MASSED VERSUS DISTRIBUTED PRACTICE IN LEARNING AND RETENTION OF SERIAL AND PAIRED-ASSOCIATE LISTS
A META-ANALYSIS

ROBERT E. ISBELL JR.

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ABSTRACT

This meta-analysis was conducted to provide a quantitative viewpoint to the existing research on the effect of distributed practice in list learning and retention. Existing research contained conflicting results concerning the influence of distributed practice. This quantitative analysis attempted to resolve these conflicts by determining the overall results of the studies. It also questioned the general finding of the majority of the studies (i.e., no significant differences between massed practice and distributed practice in learning). This meta-analysis establishes that, in relation to massed practice, distributed practice generally produces superior learning and retention of word lists.

A computer search of the Expanded Academic Index, Educational Resources Information Center, and Psychological Abstracts provided the initial list of studies. Further studies were located in the bibliographies of papers found in the original search. Twenty studies with appropriate data for meta-analysis were located. These studies yielded 82 effect sizes.

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CHAPTER I

INTRODUCTION

Practice is required to perfect a skill. Benton J. Underwood, at Northwestern University, conducted studies for more than a decade on the effect of distributed practice on verbal learning. In his research with serial and paired-associate lists Underwood manipulated distributed practice by varying the amount of time between learning trials. A 2 - 8 second intertrial interval was utilized for the massed practice conditions, whereas a 30 second - 4 minute interval was utilized for the distributed practice conditions.

Few studies have been conducted on distributed practice in list learning since the early 1970's. Recent studies have focused on the spacing effect. The spacing effect and the distributed practice effect are related concepts; however, they are not interchangeable (Shuell, 1981). The bulk of the research on the distributed practice effect in list learning found the massed and distributed practice groups to be comparable (e.g., Houston, 1966; Houston & Reynolds, 1965) whereas differences in recall after a retention interval (e.g., 24 hours) have typically favored the distributed practice group. Opposite effects occur with the spacing effect, in that items which are presented in a distributed manner (i.e., separated by other items) are typically recalled better than those presented in a massed manner upon completion of learning, with no significant differences after a 24 hour retention interval (Shuell, 1981). The following review was limited to the distributed practice effect.

Review of the Literature

Although the majority of research has indicated that massed practice and distributed practice groups are comparable upon completion of list learning, studies by Underwood, Keppel, & Schulz (1962) and Underwood and Schulz (1961a) found the massed practice groups usually performed somewhat better. However, other research (Elmes, Greener, & Wilkinson, 1972; Hovland, 1938b) found significant differences with distributed practice resulting in superior learning.

Underwood (1952a, 1952b, 1953a, 1953b) found better retention of serial lists following massed practice; however, Hovland (1940a) found opposite results. Underwood (1951a, 1952b, 1953a,1953c) found that distributed practice produced better retention of paired associate lists. However, in a later study, Underwood and Richardson (1957) described the facilitation of distributed practice as rare, occurring only as a result of very low meaningfulness of paired-associates, or by an extremely rapid presentation rate (Underwood, 1957a, 1961; Hovland 1938b, 1949). Underwood (1961) contends that the magnitude of the distributed practice effect was extremely small when it did occur.

Underwood (1953c) and Hovland (1939) found no effect of distributed practice when using lists of paired-associate adjectives. However, Hovland (1949) found significant differences between massed and distributed practice regarding number of trials to reach a criterion in paired-associate learning with distributed practice requiring fewer trials to reach criterion.

Hovland (1938b, 1939, 1940a, 1940b) found significant differences in the number of trials required to learn a serial list of nonsense syllables to criterion which favored distributed practice. Hovland (1940a) also found significant differences in retention at ten minute and 24 hour intervals which favored distributed practice.

Bloom and Shuell (1981) found evidence for the distributed practice effect in classroom instruction. They found that high school French students, under conditions of massed practice, performed similarly to those under conditions of distributed practice immediately after studying a list of vocabulary words. However, after a retention interval of four days, the distributed practice group outperformed the massed practice group on a second test.

Waugh (1980) and Bloom and Shuell (1981) distinguished between the concepts of learning and memory. They found that learning and memory involve different processes and that differences in the performances of massed and distributed practice groups stemmed from an effect on memory rather than on learning. Bloom and Shuell (1981) defined learning as "the acquisition of a task to a certain level of proficiency" and memory as the retention or "forgetting of the task once that level of proficiency has been reached" (p. 247).

Underwood, Kepple, and Shulz (1962) argued that the facilitation of distributed practice on retention does occur during the learning process in that distributed practice tends to be more effective in extinguishing interfering associations than is massed practice. According to Underwood and Shulz (1961a) these interfering associations, in the case of acquisition of paired associate lists, occurred in the response-integration phase of learning.

The majority of Underwood's research on the distributed practice effect found that more overt errors occurred early in learning in distributed practice learning than in massed practice learning (Underwood, 1961). However, Hovland (1938a, 1938b) found that significant differences between massed and distributed practice learning occurred in the middle trials with no significant differences at the anterior and posterior ends. Hovland (1940b) also found that greater list length added to the difficulty of learning the central portion.

A general lack of consensus exists in the literature regarding the effect of distributed practice on learning which provided an ideal situation to utilize meta-analytic techniques. This lack of consensus provided the basis for the present study.

Purpose of the Study

Rosenthal (1991) describes a problem of poor accumulation (i.e., a lack of orderly progression) in the social sciences. The problem, according to Rosenthal, stems from small effect sizes and failure to deal properly with the answers we already have.

It has been widely accepted that although massed practice and distributed practice produce differences in retention, they produce similar effects on learning. In the current study it was hypothesized that significant differences do exist between massed and distributed practice which favor distributed practice in both serial and paired associate learning and retention. A series of meta-analyses were conducted to test this hypothesis.

CHAPTER II

Method

Design of Prior Research

Upon review of the literature it was found that, in the bulk of the studies, a single presentation of a list of items constituted a trial, with length of intertrial interval being the central variable. Massed practice learning consisted of a 2 - 8 second intertrial interval, while distributed practice learning consisted of a 15 second or longer intertrial interval.

In the serial method the items to be learned (e.g., nonsense syllables) were sequenced by a device such as a memory drum and exposed to the subject one at a time. In the paired associate method, pairs of items were presented to the subject, and the subject was instructed to learn the pairs in such a way that when the first member of the pair appeared, he/she was able to recall the second.

Design and Effect Size Estimation

Twenty studies with relevant statistics for meta-analysis were located. These studies yielded 82 effect sizes. Six separate meta-analyses were performed to compare and combine the results of these studies.

The first meta-analysis was concerned with paired-associate learning with the dependent variable of number of trials to criterion. Five studies were located which yielded 21 effect sizes. Seven studies were included in the second meta-analysis which yielded 30 effect sizes. This meta-analysis was concerned with serial learning with the dependent variable of number of trials to criterion. The third meta-analysis applied to paired-associate learning with mean correct responses as the dependent variable. Four studies were included which yielded 12 effect sizes. The fourth meta-analysis was concerned with serial learning with the dependent variable of mean correct responses. Two studies were located which yielded 2 effect sizes.

The fifth and sixth meta-analyses applied to those studies of paired-associate retention and serial retention respectively. Seven paired-associate retention studies were included which yielded 14 effect sizes. Two serial retention studies were included in the final meta-analysis which yielded 3 effect sizes.

Effect sizes were calculated for each relevant test of significance based upon Glass's (1981) concept of effect size (ES). This effect size was obtained by taking the difference between the mean of the experimental group and the mean of the control group and dividing by the standard deviation of the control group. However, in cases where reported results yielded insufficient information to utilize the method above, effect sizes were estimated by methods reported by Holmes (1984).

Each result was treated as an independent study in reference to effect size estimation. Comparing and combining studies was carried out by utilizing methods reported by Rosenthal (1991).

Data, which were compared and combined, included the results of t-tests for independent means, effect sizes, effect sizes weighted by df, one-tailed p-levels for each independent result, Z-scores, and weighted Z-scores. Results of dependent t-tests were corrected by taking the square root of $1-r$ where r was the correlation coefficient (Holmes, 1984).

Negative t's, Zs, and effect sizes indicate results which favored the massed practice control group, while positive t's, Zs, and effect sizes indicate results which favored the distributed practice experimental group. A combined p-level below .5 indicates results which favored the experimental group, whereas a combined p above .5 indicates results which favored the control group.

In each meta-analysis that follows, the standard normal deviate, *Z*, corresponding to each *p*-level was computed. The statistical significance of the heterogeneity of the *p*-levels was then obtained by utilizing a chi-square test with *K*-1 degrees of freedom. The combined *p*-level was obtained by dividing the sum of the *Z*'s for the appropriate set of studies by the number of studies (*K*) included in that set of studies. This yielded a new statistic distributed as *Z*.

A decision was made to have the size of the study play a larger role in determining the combined *p*-level. Each independent *Z* in the appropriate set of studies was multiplied by its associated *df*. The sum of these weighted *Z*'s was then divided by the sum of the squared weights to obtain the combined weighted *Z*.

The combined effect size for each set of studies was obtained by dividing the sum of the effect sizes in the particular set of studies by the number of studies in that set. The combined weighted effect size was then obtained by dividing the sum of the weighted effect sizes for the set of studies by the sum of the weights.

CHAPTER III

META-ANALYSES OF RELEVANT STUDIES

Meta-Analysis 1

Results

This meta-analysis was concerned with learning and focused on paired-associate learning with the dependent variable of number of trials to criterion (see Table 1). A chi-square test was utilized to obtain the statistical significance of the heterogeneity of the *p*-levels. The *p*-levels in this set of studies were found to be significantly heterogeneous, $x^2 = 53.39$ (20), $p = .0014$. The *p*-levels clearly differed significantly among themselves.

A combined *p*-level was computed from this set of studies to obtain an overall estimate of the probability that the set of *p*-levels might have been obtained if the null hypothesis of no differences between massed practice and distributed practice were true. Mean effect sizes and their associated *Z* scores were calculated. The mean effect size for this set of studies was .168, $Z = 2.987$, $p = .0014$, indicating significant differences which favor distributed practice. Weighting each independent *Z*-score by its associated *df* did not lead to a different conclusion $Z = 3.80$, $p = .00007$, with a combined weighted effect size of .239.

Table 1

Paired-associate Learning for Dependent Variable of Number of Trials to Criterion

STUDY	t	df	W ES	ES	Z	P LEVEL
Underwood & Ekstrand (1967)	-1.22	104	-23.92	-0.23	-1.22	0.8874
Underwood & Richardson (1957)	3.3	111	65.49	0.59	3.19	0.0007
	4.37	166	122.84	0.74	3.7	0.00001
	1.07	110	22	0.2	1.06	0.1435
Hovland (1949)	4	17	24.14	1.42	3.3	0.0005
	5.9	17	30.77	1.81	4.27	0.00001
Underwood (1954a)	-0.87	46	-11.5	-0.25	-0.86	0.8056
Underwood (1951a)	0.61	17	4.76	0.28	0.645	0.257
	-0.44	17	-3.4	-0.2	-0.43	0.6673
	-0.09	17	-0.68	-0.04	-0.085	0.5353
	0.57	17	4.42	0.26	0.555	0.2881
	-0.14	17	-1.19	-0.07	-0.135	0.5548
	-1.14	17	-8.5	-0.5	-1.1	0.865
Underwood & Viterna (1951)	0.09	17	0.68	0.04	1.58	0.4647
	-0.1	35	-1.05	-0.03	-0.1	0.5395
	-0.05	17	-0.34	-0.02	-0.05	0.5196
	-0.07	17	-0.51	-0.03	-0.07	0.5275
	-0.689	17	-5.44	-0.32	0	0.5
	-1.04	35	-11.9	-0.34	-1.02	0.8473
	0.53	17	4.08	0.24	0.52	0.3015
	-0.06	17	-0.51	-0.03	-0.06	0.5236

Discussion

The results of this meta-analysis supported the hypothesis of significant differences between massed and distributed practice which favor distributed practice. This also supports the previous research of Underwood and Richardson (1957) and Hovland (1949). The bulk of the studies in this set of studies, however, slightly favored massed practice. Eleven out of the twenty-one studies favored massed practice.

Meta-Analysis 2

Results

This meta-analysis focused on serial learning with the dependent variable of number of trials to criterion (see Table 2). A chi-square test was utilized to obtain the statistical significance of the heterogeneity of the *p*-levels. A chi-square value of 66.917 was obtained, which for $K - 1 = 30 - 1 = 29$ *df*, is significant at $p < .000001$. The *p*-levels clearly differed significantly among themselves.

A combined *p*-level was computed from this set of studies to obtain an overall estimate of the probability that the set of *p*-levels might have been obtained if the null hypothesis of no differences between massed practice and distributed practice were true. The mean effect size for this set of studies was .612, $Z = 11.137$, $p < .0000001$, indicating differences which favor distributed practice. Weighting by the size of the study did not lead to a different conclusion $Z = 6.81$, $p < .0000001$, with a combined weighted effect size of .402.

Table 2

Serial Learning for Dependent Variable of Number of Trials to Criterion

STUDY	t	df	W ES	ES	Z	P LEVEL
Underwood (1957b)	-0.39	110	-9.9	-0.09	-0.38	0.6514
	0.79	110	18.7	0.17	0.78	0.2156
	0.65	110	16.5	0.15	0.64	0.2585
	0.96	110	24.2	0.22	0.95	0.1696
	1.72	110	42.9	0.39	1.7	0.0441
	0.4	110	9.9	0.09	0.39	0.345
	0.22	110	5.5	0.05	0.2	0.4181
	1.04	110	26.4	0.24	1.03	0.1503
	1.88	110	47.3	0.43	1.86	0.0314
	0.59	110	14.3	0.13	0.58	0.2782
	1.14	110	28.6	0.26	0.9	0.1284
	2.31	110	58.3	0.53	2.27	0.0114
Hovland (1938b)	2.92	31	27.9	0.9	2.73	0.0032
	1.21	31	12.4	0.4	1.18	0.1177
Hovland (1940a)	5.7	31	45.57	1.47	4.75	0.000001
	6.07	31	47.74	1.54	4.89	0.0000005
	5.72	31	45.57	1.47	4.75	0.000001
	6.56	31	43.71	1.41	5.2	0.0000001
Hovland (1940b)	3.69	31	33.48	1.08	3.35	0.00045
	2.46	31	23.87	0.77	2.33	0.0098
	4.54	31	39.06	1.26	3.89	0.00005

Table 2 (continued)

STUDY	t	df	W ES	ES	Z	P LEVEL
Underwood & Goad (1951)	1.58	22	14.08	0.64	1.52	0.0642
	1.55	22	13.86	0.63	1.49	0.0677
	0.48	22	10.56	0.48	2.98	0.0014
	3.18	22	28.6	1.3	2.85	0.0022
Underwood (1954a)	0.06	70	0.7	0.01	0.055	0.4762
Underwood (1951b)	1.65	46	22.08	0.48	1.62	0.0529
	2.25	46	29.9	0.65	2.18	0.0146
	2.24	46	29.9	0.65	2.17	0.015
	2.21	46	29.44	0.64	2.145	0.0161

Discussion

The results of this meta-analysis favored distributed practice and support the hypothesis of significant differences between massed and distributed practice in serial learning of word lists. This also supports the research of Underwood (1951b, 1957b) and Hovland (1938b, 1940a, 1940b). No additional research was located to dispute these findings.

Meta-Analysis 3

Results

This meta-analysis was concerned with paired-associate learning and focused on those studies of paired-associate learning with the dependent variable of mean correct responses (see Table 3). The *p*-levels associated with this set of studies were found to be significantly heterogeneous x^2 (11) = 37.95, *p* = .00008. Mean effect sizes and their associated *Z* scores were calculated. The mean effect size for this set of studies was .019, *Z* = .675, *p* = .25, indicating differences which only slightly favored distributed practice, however, failed to reach significance. When *Z*'s were weighted by their associated degrees of freedom results indicated *Z* = -.192, *p* = .5761. A combined weighted effect size of -.051 was also computed for this set of studies.

Table 3

Paired-associate Learning for Dependent Variable of Mean Correct Responses

STUDY	t	df	W ES	ES	Z	P LEVEL
Bloom & Shuell (1981)	-0.93	50	-14	-0.28	-0.92	0.8216
Houston (1966)		22	0	0	0	0.5
		22	0	0	0	0.5
Underwood & Schulz (1961b)		92	0	0	0	0.5
	2.55	28	26.04	0.93	3.13	0.0083
	-0.02	148	-0.4884	-0.0033	-0.025	0.51
	-2.89	148	-69.56	-0.47	-0.285	0.9978
	2.37	148	57.72	0.39	2.345	0.0095
	-2.38	148	-57.72	-0.39	-2.355	0.9907
	-2.69	148	-65.52	-0.44	-2.65	0.996
Underwood & Shulz (1961a)		166	0	0	0	0.5
	2.39	94	46.06	0.49	3.1	0.0094

Discussion

The results of this meta-analysis were more difficult to interpret. Combined significance levels slightly favored distributed practice; however, when *Z*s were weighted by their associated degrees of freedom combined significance levels slightly favored massed practice. Only five of the twelve studies in this set of studies favored massed practice, but there were also four studies which indicated no effect.

Meta-Analysis 4

Results

This meta-analysis was concerned with learning and focused on serial learning with the dependent variable of mean correct responses (see Table 4). The *p*-levels in this set of studies were found to be significantly heterogeneous, $x^2 = 4.712\ (1), p = .03$. The *p*-levels clearly differed significantly among themselves. Mean effect sizes and their associated *Z* scores were calculated. The mean effect size for this set of studies was .155, $Z = 2.17, p = .015$, indicating significant differences which favor distributed practice. When *Z*s were weighted by their associated degrees of freedom results indicated $Z = 2.974, p = .00147$. A combined weighted effect size of .31 was also computed for this set of studies.

Table 4

Serial Learning for Dependent Variable of Mean Correct Responses

STUDY	t	df	W ES	ES	Z	P LEVEL
Shuell (1981)		102	0	0	0	0.5
Underwood & Richardson (1958)	3.08	398	123.38	0.31	3.07	0.0011

Discussion

The results of this meta-analysis support the hypothesis of significant differences between massed and distributed practice which favor distributed practice. This also supports the previous research of Underwood and Richardson (1958). However, it is in opposition to Shuell (1981) who indicated no distributed practice effect on serial learning for the dependent variable of mean correct responses.

Meta-Analysis 5

Results

This meta-analysis was concerned only with paired-associate retention (see Table 5). A x^2 of 23.43 with K - 1 = 13 *df*, $p = .037$ indicated that the studies were significantly heterogeneous. Computation of the combined *p*-level yielded a *Z* of 5.559, $p < .000001$ and a *Z* of 3.537, $p = .00020$ when the individual *Z*s were weighted by their associated degrees of freedom. The combined effect size for this set of studies was .395, and the combined weighted effect size was .283.

Discussion

The results of this meta-analysis support the hypothesis of significant differences between massed and distributed practice in paired-associate retention of word lists which favor distributed practice. Opposition to these results rarely existed in the literature. Eleven out of the fourteen studies which were located indicated an effect size which favored distributed practice, three studies indicated no effect size, and none of the studies located favored massed practice.

Table 5

Paired-associate Retention

STUDY	t	df	W ES	ES	Z	P LEVEL
Bloom & Shuell (1981)	3.5	50	48.5	0.97	3.3	0.0005
Underwood & Ekstrand (1967)	3.82	84	68.88	0.82	3.7	0.0001
Houston (1966)	2	92	37.72	0.41	1.98	0.0241
Underwood etal (1962)		48	0	0	0	0.5
	2.28	62	35.34	0.57	2.32	0.013
	0.22	62	3.41	0.055	0.22	0.4133
	3.11	62	48.36	0.78	2.88	0.0014
Underwood & Shulz (1961a)		94	0	0	0	0.5
		94	0	0	0	0.5
	0.46	94	8.46	0.09	0.455	0.3233
	2.72	94	52.64	0.56	2.66	0.0039
Underwood & Richardson (1957)	0.5	334	16.7	0.05	0.49	0.3087
Underwood (1951a)	2.14	17	14.79	0.87	1.98	0.0236
	0.84	17	6.12	0.36	0.815	0.2063

Meta-Analysis 6

Results

This meta-analysis applied to studies of serial retention (see Table 6). A x^2 of 15.637, K - 1 = 2 *df*, p = .004 indicated that the p-levels included in these studies differed significantly among themselves. Computation of the combined p-level yielded a Z of 2.835, p = .0023. When each Z was weighted by its associated *df* different results were obtained. This combined weighted Z value was found to be .935, p = .175. The combined effect size for this set of studies was .5233, and the combined weighted effect size was .221.

Discussion

This meta-analysis indicated that there were significant differences between massed practice and distributed practice in serial retention which favored distributed practice when unweighted Z's were combined. However, combining weighted Z's by their associated degrees of freedom indicated no significant differences. These contradictory findings suggest that one should be cautious in determining a conclusion based on this meta-analysis. It should also be noted that only three studies with relevant statistics could be located.

Table 6

Serial Retention

STUDY	t	df	W ES	ES	Z	P LEVEL
Shuell (1981)	3.48	102	69.36	0.68	3.35	0.0004
	3.42	34	38.76	1.14	3.15	0.0008
Underwood & Richardson (1955)	-1.6	166	-41.5	-0.25	-1.59	0.9442

CHAPTER IV

CONCLUSION

This meta-analysis was conducted in an attempt to clarify contradictory results of past research on the effect of distributed practice in list learning and retention. It was also an initial attempt to rectify what Rosenthal (1991) describes as poor accumulation, or a lack of orderly progression , in the social sciences. The results of this meta-analysis suggested that distributed practice generally produces superior learning and retention of word lists; however, this was not the case in all circumstances. In paired-associate learning with the dependent variable of mean correct responses there were no significant differences between massed and distributed practice. In the case of serial retention of word lists the results of meta-analysis 6 were contradictory when weighting by the size of the study was taken into account. The limited number of studies could have led to the contradictory results.

An attempt was made to discern the basis for the differences of opinion in the previous research. It was found that certain settings may produce distinct differences between massed and distributed practice. For example, an increase in the similarity between items presented has generally resulted in an increase in the number of trials to reach criterion.

Underwood and Goad (1951) found that distributed practice was superior to massed practice for learning lists of adjectives by the serial anticipation method if the similarity between adjectives was high. The present series of meta-analyses found that distributed practice generally produces superior learning and retention of both serial and paired-associate word lists with one exception (i.e., paired-associate learning with the dependent variable of mean correct responses).

In an attempt to discern the basis for the differences of opinion in previous research it was found that certain settings may produce distinct differences between massed and distributed practice. For example, an increase in the similarity between items has generally resulted in an increase in the number of trials to criterion.

Underwood and Goad (1951) found that distributed practice was superior to massed practice for learning lists of adjectives by the serial anticipation method if the similarity between adjectives was high. If the similarity between adjectives was low, learning by massed practice was as effective as distributed practice. Underwood (1951a) also studied the effects of similarity on paired-associate learning. He found that highly similar stimulus and response items resulted in a greater number of trials to reach criterion.

In an applied setting where mastery of verbal materials is required Underwood (1961) contends that distributed practice should not be recommended if total time to learn is a factor. Wright and Taylor (1948) support this view with results which indicated that greater achievement will result from a greater number of trials given within a 52 minute time period. However Hovland (1940a) found that distributed practice was economical for immediate as well as for delayed recall, and that while massed practice may be an adequate method to prepare for quizzes, it was not a good method for permanent retention.

Hovland (1949) and Underwood (1953b) suggested that the level of skill or sophistication of subjects in laboratory learning may interact with the distribution of practice. Underwood (1954a) found that, following learning of serial lists, slower learners demonstrated better recall under massed practice conditions, while faster learners showed no significant differences but slightly favored distributed practice. He concluded that recall, whether by massed or distributed practice, is related to ability level in serial list learning but not in paired-associate list learning.

The results of this series of meta-analyses provide strong support for the hypothesis of significant differences between massed and distributed practice in learning and retention of serial and paired-associate lists. Any generalization of these results may, however, be limited due to the limited number of studies in some of the meta-analyses and due to the failure of this meta-analysis to consider interaction effects of other variables which some researchers consider to be critical (e.g., interference, inhibition, similarity, and I.Q.).

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VITA

Robert E. Isbell Jr. was born in Union City, Tennessee on January 08, 1964. He graduated from Obion County Central High School in May, 1982. In March, 1984 he enlisted in the United States Army as a cryptographic electronic equipment technician and attained the rank of sergeant. In June, 1989 he entered Bethel College, McKenzie, Tennessee and in May, 1991 received a Bachelor of Science in Psychology. In July, 1991 he entered Austin Peay State University, Clarksville, Tennessee, and in May, 1997 received the Master of Arts degree in Psychology.

He is presently employed with the State of Tennessee as an Adult Probation Officer and with H & R Block as a Tax Preparer. He has been a member of the American Legion and Common Cause, Tennessee since 1990. In 1996 he was appointed to represent the seventh congressional district as a state governing board member for Common Cause, Tennessee.