may not make the same pattern of error responses as the child without neurological or learning problems. The WCST can provide information about the kind of error the child makes and aid in an interpretation of the child's learning difficulties.

Further investigation is needed to clarify the clinical utility of the modified form of the WCST. It is well known that the perseverative error score of the traditional WCST

is sensitive to frontal lobe damage in adults (Milner, 1964). It would be worthwhile to perform research on the modified form of the WCST with brain-damaged and mentally retarded children to determine if and how the modified WCST is sensitive to their disabilities. Furthermore, it would be of use to know which normal abilities are related to WCST performance.

Recommendations for Further Work

The results from this study raise several issues which should be investigated in future research.

1. Is the modified form of the WCST sensitive to brain-damaged and mentally retarded children's disabilities?

   a. Is there one particular error score on the WCST which is more sensitive than others?

   b. Is the lose-stay error score a better measurement of "rigidity" in brain-damaged children, or is the perseverative error score a better measurement?

2. Is the lose-stay error score a better measurement of "rigidity" in normal children?

3. What other normal abilities are related to WCST performance?

The modified WCST is appropriate for normal children and it is hoped it will not be too difficult for abnormal

groups of children. It is probable that the modified form of the WCST will be sensitive to brain-damage and mental retardation since others have found rigid conceptualization in mentally retarded children (Halpin, 1958) and perseveration in brain-damaged children (Chess, 1972).

The lose-stay error score needs to be investigated using groups of brain-damaged and normal children. A comparison could be made between the lose-stay and perseverative error scores to determine which one best measures "rigidity" or the "inability to shift set" in normal children. If it is found that children shift set (or try other responses after a category change) then the perseverative error score may best be abandoned. This comparison between error scores should also be done using brain-damaged children. It is unknown whether these children will be able or unable to shift set on the modified form of the WCST. If they cannot shift set (i.e. if they continue to make color responses on the form category) then this could clearly differentiate them from normal children. If they do shift set after a category change then the lose-stay score may be a better measurement for this group.

Investigation is needed to determine what normal abilities are related to the WCST. As discussed earlier, mental age scores on the PPVT-R and block design subtest were significantly correlated with WCST performance. Yet, only nine

percent of the variance could be accounted for in each correlation. These correlations would probably have been higher if a broader range of children had been tested. In this study, all the children scored within the normal range on the PPVT-R and block design subtest. If mentally retarded children had been included in the study it is likely the correlations would have been higher. However, it is important to know what else WCST performance is related to in normal children.

Successful performance on the WCST may be correlated with the ability to attend to the relevant dimension and disregard the irrelevant ones. Researchers have found that as the child gets older his or her visual attention becomes more systematic and flexible (Wright & Vlietsta, 1975). Furthermore, Pick et al. (1972, 1973, 1974) have performed a series of experiments which suggest that older children's attention is more flexible than younger children's abilities. It is possible that older children may be able to more thoroughly attend to the relevant attribute on the WCST, as well as possibly be able to exhibit more flexible attending behavior when the sorting concept is switched. Therefore, it may be worthwhile to measure attention and compare it with WCST performance in children.

These issues must await future research.

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APPENDIX 1

Consent Letter

Dear Parent,

Your child's school has agreed to participate in a study approved by the Victoria School Board. The study will compare problem solving ability with other skills. The child will be given several different kinds of cards and asked to sort them according to clues from the experimenter. Other tasks include matching a word with the picture it best describes, and building block designs.

If you agree to let your child participate in the study then his or her name will be put on a list and may be randomly selected. If your child's name is randomly selected then your child will be tested in the school and it will involve 30 to 40 minutes of his or her time. Your child's name will not be on any of the test score sheets instead subject numbers will be used. Furthermore, if at any time during the experiment your child wishes to stop participating then the experimenter will stop testing immediately.

The information gathered from this experiment will provide knowledge about the normal child's developing skills.

This information can then be used tc better understand a learning disabled child's performance in these areas.

If you agree to allow your child tc participate in this study, please sign below and send the fcrm back to school with your child.

Thank you,

Jcan Machamer

Roger Graves, Ph.D.

Child's Name: Male: Female:

Child's Grade:

Name of Child's Teacher:

Child's Birthdate:

Parental Signature Date

APPENDIX 2

Verbalization Questionnaire

Subject number:

Number of Categories Obtained:

1. When you put down a card and I said it was right, what exactly did you do that was right?

Color: Form: Number: Color: Form: Number:

2. What else were you doing when I said you were right?

Color: Form: Number: Color: Form: Number:

3. What else were you doing when I said you were right?

Color: Form: Number: Color: Form: Number:

4. Was something you matched correctly to in the beginning of the test ever right later on in the test?

Color: Form: Number: Color: Form: Number:

5. Did you match the cards by the color on the cards?

Yes No

6. Did you match the cards on anything else? What?

Yes No

7. Did you match the cards by the shapes on the cards?

Yes No

8. Did you match the cards on anything else? What?

Yes No

9. Did you match the cards by the number of figures on the cards?

Yes No

VITA

Surname: Machamer Given Names: Joan Ellen

Place of Birth: Detroit, MI Date of Birth: Dec. 14, 1956

Educational Institutions Attended, with Dates of Entering and Leaving:

Earlham College, Richmond IN 1975 to 1979

University of Victoria, B.C. 1980 to 1982

_____ ____ to ____

Degrees, Diplomas, Etc., Awarded, with Dates and Names of Institutions:

B.A. (Honors) 1979 Earlham College, Richmond

_____ ____ _____

_____ ____ _____

Honors and Awards:

University of Victoria Fellowship, 1980/82

_____

Publications:

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The Modified Form of the Wisconsin Card Sorting Test: Normative Data and Analysis of Problem-solving Skill in Children.

Author [redacted]
Signature

Joan Ellen Machamer
Name

August 19, 1982
Date