AN ABSTRACT OF THE THESIS OF

TERESA L. FENWICK (name of student) for the MASTER OF SCIENCE (degree)

in PSYCHOLOGY (major) presented on APRIL 14, 1992 (date)

Title: Effects of Modality of Administration on Performance of the WAIS-R Digit Span Subtest.

Abstract approved: Cooper E. Holmes

The current study examined the relationship between modality effects in administration of the Digit Span subtest of the Wechsler Adult Intelligence Scale-Revised. Auditory and visual modalities were studied. Seventy-four lower division psychology students were individually administered the Digit Span. The students were randomly separated into two groups for administration of the Digit Span. Students in Group 1 were administered the Digit Span as directed in the Wechsler manual. Students assigned to Group 2 were administered the Digit Span as directed in the manual, except they were not facing the examiner during administration. For Group 2, the examiner sat behind the student. Each of the groups was divided by gender.

The total score for each individual was calculated by combining Digits Forward and Digits Backward. It was hypothesized that the students in Group 1 would utilize facial cues (visual modality) from the examiner for enhancing recall. The students in Group 2 would not have the visual cues from the examiner available to them, thus only the auditory

modality would be implemented. Using the mean scores obtained in each group, the variables of gender and administration modality were analyzed for effect on response scores using a 2 x 2 ANOVA. This analysis of the data found that the availability versus the non-availability of facial cues in Digit Span administration produced no significant effects upon response score within or between genders.

Effects of Modality of Administration on Performance of the WAIS-R Digit Span Subtest

---

A Thesis

Presented to

the Division of Psychology and Special Education

Emporia State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Teresa L. Fenwick

May 1992

Stephen F. Austin

Approved for the Major Division

Faye N. Powell

Approved for the Graduate Council

ACKNOWLEDGMENTS

Throughout the years there have been numerous people who have contributed to the construction of who I am today. I would like to thank the special individuals that have served as my educators, my friends, and my heroes. Without their influences I could not have reached this level of achievement. I would like to thank the more recent of my advocates who have advised, directed, and steered me through this project: the faculty, the staff, and my peers at Emporia State University. Specifically, I want to extend my gratitude to the thesis committee who offered great help to me in the writing of this thesis. And forever, I would like to express my deepest gratitude and acknowledge my indebtedness to my parents, brother, sister and other family members who have been there all along to support me through prayers and presence, even when I might have given up on myself.

CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Information-processing theory began to borrow from developments in electronic processing in the late 1950s. One model of information-processing, the modal model, soon came to the forefront. Three separate kinds of memory storage were contained in this model. Sensory memory allows us to hold information that is no longer available in the immediate environment. This information is not yet analyzed and is similar to the sensory input itself. Short-term memory holds information while it is actively being processed. Storage of vast quantities of information remembered but not currently needed occurs in long-term memory.

Research on the modes used in information-processing seemed to peak in the late 1960s and early 1970s. Much of this research referred back to a classic series of experiments on sensory memory conducted by Sperling (1960, 1963). Sperling found that visual images of a stimulus persist for a short time after the stimulus is removed and that this image can be utilized in recall. Likewise, he found auditory information storage (Sperling, 1963). A concept of separate auditory and visual memory stores evolved in which a store is a holding arena for information until further processing occurs. Many researchers followed this line of thought and a body of evidence supporting the

existence of the two stores has been built (Frick, 1984; Massaro, Thompson, Barron & Laren, 1986; Penny, 1975; Rollins & Hendricks, 1980).

Having established the utilization of both an auditory and a visual store, the next logical step for research was to determine the effects of each on short-term memory. Frick (1984) found that some improvement was noted in digit span tasks where dual storage had been used.

Literature Review

Closer consideration of Sperling's (1960, 1963) research will allow a more thorough understanding of the concept of modality effects. A number of experiments were conducted by Sperling (1960) to study quantitatively the information available to an individual following a brief visual exposure. The subjects were required to report the letters to which they had been exposed. Two types of reporting strategies were followed. In the partial report only a specified part of the stimulus was reported. All of the stimulus set was reported in the whole reports. A high accuracy of partial report was found. This finding was not dependent upon the order of report or on the position of letters, but was shown to be dependent upon the ability of the observer to read a "visual image that persists for a fraction of a second after the stimulus had been turned off" (Sperling, 1960, p. 27).

A model for visual recall tasks was presented by

Sperling (1963) which included visual information storage (VIS), auditory information storage (AIS), scanning, and rehearsal. The model was derived from what was called the "transient" response to information. In such a response, a single burst of information is given to an individual, along with time to process it. An alternative to a transient situation would be one in which continuous or "steady-state" input is occurring. While the restrictions of the model were noted, Sperling did formulate several hypotheses for use in improving responses to incoming information. First, the limitations in human responses are independent of sense modality. Also, high information requirements regarding storage exist. Rapid reading can and does occur. There is non-susceptibility to auditory interference. Finally, auditory simplification is achieved. Sperling (1963) suggested the model be applied in organization of data and experiments rather than in precise prediction, due to its complex and partially specified components.

The procedure of partial report outlined by Sperling (1960) was followed by Darwin, Turvey, and Crowder (1972). Darwin et al, however, refined the procedure further by using an auditory analogue. Three experiments were conducted through which evidence for some transient memory for auditorily presented material was gathered. From this came the conclusion that retrieval is achieved most efficiently according to the dimension of spatial location

rather than to an item's semantic category.

Penney (1975) presented a review of literature to draw attention to modality effects in short-term memory and to encourage investigations into memory to explore modality differences. Penny reported that recall for recent items was consistently superior in auditory presentation over visual presentation. Evidence was also given which supported the possibility of auditory and visual information being stored differently in short-term memory. It was further suggested that characteristics of memory trace and the variables affecting retention differ for auditory and visual input. While argument for distinct stores was found, it was also found that there appeared to be some interdependence among the stores.

Purdy and Olmstead (1984) attempted to distinguish between two alternatives for storage time in sensory memory. By means of the results, support was lent to the hypothesis maintaining that sensory storage has a large capacity. Also supported was the contention that there is independent and concurrent processing in sensory storage.

A "common resource hypothesis (CRH)" was analyzed and challenged by Klapp, Marshburn, and Lester (1983). The CRH referred to unitary immediate memory of seven-chunk capacity and equated such short-term memory span with the "working" component of primary memory. Several experiments were conducted concerning the CRH. Results of the first five

experiments indicated the existence of a form of immediate memory--used in a missing-digit task--having properties distinct from those used in ordered recall. The other three experiments produced results contradicting the notion of a common reservoir of capacity for all immediate memory, including span memory. More readily, the results led Klapp et al. (1983) to a notion of separate pools for immediate memory capacity.

Rollins and Hendricks (1980) studied simultaneous processing between visual and auditory modalities. It was found that the "analyzer mechanism" is the critical factor in a selective-attention effect rather than the modality of input. Additionally, it was determined that these modalities are able to process verbal material independently and without interference with each other.

The concept of dual storage, storage in both an auditory and a visual short-term store, was further investigated by Frick (1984). The results indicated improvement of immediate recall can occur with dual storage, but the store used to remember the visual portion did not persist beyond immediate recall. The results did not demonstrate that the capacities of these two stores are additive, but they were consistent with such a hypothesis. Frick extended this consistency to the hypothesis of independent auditory and visual short-term stores.

Research by Massaro, Thompson, Barron, and Laren (1986)

focused on the integration and evaluation of information in bimodal speech perception, particularly the developmental trend for the contribution of visual and auditory information. A set of three experiments was conducted to investigate what constitutes the difference between young children's and adults' use of the visual component of speech. The researchers found a positive correlation between lip-reading ability and the extent of visual influence during bimodal speech across the ages. It was concluded that the lesser influence by the visual component upon children existed as a by-product of poorer lip-reading ability. The data from all subjects was thought to indicate an integration of the two sources of information in a way that the least ambiguous source more largely impacted the perceiver's interpretation of a speech event.

In comparing auditory and visual presentation in single-trial free recall, Murdock and Walker (1969) conducted three experiments. Experiment I used two presentation rates: presentation was either auditory or visual, and 20-word lists were used. The results showed that the effects of modality are localized in primary memory and may last 3-4 seconds. Experiment II involved the use of mixed auditory and visual lists. The mixed-mode lists were found to increase recall with presentation rate not showing an effect. The findings suggested that switching from mode to mode was not a factor in accounting for the effects. The

third experiment was conducted to test this hypothesis. The data further supported the results from Experiment II.

Murdock and Carey (1972) studied the effects of retroactive interference (RI) and proactive interference (PI) with shifts from one presentation mode to the other. It was hypothesized that the effects would be more accentuated for auditory blocks than for visual blocks. For auditory memory, prior and subsequent items interfere more if they are in the same mode. Visual memory was found to be poorer than auditory memory but less sensitive to the modality of interfering items.

Cohen, Quinton, and Winder (1985) designed a study to test the involvement of rehearsal proficiency and item identification in developmental auditory serial short-term memory (SSTM). The first experiment tested the role of rehearsal in developmental memory for supraspan serial lists. Children from grades 1, 2, 3, 4, 5, and 6 were subjects. Experiment 2 involved three additional tasks: running memory, item identification, and digit span. The grade 1, 3, and 5 subjects were used in this experiment also. No evidence was found in support of either a rehearsal explanation or the item identification hypothesis from Experiment 1. A causal relationship was not established from either experiment. The results did lead to the conclusion that speech-sound processing may, in general, be a critical component in serial short-term memory

performance. The digit span test was found to be relatively insensitive to age differences among those ages tested.

Curley and Reilly (1983) attempted to determine whether or not teaching methods that utilize selected perceptual modalities would have significant effects on learning. Three teaching conditions were implemented: an auditory-vocal-motor, a visual-vocal-motor, and a combination channel (incorporating visual, auditory, kinesthetic, and tactile elements). The researchers unexpectedly found no significant differences in the auditory-modality group's performance under each approach. The findings overall were consistent with the contention that efficiency and speed of learning will increase with the use of a teaching method geared to an individual learner's dominant perceptual modality. It was suggested that the failure to find significant differences for the auditory modality group reflects the increased difficulty for all subjects in learning material under that approach.

Jacoby (1983) focused his study on the relationship of perception and recognition memory and the effects of enhancement on both of these. The variable relationship which was described between perceptual enhancement and recognition had a basis, according to Jacoby, similar to that of the relation between recall and recognition tests of memory. The results demonstrated some parallels between perceptual enhancement and recognition memory. There was

also found to be consistency with the claim that both perceptual enhancement and recognition memory rely on retrieval of memory for prior episodes. Jacoby concluded that both memory and perception are determined by a joint product of cues provided by the test and those coming from memory for prior episodes. Specific effects of environmental context were not obtained in this study.

Three psychological tests were used by Wilson, Thompson, and Wiley (1982) in assessing a system of PIMs--devices through which Patients Instruct Machines. The Mill Hill Vocabulary Scale (synonyms section), the AH4:Group Test of General Intelligence (part 1), and the Digit Span Test were used. The correlations were all positive and significant between automated and standard forms of the tests. There were, however, significant differences between the score sizes on the Digit Span Test. It was suggested that the practice effects for this test may be more pronounced when applied to the automated form.

Two experiments were conducted by Beaumont (1985) in which a digit span task was presented by microcomputer with various response devices. The purpose was to compare the effects of various response media upon test performance. An additional purpose was to compare the results using visual or auditory presentation. In the first experiment a standard keyboard, a keypad, and a light-pen were the response devices. The second experiment included a touch-

sensitive screen. The results indicated that the response medium does have an effect upon performance, with the standard keyboard being superior. The automated form was found to produce significantly poorer digit spans than conventional administration. Thus, there did seem to be more of an effect using the auditory presentation over the visual presentation.

Nesselroade, Pedersen, McClearn, Plomin, and Bergeman (1988) examined the validity of testing cognition of older adults by telephone. Another goal was to examine the responses for gender and age differences. Both factorial validity and criterion-related validity were addressed. For conducting the examination of criterion validity it was noted that the telephone and in-person test differed some in content and that a richer variety of tests were contained in the in-person battery than in the telephone-administered one. The conclusion was that there is "considerable promise" for "telephone assessment of cognitive abilities" (Nesselroade et al., 1988, p. 231). Gender and age differences were not found to be of concern in the scope of this study. The factorial validity assessment indicated telephone administration did mark crystallized and fluid intelligence and short-term memory dimensions. The criterion-related validity coefficients did not prove conclusive.

Literature Review of Digit Span Studies

The Digit Span consists of numbers arranged in different sequences. Each sequence is verbally presented to the subject, who is required to repeat the sequences back to the examiner. There are two divisions within the Digit Span: Digits Forward and Digits Backward. Digits Forward requires recall of the sequence as it was presented. Digits Backward requires recall of the sequence in reverse order of presentation.

Matarazzo's (1972) review of the Digit Span described it as being a test of retention. He went on to explain that the functional qualities of the Digit Span as an element of an intelligence test are: ease of administration, ease of scoring, and specificity as to the type of ability it measures. Low scores on the Digit Span are most likely due to anxiety or inattention, according to Matarazzo. It is especially noted on Digits Backward that difficulty with performance often correlates with lack of ability to perform other tasks requiring concentration. The basic utility of the Digit Span has been delineated by Matarazzo as follows. First, adults who cannot retain five digits forward and three backward will be identified as mentally deficient or mentally disturbed, for the most part. Secondly, extreme difficulty often indicates diagnostically significant memory defects (organic and other).

The Digit Span subtest of the Wechsler Adult

Intelligence Scale (WAIS) was analyzed by Griffin and Heffernan (1983) to determine the relationship of Digits Forward and Digits Backward to intellectual functioning in a pool of normal (psychiatrically and neurologically) subjects. Intellectual functioning of the subjects was restricted in that none of the Full Scale WAIS IQs were higher than 99. The results of this study indicated a more relevant relation to intellectual functioning for the performance of Digits Backward than the performance of Digits Forward. It was suggested that these two divisions of Digit Span be considered in light of their differing capacities.

Dunn, Gaudia, Lowenherz, and Barnes (1990) studied effects on performance of giving the Digits Forward and the Digits Backward in the reverse of usual administration order. The use of recall strategies was also explored. The hypothesis was that if Digits Backward preceded Digits Forward in administration, the processes and strategies used for Digits Backward would lead to their use in Digits Forward. This would result in improved Digits Forward performance. An additional purpose was to determine whether the same aspects of intelligence were being measured by Digits Forward and Digits Backward. A significant decline, rather than increase, was found for Digits Forward when it followed Digits Backward. Increased performance could be predicted with the use of a grouping strategy. The results

of the study led the researchers to suggest that Digits Forward is a possible measure of fluid intelligence and Digits Backward is a possible measure of crystallized intelligence.

A summary of research findings concerning both the nature and the importance of performance on the Digit Span was presented by Mishra, Ferguson, and King (1985). It was concluded, after reviewing the literature, that the Digit Span is a measure of more than short-term auditory memory. The factor structure has been found to included attention and possibly sequencing ability. Two information-processing variables were found: speed of item identification and the use of mnemonic strategies (i.e., rehearsal and grouping or chunking). Findings in some areas of research point to the Digit Span as offering two distinctly different tasks. Viewed in the context of a unitary task, performance can contribute to the evaluation of anxiety and distractibility, symbolic and numerical reasoning ability, along with auditory memory and sequential processing. In the dual capacity of Digit Span--Digits Forward and Digits Backward--it has been noted that Digits Backward may use different or additional information processing abilities when compared to Digits Forward. Impairment of Digit Span performance has been found to occur with specific brain injuries, mental retardation, and learning disabilities.

Some literature in the area of short-term memory has

focused on the dual storage concept. In the studies examined, the prevalent focus has been on auditory and visual storage. Experiments conducted on this dual storage have found that two separate stores do exist and each can process independently of the other. Groupings of letters and digit spans have been the primary instruments in these studies.

Statement of the Problem

Research on auditory and visual short-term memory has used digit span measures previously. However, the visual component in the present study differed from those previously. The visual component for the current study was the facial cues available from the examiner mouthing the digits as they were read to the subject. In past experiments the visual component has been a written text of the stimuli to be recalled.

Statement of Significance

The results of this study may have implications for the administration of the WAIS-R Digit Span subtest. It may also impact the focus of research concerning administration of similar tests according to the usage of visual and auditory stores. The notable value of this study may be heuristic in that it could generate more research in the area of auditory and visual stores in general, and even extend the research in the area of facial cues as recall devices.

CHAPTER II

METHOD

Sample

Students were drawn from Introduction to Psychology courses and sophomore-level psychology courses at Emporia State University. The students were not drawn randomly as participation occurred on a voluntary basis. Only men and women ages 18 or 19 were used in the study, with a total of 74 students. Forty-three women and 31 men participated. Intellectual ability of the students as a whole was assumed to be at least average. Due to the nature of the study, volunteers who had obvious severe visual or hearing impairment were excluded from the study.

Instrument

The series of Wechsler intelligence scales now in use are derived from the original Wechsler-Bellevue Intelligence Scale, developed by David Wechsler and published in 1939. Every scale is comprised of several subtests which are combined to generate a full scale intelligence quotient. The subtests have been designed to measure particular aspects of what has been deemed global intelligence.

This study used the subtest referred to as Digit Span within the Wechsler Adult Intelligence Scale-Revised (WAIS-R). Digit Span has been defined as being a measure of span of attention and immediate auditory recall. This task requires the subject to repeat from memory numbers, both

forward and backward, given orally by the test administrator. The response scores from both Digits Forward and Digits Backward are combined to yield a single score.

The WAIS-R manual states the average composite group reliabilities taken from the standardization sample for the Verbal, Performance, and Full Scale IQs of the WAIS-R as being .97, .93, and .97, respectively. The average test-retest reliability of the Digit Span was found to be .83. The manual also discusses validity issues. The validity of the WAIS-R stems back to the validity established for the original Wechsler-Bellevue. Test selection for the Wechsler-Bellevue was based upon correlations with other established tests of intelligence and with empirical judgments of intelligence, on ratings by experienced clinicians, and on empirical studies of several groups of known intellectual level. The eleven subtests placed in the Wechsler-Bellevue have been retained in both the Wechsler Adult Intelligence Scale and the WAIS-R, with some revision of items (Wechsler, 1981).

Procedure

A sign up sheet was passed around Introduction to Psychology and Developmental Psychology classrooms after the instructors gave an explanation of the study to the students. The sign-up sheet had time slots available in which the student signed his/her name, gender, and a phone number at which he/she could be reached. The phone number

was used to call the students and confirm their time slots. Following sign-up the instructors gave the volunteers instructions on the location of the testing. Extra credit for the participation went towards the total point earnings for the Introduction to Psychology and Developmental Psychology courses.

After signing a consent form students were administered the Digit Span on an individual basis. The testing took place in a testing room which had a solid door and no windows. Four women graduate students skilled in administration of the WAIS-R served as examiners and conducted the tests. These were persons other than the researcher.

Individuals in the group receiving traditional administration of the Digit Span had the examiner seated across the table from them. The examiner administered the Digit Span and recorded responses according to the directions in the manual. The age of the student was ascertained by the examiner following testing. Students whose ages were outside the range of 18 or 19 were not included in the study.

Individuals in the group receiving the altered administration of the Digit Span did not have the examiner available for visual cues. Testing was conducted with the examiner in position behind the student. The student had no opportunity to view the examiner while the Digit Span was

being administered. In all other aspects the administration was according to the manual. The age of the student was determined by the examiner following testing, and the students whose ages were outside the range of 18 or 19 were not included in the study.

CHAPTER III

RESULTS

The scoring procedures outlined in the WAIS-R manual were followed and the data from each individual were collected using the total Digit Span score, that is, the combined score of Digits Forward and Digits Backward. Using totals of the individual student scores, the mean and the standard deviation for each group were calculated. The groups were divided as follows: Auditory-Visual--Men, Auditory-Visual--Women, Auditory--Men, and Auditory--Women. Group 1 represents the group of students receiving the traditional administration of the Digit Span, where auditory and visual cues were available. Group 2 represents the group of students receiving the administration of the Digit Span where only auditory cues were available. The resulting group means and standard deviations are shown in Table 1, which is presented on the following page.

Table 1

Mean Response Scores and Standard Deviation as A Function of Presentation Modality and Gender

	Gender	
Group	Women	Men
Auditory-Visual	M=15.04	M=16.00
	SD=3.81	SD=3.74
Auditory Only	M=14.90	M=13.80
	SD=4.35	SD=2.88

As is shown in Table 1, the men in Group 2 produced the smallest mean score (M = 13.80; N = 15), while the men in Group 1 produced the highest mean score (M = 16.00; N = 16). The mean scores achieved by women in each group were similar to one another, with Group 1 having M = 15.04 (N = 22) and Group 2 having M = 14.90 (N = 21).

These results were analyzed using a 2 x 2 ANOVA. The level of significance was set at $p < .05$. The dependent variable was the total score on the Digit Span. The independent variables were the presence versus the absence of the examiner in the visual field of the student and gender. Table 2 contains the results of the analysis of variance.

Table 2

ANOVA Summary of Modality and Gender Effects

Source of Variation	SS	df	MS	F	p
Gender	.10	1	.10	.01	.933
Group	24.65	1	24.65	1.71	.195
Gender by Group	19.08	1	19.08	1.32	.254
Within Cells	1009.16	70	14.42		
Total	1052.99	73	58.25		

The information in Table 2 shows that no statistically significant differences were found for either modality of administration with Groups 1 and 2 (F = 1.71) or gender (F = .01), or the interaction between them (F = 1.32) at $p < .05$.

CHAPTER IV

DISCUSSION

Research in the area of modality effects has irrefutably demonstrated that separate auditory and visual stores do exist (Frick, 1984; Penney, 1975; Rollins & Hendricks, 1980; Sperling, 1960,1963). Since the initial work in this area by Sperling (1960, 1963), other research has tried to establish the nature of the relationship between these two stores; the Digit Span has been a widely-used instrument in such studies. In much of this research, the visual input referred to a series of letters or numbers presented to the subjects in the form of visual text, as opposed to or accompanying auditory input. Using this type of visual information, effects of the visual stimulus have been produced (Klapp, Marshburn, & Lester, 1983; Murdock & Walker, 1969).

The present study was concerned with the relationship and interaction of the auditory and visual modalities for sensory storage. Unlike earlier studies, the present study examined the effects of visual cues available from the examiner's face. The effects were not found to be significant. Perhaps the absence of effect is in part due to the methodology of the present study. The students in Group 1, where auditory and visual cues were both available, were not specifically instructed to observe the examiner's face while being administered the Digit Span.

Neither were there other procedures implemented which would ensure the use of the facial cues. Thus, the use of facial cues was at the discretion of the individual participants in Group 1. Each student may or may not have chosen to acknowledge and use the available visual cues.

As another possibility, it may be that visual cues did indeed play a role in sensory storage by students in Group 1. In this case, the visual cues would have been noticed and used in storage of the digits. The absence of effect would then be attributable to something other than the non-use of the visual cues. Some of the research in the area of modality and storage is consistent with a hypothesis allowing for the existence of a primary modality for storage in various situations. It is subsequently this modality's information that will be used over that of other sensory modalities (Massaro, Thompson, Barron, & Laren, 1986; Penney, 1975). In applying this hypothesis to the present study, auditory input could have been of primary influence in recall for digits. Therefore, it is possible that facial cues (visual modality) were used by the subjects, but that these cues were of minimal impact upon the sensory storage where auditory cues were also utilized.

Finally, the results of the present study with their lack of statistical significance may depict the true interpretation of modality interactions when applied in this way. There may, in fact, be no real utilization of the

visual cues to the extent that they would impact upon the overall response scores.

Further study in this area could once again focus on the auditory and visual modality influences in recall by presenting written text to the subjects. As stated before, the visual input in such research has been found to play a contributing role in recall, and assuredly there is still much that can be pursued in research with this.

Other future research may want to explore more in depth the existence of primary and secondary modalities. Knowledge of which modality to employ for maximum recall would be beneficial in areas ranging from education to modern business.

Research conducted to extend the current study might concentrate largely upon general usage of facial cues and the prevalence of this usage. Differences in the utilization of facial cues may exist in assorted cultures, ages, handicaps (i.e. speech or hearing impediments) and on, which were not tapped in this study. If such differences exist, the impact upon Digit Span administration may be more readily apparent.

REFERENCES

Beaumont, J. G. (1985). The effect of microcomputer presentation and response medium on digit span performance. International Journal of Man-Machine Studies, 22, 11-18.

Cohen, R. L., Quinton, C., & Winder, S. (1985). Critical processes in serial short-term memory: A developmental study. Intelligence, 9, 171-188.

Curley, J. F., & Reilly, L. J. (1983). Sensory process instruction with learning disabled children. Perceptual and Motor Skills, 57, 1219-1226.

Darwin, C. J., Turvey, M. T., & Crowder, R. G. (1972). An auditory analogue of the Sperling partial report procedure: Evidence for brief auditory storage. Cognitive Psychology, 3, 255-267.

Dunn, G., Gaudia, L., Lowenherz, J., & Barnes, M. (1990). Effects of reversing Digits Forward and Digits Backward and strategy use on Digit Span performance. Journal of Psychoeducational Assessment, 8, 22-33.

Frick, R. W. (1984). Using both an auditory and a visual short-term store to increase digit span. Memory and Cognition, 12, 507-514.

Griffin, P. T., & Heffernan, A. (1983). Digit Span Forward and Backward: Separate and unequal components of the WAIS Digit Span. Perceptual and Motor Skills, 56, 335-338.

Jacoby, L. L. (1983). Perceptual enhancement: Persistent effects of an experience. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 21-38.

Klapp, S. T., Marshburn, E. A., & Lester, P. T. (1983). Short-term memory does not involve the "working memory" of information processing: The demise of a common assumption. Journal of Experimental Psychology: General, 112, 240-264.

Massaro, D. W., Thompson, L. A., Barron, B., & Laren, E. (1986). Developmental changes in visual and auditory contributions to speech perception. Journal of Experimental Child Psychology, 41, 93-113.

Matarazzo, J. D. (1972). Wechsler's measurement and appraisal of adult intelligence. New York, NY: Oxford University Press.

Mishra, S. P., Ferguson, B. A., & King, P. V. (1985). Research with the Wechsler Digit Span subtest: Implications for assessment. School Psychology Review, 14, 37-47.

Murdock, B. B., Jr., & Walker, K. D. (1969). Modality effects in free recall. Journal of Verbal Learning and Verbal Behavior, 8, 665-676.

Murdock, B. B., & Carey, S. T. (1972). Release from interference in single-trial free recall. Journal of Verbal Learning and Verbal Behavior, 11, 398-402.

Nesselroade, J. R., Pedersen, N. L., McClearn, G. E., Plomin, R., & Bergeman, C. S. (1988). Factorial and criterion validities of telephone-assessed cognitive ability measures. Research on Aging, 10, 220-234.

Penney, C. G. (1975). Modality effects in short-term verbal memory. Psychological Bulletin, 82, 68-84.

Purdy, J. F., & Olmstead, K. M. (1984). New estimate for storage time in sensory memory. Perceptual and Motor Skills, 59, 683-686.

Rollins, H. A., Jr., & Hendricks, R. (1980). Processing of words presented simultaneously to eye and ear. Journal of Experimental Psychology, 6, 99-109.

Sperling, G. (1960). The information available in brief visual presentations. Psychological Monographs, 74, Whole 11.

Sperling, G. (1963). A model for visual memory tasks. Human Factors, 5, 19-31.

Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised manual. San Antonio, TX: The Psychological Corporation.

Wilson, S. L., Thompson, J. A., & Wiley, G. (1982). Automated Psychological Testing for the severely physically handicapped. International Journal of Man-Machine Studies, 17, 291-296.

Appendix A

Informed Consent Form

APPENDIX A

Consent Form

Please read carefully the following paragraph and sign below to indicate your agreement.

The purpose of the present study is to assess differences in responses made on the Digit Span subtest of the Wechsler Adult Intelligence Scale-Revised. Participation involves taking the Digit Span portion of the intelligence scale. This will require approximately 10 minutes. The only identifying information to be taken for this study will be your age and your gender. Your results will be confidential. If for any reason during the session you feel uncomfortable, you have the option to discontinue participation.

I (print name) _____ have read and understand the preceding information and agree to participate in this study.

_____

Signature of Participant/Date

TO: All Graduate Students Who Submit a Thesis or Research Problem/Project as Partial Fulfillment of the Requirements for an Advanced Degree

FROM: Emporia State University Graduate School

I, Teresa L. Fenwick, hereby submit this thesis/report to Emporia State University as partial fulfillment of the requirements for an advanced degree. I agree that the Library of the University may make it available for use in accordance with its regulations governing materials of this type. I further agree that quoting, photocopying, or other reproduction of this document is allowed for private study, scholarship (including teaching) and research purposes of a nonprofit nature. No copying which involves potential financial gain will be allowed without written permission of the author.

Teresa L. Fenwick
Signature of Author

April 24, 1992
Date

Effects of Modality of Administration on Performance of the WAIS-R Digit Span
Title of Thesis/Research Project

Jackie Tolbert
Signature of Graduate Office Staff Member

April 24, 1992
Date Received

Distribution: Director, William Allen White Library
Graduate School Office
Author