Effects of integrating functions of left and right hemispheres on recall memory

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EFFECTS OF INTEGRATING FUNCTIONS OF LEFT AND RIGHT HEMISPHERES ON RECALL MEMORY

A Project Submitted to
The Faculty of the School of Education
In Partial Fulfillment of the Requirements of the Degree of Master of Arts in Education: Elementary Option

By

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Summary

This study attempted to determine if first grade students' performance scores on recall memory of both verbal and numerical data would be affected by any of three ways the material was presented and rehearsed. Each of the three teaching and rehearsal methods were designed to impose different levels of task difficulty and bilateral hemispheric involvement. Group A, the control group, was taught the Seven's Time Table and a nonsense paragraph through a traditional method of teacher student oral interaction. The teacher presented the material orally to the students and the students repeated it back. Group B was taught the same way, except that all student teacher interactions were done by singing the material to the tune of "Twinkle, Twinkle Little Star". Group C learned the material in the same way only during presentation and rehearsal they also engaged in a spinning and jumping motor activity. Subject's recall memory of the numerical and verbal data was tested both orally and on written tests, and both on immeidiated and time-delayed tests. Twenty-four different hypotheses were tested using a two-tailed t-Test at the .05 level of significance. Significant differences were found in the scores when the tests were oral and the data was verbal. In these cases, both Groups A and B outscored Group C. Significant differences
were also found when the material was again verbal and the tests were written and time-delayed. Again, both Groups A and B outscored Group C. No other significant differences were found between the groups. Theoretical and practical implications of this study were discussed.
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Introduction

Whole brain learning is an educational concept which currently enjoys wide popularity. This term refers to the process of teaching children through methods which require functions of both left and right hemispheres of the brain.

The concept has stemmed from the research on human cerebral asymmetries which suggests that the human brain is divided into two separate hemispheres which are almost identical in appearance but whose functions differ, even though this difference may vary among people (Restak, 1979, p. 173). Much research indicates that the left hemisphere is basically more analytical, intellectual and auditory, and deals with secondary thought processes that develop with rational thinking, reasoning, ego development and verbal tasks; in contrast, the right hemisphere comprehends gestalts, spatial perceptions, visual aspects of learning music, art, emotions and primary thought processes (Bradshaw & Nettleton, 1983; Gazzaniga, 1978; Gottlieb & Strichart, 1981; Levy, 1983, Sage, 1976; Samples, 1975; Sperry, 1975). Using the electroencephalograph (EEG) to study hemispheric asymmetry associated with cognitive function, researchers have found that left hemisphere activity increases during semantic, verbal or mathematical tasks, while right hemisphere activity increases for visual, spatial or musical
tasks (Warren, Peltz, Haueter, 1976). Experiments with animals show that each separate hemisphere not only learns independently but also has a separate memory (Sage, 1976). Furthermore, it is interesting to note that Austin (1978) reports that the left hemisphere is dominant when we "actively" memorize, while the right hemisphere is more adept at incidental memorization. Sperry (1975) describes the genetically inherent differences people have in their thinking patterns; he suggests that these differences are determined by a person's cerebral dominance. Cerebral dominance refers to a physiological bias of one hemisphere to take the lead in a person's psychophysiological function. A right hemisphere dominant person would be more inclined to work out problems by focusing on internal, subjective experiences, while left hemisphere dominant people would be more objective and scientific (Austin, 1978).

Evidence of the different processing abilities and styles of the separate hemispheres has led many to conclude that our educational system with its heavy emphasis on skills of reading, writing and arithmetic, is geared predominantly toward left hemisphere activity (Sage, 1976; Samples, 1975; Sperry, 1975). An educational system which is partial to left hemisphere cognitive functions is therefore partial to people who are left hemisphere dominant in their thinking.
strategies. The possibility of this left hemisphere bias in education has led Robert Samples to propose that right hemisphere cognitive processing requirements should be a part of education also (1975). Specifically, it has been suggested that there needs to be an integration of the left and right hemispheric cognitive processes in our educational system. Such thoughts are reflected by statements such as the following one made by J. Bogen in The Human Brain (1977):

"For the future...we need to study and learn more about how our teaching techniques can be designed to stimulate the two hemispheres and their processes to interact with one another to construct representations that are long remembered." (p.174)

It is possible that students manifesting signs (which educators generally interpret as boredom) such as doodling or daydreaming, are really exhibiting the desire of the right hemisphere to be involved in the thinking process. In other words, perhaps there is a connection between so-called "boredom" and the activation of the hemispheres. This is certainly a possibility if most of the activity done in school (language, spelling, reading, math) requires the function of the left hemisphere, while visual imagery, and drawing abstractions are functions of the right hemisphere (Segalowitz, 1983 p. 206; Samples, 1975).

Whole brain learning could be a solution to the problems of boredom which seems so evident in our schools today (Bettleheim & Zelan, 1982). John Holt states that in one
Boston school 30% of 65,000 youngsters registered are missing on a typical day; he says most stay away because they hate school and say it is wasting their time (Harris, 1979).

There is evidence that throughout the history of education, attempts to involve the right hemisphere have been made in response to the problem of boredom, although the terminology may have been different. These attempts to involve the right hemisphere may be reflected by such movements as the progressive movement which began in the 1890's by Joseph Rice (Finn, 1981). Rice, along with other reformers such as Thomas Palmer and Horace Mann, believed the traditional method of rote memorization of math facts and the alphabet was detrimental to learning because it was tedious, boring, and stifled creativity and enthusiasm. The progressive movement rejected tedious memorization of specific facts such as the alphabet for a more whole concept type of approach reflected by such particular methods in reading as the "look and say" method and the "words to reading" approach. This movement, characterized by creativity and freedom in education, flourished during the 1900's until a decline in the literacy rate and student achievement was noted in the mid-1960's (Holnar, 1982). This observation led to a great public dissatisfaction with schools which eventually resulted in the "Back to Basics"
movement, characterized by the traditional approaches and methods including rote memory of the basic concepts of reading, writing, and arithmetic (Brandt, 1980). This fluctuation in education reveals a pattern which begins with traditional (or left hemisphere) pedagogical methodology, then switches to the progressive movement and a time with all kinds of alternative schools created (right hemisphere), then shifts back to the left hemisphere (Back to Basics), and finally, today's "whole brain learning". Perhaps this whole conflict reveals the efforts of man to achieve an educational system that integrates both left and right hemisphere functions in its cognitive activities.

G. Lozanov (1978) and Jerre Levy (1983), both address the issue of boredom in education and how whole brain learning may be the solution to this problem. Lozanov (1978) has developed an instructional technique which reports a highly accelerated learning rate for everyone regardless of I.Q. or past achievement record. His method, described as "whole brain learning", is an approach in which both left and right hemispheres are stimulated during instruction. One of the premises motivating Lozanov to come up with whole brain learning was his belief that the mind could learn a great deal more if it were more open to receive the information. He believed that one of the barriers to block the mind from learning was boredom (Prichard and Taylor, 1980).
Jerre Levy (1983) believes that boredom is the inability to sustain attention. She suggests that boredom yields poor learning because it results from requiring cognitive processes which are not sufficiently complex to activate both sides of the brain. She believes that when tasks are at a very simple level, bilateral activation may be at a low level with reliance on a single hemisphere and only weak facilitation from the other side. She observes that normal brains are built to be challenged. These observations stem from studies on split brain patients and from the work of Joseph Hellige and associates which have shown that as task complexity increases, bilateral hemispheric engagement increases and performance is consequently enhanced. Studies on split brain patients show that with the corpus collosum severed, only one hemisphere at a time is operating (Levy, 1983). This implies that it is the function of the corpus collosum to interconnect both the left and right hemisphere which makes it possible for both hemispheres to be simultaneously aroused and activated. Hellige and associates have shown that with a simple task only a single hemisphere operates. As the task becomes more complex, unihemispheric dominance decays and hemispheric operations emerge (Levy, 1983). Kinsbourne and Cook (1971) call this the "challenge effect" which refers to enhancement of performance due to
increased motivation when an easy task is made more difficult.

In summary then, the recent increased understanding of cerebral asymmetry has stimulated the origins of the concept of whole brain learning in education. This concept of whole brain learning refers to teaching methods which stimulate and activate both hemispheres simultaneously. The failure to induce bihemispheric activation in school may be the source of the boredom which so many associate with learning problems (Harris, 1979). Exactly how educators can achieve whole brain learning and what effects it will have on learners, remains unresolved (Levy, 1983). Much of the research done as yet on this subject of hemispheric integration has only created more questions, questions which can only be answered by more research. The purpose of this present study is to address some of these issues by exploring the effects of coupling tasks requiring different levels of hemispheric functioning and integration.
Review of Literature

According to Michael Posner (1969), the concept of human performance being facilitated by the addition of a concurrent task dates back as far as 1892 when Bliss; and again, Border (1935), suggested that certain automated tasks (tasks requiring very little attention) would be performed better with the addition of a concurrent activity. The rationale supporting this hypothesis was that simple repetitive motions are controlled by lower centers of the brain. The addition of a secondary task would require higher centers of the brain to function. Performance of both tasks would then be facilitated due to the increased activation of the higher centers of the brain (Posner, 1969).

Continued research on the human brain has resulted in a shift from the study of "lower" and "higher" centers of the brain to the study of human cerebral asymmetry; that is the bilateral division of the brain into left and right hemispheres. However, the lateralities of the brain are not fully understood. As previously mentioned, there is extensive evidence that the left hemisphere usually mediates language-related cognitive activities and the right hemisphere usually mediates visual-spatial, nonlanguage cognitive activities; however, Bradshaw and Nettleson (1983) cite Moscovitch (1969) as saying these laterality effects are
influenced by the amount and type of task load a person is engaged in. Hellige, Cox and Litvac (1979) also believe that "...it is the magnitude of the processing demands that determine whether primary task asymmetries are enhanced or reversed by adding a secondary task."

Several theories of interhemispheric interaction have emerged from the research to account for the different laterality effects found with different task difficulty, expectation, amount of practice, adopted strategies, etc. Bradshaw and Nettleson (1983) describe Kimura's structural account as stating that the different ear and visual field superiorities are a reflection of the process of the transference of incoming information to the hemisphere most capable of processing it (p. 118).

On the other hand, Kinsbourne's attentional model states that the functional specialization of the hemispheres accounts for only a small part of the asymmetry effect. Instead, the difference is due to the allocation of attention, which is caused by the cognitive set expected and the concurrent processing load (Kinsbourne, 1978).

According to this theory then, "...an auxiliary task will facilitate performance only when the task demands a sufficient amount of effort to prime related structures in the same hemisphere, but not so much that it deprives the other task of its needs" (Bradshaw & Nettleton, 1983, p. 111).
In other words, small loads may prime a hemisphere, enhancing performance; while larger loads may overload it, depressing performance (Bradshaw & Nettleton, 1983, p. 129).

**Dual Task Technique**

There has been much research attempting to identify effects of task load on laterality and performance in human subjects. One technique used to further identify the functions of the hemispheres and how they interact has been called the "dual task" technique (McFarland & Ashton, 1978). The dual task technique consists of studying performance when tasks, which are processed in the left hemisphere, are coupled with tasks which are processed in the right hemisphere. Specifically, left hemisphere cognitive functions such as verbalization tasks or a right hemisphere visual-spatial or humming task have been coupled with some type of motor skill (Hicks, 1975; Johnson & Kozma, 1977; White & Kinsbourne, 1980).

It is suggested that coupling either a left or right hemisphere cognitive activity with a motor task would activate both hemispheres since motor skill is predominantly contralateral. That is, the left hemisphere controls the right side's motor activity and the right hemisphere controls the left side's activity (Boll, 1973).
It is thought that coupling the learning of numerical and verbal material (left hemisphere activity) with singing activates both hemispheres because there is evidence that the right hemisphere is activated to a greater degree than the left hemisphere when subjects sing or whistle compared to just speaking the words to a song (for non-musicians only), (Davidson & Schwartz, 1977; Smith, Chu & Edmonston, 1977; Taub, Tanguay, Doubleday, Clarkson & Remington, 1976, cited in Segalowitz, 1983.) When the right hemisphere was removed or temporarily anesthetized in subjects, dramatic loss of singing skills resulted; whereas, left side damage or incapacitation did not affect the ability to carry a tune (Smith, 1966; Gordon & Bogen, 1974, cited by Gates and Bradshaw, 1977). There is also greater increase of blood flow to the right hemisphere when patients listen to music than when listening to speech (Carmen, Lavy, Gorden & Pertnoyu, 1975, cited by Segalowitz, 1983, p. 98). The right hemisphere also proves to be superior to the left hemisphere for melody recognition (Levy, 1983; Gates & Bradshaw, 1977).

Research done on hemispheric asymmetry and integration has involved the use of both brain-damaged and normal subjects. The first group are those who have normal intelligence but for reasons yet unknown, do not have normal learning ability; they are known as learning disabled. It has been estimated that up to 25% of all school children in
the primary grades have some degree of visual deficit related to learning disabilities (Harwell, 1982). This means that many teachers are working with children who have learning problems, but do not qualify for special programs.

Second, there are those children who are of normal intelligence and have normal learning ability but who are not operating at their maximum potential because of lack of motivation or boredom. The concept of whole brain learning, or interhemispheric integration, may be a partial solution to both problems, since a typical classroom is composed of both groups to varying degrees.

Lateralization Effects: Music and Learning Disabled Subjects

Gardner (1975), discusses two types of therapies designed for the learning-disabled. The first one, developed by Edgar Zurif, is still in its experimental stage. In this therapy, visually drawn symbols associated with actions and objects are used as a form of communication. In other words, a right hemisphere function (visual symbols) is used to aid in the left hemisphere function of language (Gardner, 1975).

The second therapy is Melodic Intonation Therapy, devised by Martin Albert, Nancy Helm, and Tobert Sparks (1973). This therapy involves the use of singing in order to aid a patient who is unable to express himself orally. Segalowitz (1983),
cites a study in which a man was unable to speak after three months of language therapy. Two days after beginning Melodic Intonation Therapy, he produced a few words (Albert, Sparks & Hem, 1973). The success of this therapy provides support for the theory that integrating left and right hemisphere functions may benefit people with brain damage. This information may help us to better understand students experiencing some form of learning disability.

Others, such as Dorothy Van den Honert (1977), have utilized music to aid learning disabled school children in hemispheric lateralization. Van den Honert advocates the necessity of lateralizing (using one given side of the brain for a specific function) in reading. She determines that reading is a left hemisphere function by first breaking the process of reading into the following steps: 1) analysis of sounds into phonetic elements; 2) transcription of those auditory elements into corresponding visual elements; 3) assembling the visual elements into a sequence that matches the auditory sequence in a word; 4) assembling words into sentences. Then she cites the following literature to suggest the notion that the left temporal lobe's function is particularly involved in sequencing, logic, and analytic processes (Bogen, 1969; Geshwind, 1970, Carmon & Nachschon, 1971; Pines, 1973; Greenblatt, 1973; De Renzi, Faglion,
Scotti & Spinnler, 1973). Then, coupling this information with a theory proposed by Michael Gazzaniga (1972) which states that learning disability may be caused by a malfunction in the way the brain processes information, she suggests that learning disabled students may use the nonverbal right side of the brain for the task of reading instead of the verbally geared, more efficient left side.

Gazzaniga (1967, cited by Van den Honert, 1977) did a study in which he was able to train split-brain monkeys to lateralize using a reward system; and he suggested that it may be possible to teach learning disabled children to lateralize also. Van den Honert attempted to test the theory that student's reading ability could be improved if they could be trained to use the left side, which is specialized for the task of analyzing specific phonetic elements needed for reading. The method she advocated engages the right hemisphere in the task of listening to music so that the left hemisphere is required to process the information presented to it. She stressed the necessity of this information being the type used in the phonics method of reading, which analyses auditory, phonetic and verbal sequences, breaking them down and then reassembling them; all tasks which the left hemisphere specialized in. This is opposed to the pattern recognition type (sight words) that the right hemisphere is more suited to (Van den Honnert, 1977).
Students taught by Van den Honnert's method did experience significantly more reading success than students who did not (Van den Honnert, 1977).

Schuster & Vincent, (1980) also reported significant gains on learning disabled student's scores in math and reading. Their method included using the addition of the right hemisphere tasks of visual imagery and music.

Another remedial specialist for a junior high school, Mariellen Martin, obtained a successful increase in student performance by incorporating music into her teaching method of spelling words (Martin, 1983).

Steven S. Bottari and James R. Evans (1982) did a study using learning disabled students in order to determine if children with strong visual-spatial skills (right hemisphere) and weak verbal skills (left hemisphere) would be able to retain more verbal information when the information was presented in a musical context. They also wanted to see whether the effect would be reversed for students with the opposite pattern of abilities (strong verbal, weak visual-spatial). The results of their investigation indicated that subjects in the visual-spatial group did obtain significantly higher recognition scores (but not higher recall scores) when the lyrics were sung rather than spoken, regardless of whether there was instrumental musical accompaniment. The
scores of the verbally-oriented group did not differ across conditions. These puzzling findings have led the authors of this study to suggest that more research be done, and that a particularly interesting area to explore would be the possibility that recall would be facilitated by requiring subjects to sing the answers. The present study explores that possibility.

**Lateralization Effects: Music and Normals**

Studies on the relationship between music and language using normal subjects have shown conflicting results. Jellison (1976) found that song facilitated digit recall for both musically trained and untrained undergraduates. However, in a later study (Jellison & Miller, 1982), Jellison found that sung input and recall task resulted in a decrement in recall performance for digits; while recall performance for words remained the same in both sung and spoken conditions.

Music was also found to aid thirty-eight seventh graders in the learning and retention of lexical units in the German language sequences, with subjects scoring higher when material was presented through song, as opposed to dialog (Hahn, 1972).
Lateralization Effects: Motor Tasks and Normals

Studies which couple cognitive activity and motor tasks have been done in a variety of ways with differing results. One study using the dual task technique was done by Kinsbourne and Cook (1971); subjects in this study balanced a dowel rod on either their left or right index finger, with or without concurrent verbalization (repeating sentences aloud). Subject's scores resulted in lowered balancing time with verbalization for the right hand (left hemisphere) than for the left hand (right hemisphere). Concurrent verbalization facilitated left hand balancing compared to the condition with no verbalization. The Hicks (1975) and Johnson and Kozma (1977) studies replicated these findings that verbal tasks disrupted right-hand performance; however, Hicks found it true only for dextrals and Johnson and Kozma found this effect was not true for females.

Other studies support the notion that concurrent tasks interfere more with right than with left-hand motor skills (Hicks, Provenzano, & Rybstein, 1975; Kinsbourne & McMurtry, 1975; and Hiscock & Kinsbourne, 1978).

When dowel balancing was performed with non-verbal concurrent tasks (remembering faces or shapes; humming musical themes), cognitive functions of the right hemisphere,
the left hand's performance was affected negatively (McFarland & Ashton, 1978).

It appears then, that doing a left hemisphere function (verbalization) while concurrently doing a left hemisphere motor activity (dowel balancing with the right hand) decreases the performance of the motor activity. Conversely, when doing a right hemisphere cognitive activity (humming) while doing a right hemisphere motor activity (dowel balancing with the left finger) again the performance of the motor activity decreases. Evidently, two concurrent unrelated tasks processed in the same hemisphere, decreases performance, at least for the motor activity task.

What about the reverse effect though? Is the cognitive task affected by a simultaneous motor task? Bowers, Heilman, Satz and Alman (1978) found that verbal tasks interfered with right handed tapping but that the verbal tasks were not affected by the right handed tapping. These findings imply that concurrent tasks may affect motor activity differently than cognitive functions.

White and Kinsbourne (1980) did a study where, again, the focus was primarily on how finger tapping, with both right and left hands, was affected by saying a rhyme (left hemisphere function), naming animals (left hemisphere function), and recognizing shapes (right hemisphere function). Once more, the results showed that there was more
interference and decreased performance of the motor task when a concurrent task was performed which was controlled by the same hemisphere as the hand doing the motor task. Kinsbourne and White did look at the effect of the motor activity on the verbal performance and found that children reciting "Jack and Jill" were able to recite more syllables of the rhyme while tapping with their left rather than right hand; however, there was no difference in the number of animals named while tapping with either their left or right hand. Even if more syllables of the rhyme were recited while tapping, we do not know whether the children who concurrently tapped their fingers recited more syllables of the rhyme than would children who said the rhyme alone. In other words, it does seem that the effects of concurrent tasks on cognitive activity is different than on motor activity, but it is not clear what this difference is. It also remains unclear as to what effects the addition of motor tasks, in particular, have on verbal tasks.

Finger tapping and dowel balancing were changed to tapping between two targets, differing in proximity, in studies by McFarland and Ashton (1978) and Cremer and Ashton (1981) because of the growing evidence that there is a decrease in the strict contralateral control of the hands and limbs by the cerebral hemispheres as the manual task.

"In particular, increases in the rapid movement and sequencing aspects of motor activity appear to increase the relative left hemisphere control of execution for either hand (Wyke, 1971). Further, an increase in the tactile-somatosensory aspects of motor activity appears to increase right hemisphere involvement (Boll, 1974)".

McFarland and Ashton (1978) found that there was a difference of right and left hand target hitting performance while concurrently doing faces (right hemisphere) or word (left hemisphere) memory tasks, when the targets were either close together or further apart. It appears then, that changing the load of the manual activity affects the performance of the cognitive task.

Cremer and Ashton (1981) did a study similar to the McFarland and Ashton (1978) study. This study differed in that, not only was the distance between the targets changed, but the size of the targets were also decreased so that the manual activity became even more difficult. The results of this study were consistent with the findings previously cited in the literature that verbal tasks disrupt right hand performance and nonverbal tasks disrupt left hand performance. The increased difficulty of the manual task did not change the disruptive effects caused by the lateralized cognitive tasks.
Summary

The literature thus far reviewed, in which performance has been studied when contralateral hemispheric tasks have been coupled together, shows inconsistent findings. There is no support in general for the theories set forth by Bliss (1892), Border (1935), Kinsbourne and Cook (1971) and Levy (1983), stating that performance of a simple task will increase when coupled with a concurrent task. The addition of music with cognitive activities for disabled subjects did increase performance (Van den Honnert, 1977; Martin, 1983; Schuster & Vincent, 1980 and Bottari & Evans, 1982). However, the results were not consistent for normal subjects. Jellison (1976) and Hahn (1972) found singing facilitated digit and verbal recall, while Jellison and Miller (1982) found it decreased recall performance. Cremer and Ashton (1981), White and Kinsbourne (1980), Bowers, Heilman, Satz and Alman, (1978), Hicks, Provenzano, Rybstein (1975) and Hiscock and Kinsbourne (1978 & 1980), all found that concurrent verbal tasks interfered more with right than with left-hand motor skills; however, Hicks (1975) found this true only for dextrals and Johnson and Kozma (1977) found it true only for males.

Thomson and Clausnitzer (1980), Piazza (1977), McFarland
and Ashton (1978) all cited by Bradshaw and Nettleton (1983), found that the left hand dowel balancing scores were affected negatively when performed concurrently with right hemisphere cognitive activities. Kinsbourne and Cook (1971) did report that left handed dowel balancing was facilitated with the addition of concurrent verbalization.

When performance was measured by the cognitive task, Bowers, Heilman, Satz and Alman (1978) found no effect for concurrent right handed tapping; however, Kinsbourne and White (1980) found that certain cognitive tasks were facilitated with a contralateral motor activity, while other cognitive tasks remained unaffected. McFarland and Ashton (1978) found that changing the manual activity load affected both right and left hand motor performance when performed concurrently with either a right or left hemisphere cognitive activity. No studies were found that coupled concurrent motor tasks with cognitive tasks when learning disabled subjects were used.

A closer look at these dual task studies reveals a common element which may have been missing in some of them. That element is boredom or lack of motivation. Bliss and Border (1935) emphasize the automation of the tasks or that which require "little attention" which Levy suggest leads to boredom (1983). Kinsbourne and Cook (1971) also suggest motivation is a factor since they propose that motivation be
increased by making a simple task more difficult.

It has already been stated that an aspect of education which is particularly boring is the left hemisphere activity (Austin, 1978) of learning and retaining (or memorizing) basic facts (Horace Mann, Thomas Palmer, Joseph Rice; cited by Finn, 1981). Possibly, in the particular case of tedious memorizing, performance will be enhanced by the addition of a secondary contralateral hemispheric task. A scan of the previously reviewed literature does reveal that subjects improved when the performance measured was that of learning and memory of either verbal or numerical material when coupled with singing or music (Van den Honnert, 1977; Bottari & Evans, 1982; Jellison, 1976; Hahn, 1972).

The motor task studies usually measured performance according to the motor task. These studies indicate the necessity of the dual tasks being in contralateral hemispheres, but they do not really tell us much about whether learning and memorization requirements of school could be enhanced by coupling them with a contralateral task such as a motor task. No such particular studies using motor tasks were found. The present study investigates the effects of a motor task done concurrently while learning verbal or numerical material, on a students' performance.

Since performance in this study is measured by memory,
specifically recall memory, a brief review of the literature on recall memory is appropriate at this time.

Memory

According to Roy Rowan (1978), scientists are still not sure whether human memory is chemical or electrical, highly structured or random, or whether it is limited or unlimited. It is still not known exactly where in the brain memories are filed. Elaborate models have been constructed to account for the distinctions between episodic memory (recall of single events) and semantic memory (recall of entire information systems). There is short term memory and long term memory, recall memory and recognition memory. Two models accounting for the difference between recall and recognition memory are: (1) Brown (1976), who suggests that recall and recognition are non-equivalent measures of memory because recall requires the processes of generating and searching or retrieving, and recognition requires discrimination; (2) Lockhart, Craik and Jacoby (1976) cite Kintsch (1970) as saying recall involves both search and decision while recognition only involves decision (cited in Brown, 1976). The difference between a recall and recognition test is described by John Brown (1976) in the following:

The essence of a recall test is that the subject has to generate the target or targets meeting the definition of the target in the recall in-
struction. The target may or may not be a member of a well-defined set and the set may be either large or small. If the target is a word, he may have to speak or write it; if it is a picture or an idea he will have to describe or draw it.

The essence of a recognition test is that one or more potential targets are presented to the subject. Accordingly, there is no requirement for overt generation of the target. The recognition response may consist in accepting or rejecting a given choice, rating it, assigning a subjective probability to it, ranking it in relation to other choices present, or, in the case of a multiple-choice test, choosing the most plausible item (p. 1).

Recognition tends to be easier than recall because the presence of a target word facilitates access to a certain amount of stored information.

On the other hand, Endel Tulving (cited by Brown, 1976) expounds on a second theory of recall and recognition which holds that they are basically similar processes of utilization of stored information and that the differences between them are minor.

Even though the actual process of memory remains an enigma, many continue to study memory by studying factors which influence memory. These studies again result in conflicting findings. Roberta Klatsky (cited in Lane, 1978) suggests that early training by heavy emphasis on rote-memorization in school may have been a large contributing factor to the incredible recall of several well known people, such as the Russian Psychologist Alexander Lauria;
this notion suggests that memory can be improved.

On the other hand, Halacy (1970) states, "We really can't improve memory at all. Memory systems that work actually operate by making us learn better in the first place," (p. 91). Merely exercising our memory ability does not improve it. Memory, according to Halacy, can, however, be influenced by certain conditions. These conditions include experiences which are pleasant and used material tied in with muscular skills. He also contends that memory improves when meter, rhyme, melody and repetition are used (Halacy, 1970).

Kinsbourne, in Children's Learning and Attention Problems (1979), states: "The only way a teacher can improve a child's memory for any kind of material is by working to improve the way the child experiences the material in the first place" (p. 62). Furthermore, material remembered best is that which is experienced the most and paid attention to most effectively (Kinsbourne, 1979). Perhaps the conditions mentioned by Halacy and Kinsbourne, which appear to enhance memory, work because they increase task complexity by engaging both hemispheres in the learning process which reduces boredom and increases motivation. Then, with both hemispheres actively engaged in the learning process, more is remembered since more of the brain is activated.
However, we cannot stop there. Learning is a process of interrelated steps. Information must be recorded in the brain (input), organized and comprehended (integration), stored and retrieved (memory) and communicated (output), (Silver, 1980). Perhaps in the concept of whole brain learning, we must not only integrate all parts of the brain but also the entire process of learning. Perhaps both left and right hemispheres need to be stimulated not only during input, but also during output and the retrieval process. As previously mentioned, Bottari and Evans (1982) suggest that students' recall may be facilitated if they are required to sing the answers. It should be noted that students in this study were able to recognize more verbal information when it was sung rather than spoken, but were not able to recall it. So in this case, bihemispheric tasks aided in the learning process, possibly because boredom was reduced. Perhaps the retrieval process needs to be stimulated in the same way.

This certainly is a possibility according to a theory concerning human memory proposed by Michael S. Gazzaniga and Joseph E. LeDoux (1973) in *The Integrated Mind*. Their theory, based on observations of brain damaged patients, is that memory or engrams for things or events are multiply represented in the brain, because the experiences themselves have multiple aspects. These experiences may be stored at a variety of sites in the cerebrum. Each separate memory bank
may be independently and coherently organized, as well as having logic and its own set of values. These memory banks, they believe, may not necessarily communicate with one another inside the brain, since brain damaged people only experience partial memory loss at times. Suppose, they suggest, that we have a verbal memory system which simultaneously operates with several nonverbal systems which use gestures and movements to respond with instead of verbal language?

It is widely known that people can "recall" much less information than they can "recognize", a fact which has led to the distinction between recall and recognition memory. This distinction could be explained by the theory that recall is only represented by the verbal system, while recognition, through cueing, pointing, matching, etc., could utilize both verbal and nonverbal memory systems (left and right hemispheres) which would increase the amount of material remembered. The verbal memory system could become aware of information possessed by nonverbal memory systems by observing emitted behaviors (stored information), (Gazzaniga and Le Doux, 1978).

Possibly then, when information of a perceptual nature, regardless of the input modality, is encoded with language systems activity, the information is encoded verbally as well as nonverbally, and a bond or association is formed that
allows the language system some access to these stored memories laid down by the nonverbal systems. According to this theory, then, encoding information verbally as well as nonverbally would facilitate recall of the information as long as both the verbal and nonverbal systems were active in the encoding process as well as in the retrieval process.

The normal adult language system does develop such bonds with the nonverbal naturally. The results being that the ability to recall verbal aspects of an event is increased as a person reenters the physical circumstances of a memory, including the time, space, color, sounds, smells, temperature, etc.

Perhaps this concept could be taken a step further. Our present day approach to teaching and learning may not effectively utilize our nonverbal systems of learning and memory. Possibly, by coupling a verbal and nonverbal activity together, our subsystems of the brain would be activated for both the receiving and storing of information. Then if these systems were again activated during retrieval, greater recall would occur because both the verbal and nonverbal memory systems would be contributing more to the total recall, as opposed to just the verbal system facilitating recall.

Hardyck and Haapanen (1979) have entertained the idea that hemispheric differences may be differences in memory,
rather than in thinking. They base this belief on a study done by Hardyck, Tzeng and Wang (1978), which revealed that there was no difference between the left or right hemisphere in accuracy of judgement or speed of response when English and Chinese words were presented to it. However, subjects remembered significantly more words shown to the left hemisphere. Bradshaw and Nettleton (1983) cite several studies supporting the belief that laterality effects are greater when memory is compared rather than when perceptual matching is compared (Dee & Fontenat, 1975; Hannay & Malone, 1976; Hines, Satz & Clementino, 1973, Moscovitch, Scullion & Christie, 1976).

Our present day traditional pedagogical methodology, as previously mentioned, largely consists of the left hemisphere activity of listening, reading, and writing of verbal material (Samples, 1975). Would coupling the left hemisphere activity of memorizing verbal and numerical material be increased (by the measure of recall) when the material is coupled with the right hemisphere nonverbal activity of singing? It is the intent of the present study to investigate this possibility.

Three groups of first grade children will be taught and told to rehearse both numerical and verbal material under conditions which impose different levels of bihemispheric
activation and task loads. It is expected that there will be no significant difference between the oral or written retention scores of either the verbal or numerical data (whether the testing is immediate or time-delayed) when students learn and rehearse the material in a normal student-teacher interaction method or when presentation and rehearsal are done by singing or concurrently with a motor activity.
Statement of Hypotheses

H1.0 There will be no significant difference between the control group's and the music group's immediate retention scores of the numerical data, as measured by the oral testing procedure.

H2.0 There will be no significant difference between the control group's and the music group's time-delayed retention scores of the numerical data, as measured by the oral testing procedure.

H3.0 There will be no significant difference between the control group's and the motor group's immediate retention scores of numerical data, as measured by the oral testing procedure.

H4.0 There will be no significant difference between the control group's and the motor group's time-delayed retention scores of numerical data, as measured by the oral testing procedure.

H5.0 There will be no significant difference between the control group's and the music group's immediate retention scores of verbal data, as measured by the oral testing procedure.
H6.0 There will be no significant difference between the control group's and the music group's time-delayed retention scores of verbal data, as measured by oral testing procedure.

H7.0 There will be no significant difference between the control group's and motor group's immediate retention scores of verbal data, as measured by the oral testing procedure.

H8.0 There will be no significant difference between the control group's and the motor group's time-delayed retention scores of verbal data, as measured by the oral testing procedure.

H9.0 There will be no significant difference between the music group's and the motor group's immediate retention scores of verbal data, as measured by the oral testing procedure.

H10.0 There will be no significant difference between the music group's and the motor group's time-delayed retention scores of verbal data, as measured by the oral testing procedure.
H11.0 There will be no significant difference between the music group's and the motor group's immediate retention scores of numerical data, as measured by the oral testing procedure.

H12.0 There will be no significant difference between the music group's and the motor group's time-delayed retention scores of numerical data, as measured by the oral testing procedure.

H13.0 There will be no significant difference between the control group's and the music group's immediate retention scores of the numerical data, as measured by the written testing procedure.

H14.0 There will be no significant difference between the control group's and the music group's time-delayed retention scores of the numerical data, as measured by the written testing procedure.

H15.0 There will be no significant difference between the control group's and the motor group's immediate retention scores of numerical data, as measured by the written testing procedure.
H16.0 There will be no significant difference between the control group's and the motor group's time-delayed retention scores of numerical data, as measured by the written testing procedure.

H17.0 There will be no significant difference between the control group's and the music group's immediate retention scores of verbal data, as measured by the written testing procedure.

H18.0 There will be no significant difference between the control group's and the music group's time-delayed retention scores of verbal data, as measured by the written testing procedure.

H19.0 There will be no significant difference between the control group's and motor group's immediate retention scores of verbal data, as measured by the written testing procedure.

H20.0 There will be no significant difference between the control group's and motor group's time-delayed retention scores of verbal data, as measured by the written testing procedure.
H21.0 There will be no significant difference between the music group's and motor group's immediate retention scores of verbal data, as measured by the written testing procedure.

H22.0 There will be no significant difference between the music group's and the motor group's time-delayed retention scores of verbal data, as measured by the written testing procedure.

H23.0 There will be no significant difference between the music group's and the motor group's immediate retention scores of numerical data, as measured by the written testing procedure.

H24.0 There will be no significant difference between the music group's and the motor group's time-delayed retention scores of numerical data, as measured by the written testing procedure.
Method

Subjects

Subjects were 51 children from two First Grade classes at an elementary school in a small school district in Southern California. Twenty-four of the students were from one class and 27 were from another class. All of the children were between the ages of six and eight, and were within the range of normal intelligence and achievement. There were 25 males and 26 females. Forty-three were right-handed and 8 were left-handed.

Location and Time

The location of the experiment was an empty classroom set up with four rows of desks facing the teacher's desk and the blackboard. The room was very non-distracting, spacious, and quiet.

The experiment was conducted during a 2-day period. The children's normal school day schedule pertaining to lunch, recess breaks, and dismissal time was not interrupted. The experiment occurred only within the time normally allotted for regular classroom activity.
Procedure

Subjects were assigned to one of three groups by a random number procedure. The three groups were Group A (the control group), Group B (the music group), and Group C (the motor activity group).

A counter-balance order of presentation was used to introduce and rehearse both numerical and verbal material to all three groups. Presentation and rehearsal occurred over a three day period. Each group had a fifteen minute time segment allotted to it for both the numerical and the verbal data.

The numerical data used was the 7 times table. Each equation, from $0 \times 7 = 0$ to $10 \times 7 = 70$, was written on two different, large, flashcards. The first flashcard showed both the equation and the answer on the front. The second flashcard showed the equation on the front and the answer was written on the back. Multiplication was chosen because it is material that is not found in the First Grade Math Curriculum, and first graders would normally have had little or no previous exposure to it.

The verbal material consisted of a nonsense paragraph written by the experimenter (see Appendix A). The paragraph was printed on a large posterboard in black ink with certain designated words underlined with orange crayon. Nonsense
words were used with the intent of providing no concrete pictures for students to visualize mentally; thus, keeping the normal processing of this data a left hemisphere function. Furthermore, students would again have had no prior exposure to this material.

Normal classroom activity continued for both classes from which the subjects were drawn during the experiment. Subjects were run on a pull-out basis, one group at a time.

The first group, Group A, was shown the flashcard containing both the equation and the answer on the front side. The experimenter read the equation and answer outloud to the subjects. The subjects were instructed to repeat the equation and answer back to the experimenter while looking at the flashcard. Next, the experimenter presented the second flashcard, which had the same equation written on the front but in this case, the answer was on the back. The subjects were told to read the equation and attempt to supply the answer by memory. The answer on the back of the flashcard was revealed to the students after each attempt to supply the answer, whether it was successful or not. Subjects were drilled in this manner by rows and with the group as a whole.

This type of presentation and rehearsal procedure continued for fifteen minutes a day for each group for three days. Five of the ten equations were randomly presented on
Day One for all three groups. The remaining five equations were randomly presented on Day Two and all ten equations were reviewed on the third day.

After Group A's fifteen minute segment was completed, they were taken back to their classroom and Group B was collected. A five minute training period was necessary on Day One for Group B in order for the experimenter to be sure that all subjects knew the tune of "Twinkle, Twinkle Little Star". After all subjects had acknowledged that they did know this song and the group had sung it once, the experiment continued. The same procedure outlined for Group A was followed with Group B; however, this time all verbal transactions occurred to the tune of "Twinkle, Twinkle Little Star". The experimenter presented the flashcard and sang "Seven times zero equals zero". The students sang the equation and answer back.

At the completion of Group B's time, they were taken back to their classrooms and Group C was assembled. A five minute training period prior to the fifteen minute learning segment was also required for Group C. The experimenter explained and demonstrated the motor activity to the subjects. The children were required to spin all the way around one time and when facing the front of the room again, they were to jump up, tucking their legs under themselves, slapping the tops of their knees with their hands. This
motor activity was called a "Spin and Jump-tuck".
After it was determined that all subjects could adequately perform this motor activity, the fifteen minute learning period began. The experimenter presented the equations on the flashcards in the same manner as with the other two groups; however, when the equation was read, both the experimenter and subjects were required to spin and when the answer was either said or read, a jump-tuck was done. Presentation and rehearsal followed the same format as the other two groups.

After all three groups completed their learning period for the numerical data, the learning periods for the verbal data began. Groups were called out from their class in the same manner as previously described in counterbalance order.

Group A was shown the nonsense paragraph written on the posterboard while the experimenter read the first line. The subjects were required to repeat the line back to the experimenter. Then the posterboard was turned over (so nothing was in view) and the subjects attempted to repeat the first line by memory. After each attempt, the posterboard was turned back over so the nonsense paragraph was in view and subjects could get feedback on their responses. The presentation and rehearsal procedure continued in this manner for the three-day period. Each line of the nonsense
paragraph was gradually introduced and rehearsed until the entire paragraph had been presented.

The procedure for Group B was similar to the procedure for Group A except that all verbal transactions were done to the tune of "Twinkle, Twinkle Little Star," by both experimenter and subjects. The words of the paragraph fit the tune of this song exactly.

The material for Group C was presented by the experimenter while performing the motor activity. The first sentence was read while spinning around and when coming to a word underlined in orange, a jump-tuck was executed. Subjects were required to repeat the material in the same manner. The paragraph had been written so that there was a nice steady, rhythmical flow of spinning and jumping.

Assessment Techniques

A written test was given immediately after all three groups had completed all six of the required instructional periods and, thus, occurred the last hour prior to the termination of the school day on Day Three of the experiment. All subjects remained in their own seats in their own classrooms, regardless of which group they were in. Efforts to ensure that no subject copied from another subject's paper
were made by directing subjects to move their chair so that there was a three to four foot distance between every subject. The experimenter and classroom teacher walked around the room monitoring the testing.

The written test (see Appendix 3), was placed face down in front of each subject with only the subjects name, sex and group number written on it. The instructions given by the experimenter, for the numerical data, were as follows:

"Think about the numbers we have been learning. See how many you can remember. When you remember a number that goes with the numbers you see written on this paper, write that number on the blank line you see there."

The instructions for the verbal material were as follows:

"On your paper you see some blank lines. I want you to think of the sentences we have been learning and write as many of them as you can think of on these blank lines. Write them in the order that we learned them. If you can not remember some of them, then just skip that part and continue writing what you do remember."

After the instructions for both parts of the test were given, and the experimenter felt confident that all the subjects understood what to do, the experimenter told the subjects to turn their test over and begin. Each subject was given twenty minutes to complete the test. Subjects who finished early were told to turn their paper over and draw a picture while they were waiting for everyone else to finish.
Each classroom teacher monitored the test for his or her own class while the experimenter went back and forth between rooms giving instructions and ensuring that everything was running smoothly. The teachers did not know which group number went with which experimental condition. They were told to make sure everyone was doing the test correctly and when any child asked a question about the test contents, teachers were told to tell the child they could not help them with any answers and to just try their best to remember what they could and write it. At the end of twenty minutes, all the tests were taken up.

The fourth day of the experiment was the oral test for all subjects, for both the numerical and verbal material. Testing began during the first hour of the school day and terminated an hour after lunch. A hired assistant sat outside the two classrooms at a table. The classroom teachers were given a randomly ordered list of students to send out to the assistant one at a time. The order in which each class was tested was determined by attempting to fit the testing schedule to the classroom teacher's plans; thus, on the first oral test, one class went first, and on the second time-delayed test the other class went first. The students went from their classroom to the assistant. They were told to sit in a chair in front of the assistant's table and were
then given test instructions. All subjects were shown the same randomly ordered flashcards for the 7X's table, without the answers shown, as were used during instruction. The assistant possessed the same list of the student's names as the teacher except that her list included the subject's group letter also. Subjects in Group A, the control group, were instructed to sit in the chair, say the equation they saw on the flashcard and the number that went in the blank. The assistant recorded all answers on the student's previously taken written test by marking a check for a correct response and an X for an incorrect response next to each equation.

Each subject in Group B, the music group, was instructed to sing the equation and answer to the assistant as the flashcard of the equation was shown to them. (The tune they were to sing was "Twinkle, Twinkle Little Star").

Subjects in Group C, the motor group, were instructed to look at the flashcard of the equation, then spin around while saying it, and do a jump-tuck when they provided the answer.

Again, all groups were instructed to remember as much as they could. When a subject had finished all ten multiplication equations, he or she was told to walk down the hall to the experimental room. The experimenter was seated in the room at a table with a tape recorder. Subjects sat in a chair across from the experimenter and were given
instructions for the oral test of the verbal material according to the group they were in. Group A subjects were told to speak into the microphone and say as many of the sentences they had learned as they could remember. All responses were recorded on tape. The music group were asked to sing as many of the sentences as they could remember, and those in the motor group was asked to spin while saying the sentences and when saying the one word in the sentence which had been underlined with orange, they were to do a jump-tuck.

If subjects paused a moment and it appeared they were thinking, the recorder was turned off and they were given a moment to think. They were allowed to start over if they wanted to only one time. When it was clear that the subject had said as much as he or she could remember, the child was told to go back to their classroom.

Time-Delayed Test

After a four day time delay, the experimenter and assistant came back to the school for both a time-delayed written and an oral re-test. All subjects were again given the written and the oral test exactly as before, except that the original experimental room was unavailable so the oral verbal test was given in a small storage room at the school.
Scoring Procedure

The numerical data were very easy to score for all tests. Subjects either had to say or write the answer to each equation correctly to get it right. All numbers written in backward order were counted as wrong. For example, if the answer 28 was written 82, it was counted as incorrect. All numerals that were in themselves written backwards were counted correct. For example, if the numeral 3 was turned around and written backwards, it was still counted as correct. Subjects were given scores that indicated the number of correct responses made out of ten possibilities (ex. 6 out of 10).

The verbal material was more difficult to score. The experimenter did all of the scoring using the following criteria: a response of a nonsense word was accepted if the word either seen or heard contained the correct 1) initial and final consonant, 2) initial consonant and vowel sound, or 3) the vowel sound and the final consonant. For example, the nonsense word "slark" was counted correct in the following ways: "svark" (correct vowel sound and final consonant), "slarp" (correct initial consonant and vowel sound), or "slerp" (correct initial and final consonant). All responses not meeting this criteria were crossed out and scores resulted from the compilation of all correct responses.
Responses were counted incorrect if their correct order was prior to something already said, but correct if they occurred further down in the paragraph and were only out of order because something was omitted. For example, in the sentences, "The wraggle and the slark went wimbling down the glimb, then the shnow flooped the frip," a subject would be correct when writing "The wraggle and the slark, then the shnow flooped the frip" because the order is wrong only because of an omission. However, in this response the order is wrong for reasons other than strictly omission: "The shnow and the slark glimb wraggle." The only words counted as correct here would be the phrase "and the slark".

The tapes were transcribed by the experimenter onto paper. The words were written onto the paper phonetically, according to the way the child pronounced the word and then scored according to the previously mentioned criteria.

All subjects received eight scores. The first four scores were the number of correct responses out of ten for the numerical data for immediate written and oral tests and time-delayed written and oral test. The last four scores were the number of correct verbal responses out of 38 possible for all assessment techniques used for the verbal material.

The independent variables in this study were the three
different treatments applied to the three groups of randomly
selected subjects. Group A was the control group, Group B
was the music group, and Group C was the motor activity
group. These groups each reflect the different mode of
presentation and rehearsal previously mentioned, of both the
numerical and verbal data.

The dependent variables were the scores of the data,
involving the learning content of both numerical and verbal;
testing procedures, oral and written; and time of testing,
immediate and time-delayed.

Twenty-four hypotheses were written in order to compare
each of the groups to every other group under all test
conditions individually. The recall mean score of each of
the groups, under each test condition, was compared to every
other group's mean score by a two-tailed t-Test with a
significance level of .05.
Results

The t-values for each of the twenty-four hypotheses can be seen in Table 1. These values indicate that there was a significant difference in scores for seven of the hypotheses. However in H2.0 comparing Group A to group B on the numerical, time-delayed, oral test, the difference was very small. Mathematically, the t-value fell into the area of rejection of this null hypothesis, with B outscoring A; however the difference of .007 is so slight that the null hypothesis for this condition, will be accepted.

The other six conditions where the null hypotheses were rejected because a significant difference was found between the mean scores are the following: Group A outscored Group C on the verbal, immediate oral test (t = 3.08118, P < .05); Group A also outscored Group C on the verbal, time-delayed, oral test, (t = 4.0392, P < .05); Group B outscored Group C on the verbal, immediate, oral test (t = 2.14219, P < .05); Group B scored higher than Group C on the verbal, time-delayed, oral condition (t = 3.0284, P < .05); Group A scored higher than Group C on the verbal, time-delayed written test (t = 2.1268, P < .05); and Group B scored higher than Group C on the verbal, time-delayed, written test (t = 2.395, P < .05).
Thus, the main differences occurred when the tests were oral and the content was verbal with both Groups A and B outscoring Group C in all conditions. Groups A and B scored higher than Group C, when the testing was written and time-delayed, and the content was verbal.

The t-values for the other eighteen hypotheses indicate that there was no significant difference between the mean scores and thus these null hypotheses are accepted.
<table>
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<tr>
<th>Hypotheses</th>
<th>Dependent Variable</th>
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N = Numerical  
V = Verbal  
C = Motor Group
B = Music Group
A = Control Group
Null Hyp.
Critical t values = -2.042 and 2.042

No = Accept Null Hyp.
Yes = Reject Null Hyp.
Discussion

Explanations

This study resulted in several significant findings. First, both the control and the music group scored higher than the motor activity group when the tests were oral and verbal, regardless of whether they were immediate or time-delayed. Secondly, the music and control group outscored the motor activity group when the tests were verbal and written, but only on the time-delayed tests.

Definite conclusions concerning the functions and specializations of the hemispheres under different task loads cannot be drawn. In general, however, there is no support for the theories of Bliss (1892), Border (1935), Kinsbourne and Cook (1971) and Levy (1933), that performance scores of a simple task will increase when coupled with a concurrent motor task.

There are several possible explanations for the scores of the music and control groups being higher than the motor activity group, when the tests were verbal and oral or verbal, time-delayed and written. First of all, the difference may lie in the nature of the groups. It is particularly interesting to note that in all cases of significance, the motor activity group scored lower than the
group it was compared to. Possibly, this is because Group C, compared to the other two groups, had more boys in it. Group A had eight girls and nine boys, Group B had thirteen girls and four boys, and Group C had five girls and twelve boys.

There is evidence that boys are more lateralized than girls (Segalowitz, 1983), and that males are more detrimentally affected than females on a motor task when engaged in an additional concurrent verbal task (Johnson and Kozma, 1977).

The handedness of the subjects may provide increased additional insight also (Hicks, 1975). The subject's handedness in this experiment was not taken into account.

Group C also appeared to the experimenter to be more "rowdy" than the other two groups. This could be due to the sex ratio of the groups or the activity the group was involved in. Group C was highly excited about doing the spin and jump-tuck in class and on several occasions the experimenter found it necessary to reprimand and discipline subjects in this group. There was no necessity for disciplinary procedures for the other two groups which gave them a slight increased amount of learning time.

The Hawthorne Effect, or novelty of the experimental conditions, may be another factor influencing the results of this experiment. All three groups were visibly stimulated and excited to be taken out of their classroom to the
experimental room. They were alert and curious about the experimenter and the required activities. This may have been very detrimental to this experiment because it may be that the addition of a concurrent, contralateral hemispheric task may only facilitate the performance of an activity when that activity is perceived and experienced as boring to the subject. Thus, once again, the element of boredom was really missing. Although the rote memorization of words and numbers may generally be perceived as boring (Finn, 1981) in the case of this experiment there was no daydreaming, doodling, sleeping, or any other signs of boredom evident in any group. The subjects thought the material to be learned was "neat" and they were very excited to do the activities. The excitability level seemed to increase with the novelty of the required activity. In other words, Group A learned the material by straight subject-experimenter oral activities. The subjects were excited to be in a new room with a new teacher learning new things, but the activity was not too different than their usual school experience. Group B, who learned the material through singing were a little more excited but not much. Singing is quite often a part of learning in an elementary classroom. However, Group C, as previously mentioned, was far more excited than the other two groups. Whether this was because of the predominance of
male subjects or because the motor activity required was the most novel of the three teaching conditions, is not yet known. Students usually don't spin and jump-tuck in class while learning material. This group almost had an attitude portrayed at recess rather than classtime. They seemed to have their attention focused more on the motor activity than on the material to be learned.

The motor activity condition was also more difficult than the other two conditions. It is possible that a more difficult tune than "Twinkle, Twinkle Little Star" may have altered the outcome of these results.

The control group (A) had the left hemisphere task of actively memorizing numerical and verbal data. The music group (B) had the left hemisphere task of actively memorizing numerical and verbal data with the addition of a right hemisphere task of singing a tune. The motor group (C) had the left hemisphere task of actively memorizing verbal and numerical material with an additional both left and right hemisphere load imposed by the motor activity, since both sides of the body were used. It is possible that this additional load caused an overload on the cognitive capacities, thus reducing performance. It will be remembered that Bradshaw and Mettleton (1983, p. 129) are previously cited as saying that small loads may prime a hemisphere, enhancing performance; while larger loads may overload it,
depressing performance.

The fact that Group B did not outperform Group A remains unexplained; especially when considering the theory that performance may increase when a simple task is made more difficult (Kinsbourne and Cook, 1971; Levy, 1983). Why didn't subjects retain more information when it was sung instead of spoken? Possibly, it is the age group of the subjects used in this experiment. A first grader may be much more aware and stimulated by "Twinkle, Twinkle Little Star" than a fourth grader for example. Possibly, the first grade child's attention would be focused more on the song than on the material to be learned, where a fourth grader would be bored with the tune of "Twinkle, Twinkle Little Star" and thus, his or her attention would be predominantly focused on the data to be learned. Perhaps the task of singing was not automatic enough to be secondary to a first grader, and thus it became the primary task. Perhaps dual tasks over load the cognitive capacities for a first grade child while it would facilitate cognition for a fourth grader.

Similarly, the motor activity may have needed to be simplified in order for it to be automatic for a first grader, where an older child could spin and jump-tuck without any effort. Perhaps these tasks were not boring, automated, or simple enough to facilitate the memorization of numerical
and verbal data.

Another point of interest is why was the performance of Group C lower than that of Group A and B only when the material was verbal. Perhaps the verbal content was more difficult than the numerical. The nonsense words were totally foreign to the subjects, where the Seven's Time Table consisted only of numbers the children were already familiar with. The sequence and words of the verbal material had to be learned, whereas only the sequence of the numbers had to be learned. This may have increased the difficulty enough to affect the motor group but not the other two groups.

Another explanation may be that the subjects were visualizing pictures to go with the nonsense paragraph; thus, utilizing the right hemisphere to aid in memory. This may not have been the case with the numerical data. Group A, whose total mean score was the highest, may have been able to do this the most efficiently since their complete attention was on the verbal data. Group B, scoring second highest, may have been utilizing the right hemisphere, but not as efficiently since the right hemisphere was involved in singing; and Group C, with the lowest mean score, was not able to utilize the right hemisphere for visualization, since its load was already at capacity and thus, they were at a disadvantage.

There also was a greater difference in most cases
between Groups A-B and C when the tests were oral rather than written. This difference may be accounted for by the fact that both Groups A and B could silently, if necessary, recall information in exactly the same way they had learned in on both oral and written tests; while Group C could only do the motor activity during the oral tests. They could not spin and jump-tuck during the written test. Possibly, this helped the motor group score better on the written tests than on the oral tests.

Finally, the only two cases where A and B outscored C for the verbal, written condition was when the tests were time-delayed. It is certainly possible that students in Groups A and B rehearsed the verbal material under the conditions that enhanced learning more than under condition C. It would be easier and much more probable that students would silently say or sing the nonsense paragraph to themselves than it would be likely for a subject to spin and jump-tuck while silently rehearsing the paragraph; when at home, alone, or on the playground. Perhaps both Groups A and B scored significantly higher than Group C on the time-delayed test situations, because of the amount of rehearsal done by each group privately.

In summary then, the control and music group may have scored significantly higher than the motor activity group.
when tests were both verbal and oral, or verbal, written, and time-delayed, because of several reasons. These reasons may be 1) the characteristics of the subjects in each group such as sex, age, and handedness 2) the difficulty, novelty, and stimulating effect of the additional concurrent task 3) the additional aid of the right hemisphere visualization abilities 4) and because of the amount of rehearsal done by each group.

Limitations

The main limitations of this study were the size of the groups and the distribution of males and females in each group. The smaller the sample size and the greater the variation within groups, the greater the expectation of larger random differences between groups. Thus, a larger N with a more evenly distributed sex ratio, may have altered the results of this study.

Suggestions for Further Research

The results of this research project have in many ways created more questions than have been answered, concerning task load and recall memory. Thus, replications of this study may prove to further benefit our understanding.

It would be very interesting, for example, to compare 1) boys to girls 2) dextrals to sinistrals 3) first graders to
fourth graders under the three grouping conditions of control, music, and motor activity. Another factor which may be interesting to explore is the difference between normal and learning disabled children. In most of the studies previously cited, where music facilitated recall, the subjects were learning disabled (Van den Honert, 1977; Bottari and Evans, 1982).

It would also be very interesting to repeat this study with a more simplified motor activity, which required the function of the right hemisphere only.

Right hemisphere cognitive strategies such as visualization, emotions, intuition, etc. may be more advantageous than music and motor activity. Music and motor activity were chosen in this study because it seemed easier to apply with first graders and with rote memory type material. Perhaps it is possible to incorporate these other right hemisphere activities with this type of material for future study and receive totally different results. Perhaps "Whole Brain Learning" is still the solution to boredom in education, but not the kind attempted in this study. Much research is yet needed.

Implications for Education

The results of this study basically say that first grade children cannot repeat as much verbal data orally or in some
cases written test conditions, when they have an additional motor activity to do, as can children who do not have an additional motor activity to do. This information may be very beneficial to educators in that it may reinforce the idea that it is necessary to first, keep material very simple and clear and second, that some material is learned best when students are sitting quietly with their total attention focused on the material to be learned.

The second point is particularly important in light of the articles criticizing the traditional methods of teaching, saying it is boring and stifles creativity (Finn, 1981) and the articles proposing whole brain learning (Samples, 1975). What is whole brain learning and how can it be applied in education? We still don't know.

There is still a problem in education. Students at the primary level, need to know certain basic facts, such as the times tables etc. in order to score well on many achievement test. Much of this information can only be learned through rote memorization. This process of rote memorization is often very difficult for teachers and students, since it is often necessary to engage in tedious, redundant activity in order to learn it. This study attempted to address this problem by coupling rote memorization with fun activities for
children, such as singing and motor activity. On one hand, this study has implied that when learning numerical data, that at least singing and motor activity is not significantly detrimental. Possibly then, educators may allow children to move around, clap, or sing when learning numerical data. On the other hand, these kinds of activities are detrimental when learning verbal material. Thus, teachers should feel free to make students sit quietly, in a noise-free environment, with their attention focused on the material to learned, without feeling guilty that they are hurting the children by boring them. Maybe what this study says to educators is that for some material, requiring the maximum attention of the left hemisphere, that traditional methods of teaching, and a traditional teaching environment is the best. Maybe, instead of feeling guilty if our classes aren't always fun and exciting, teachers need to have the attitude that we have certain material we need to teach students and we must do our job to the best of our ability in the most efficient way, regardless of whether everyone is having "fun", or whether we are addressing both hemispheres. Perhaps, as usual, the answer lies in the middle. School needs to consist of both hard work and fun, activity and quiet, physical exercise and mental exercise and sometimes, in some cases, a combination of both.
Additional research will further clarify these issues but for now the major implication for education of this study is that for first grade children, keep lessons very simple, clear, and as free from any distractions (from additional tasks) as possible, when learning material that is verbal in nature.
Appendix A

Nonsense Paragraph

The wraggle and the slark went winbling down the glimb, then the shnow flooped the frip. The grapplint frengt mamo ibee tay, while glantering on imbutle. Roop and trat, frid and blut, and the clirp, swaled in drod.
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