R E P O R T   R E S U M E S

ED 010 291   24

PROBLEM SOLVING AS A FUNCTION OF LANGUAGE.

BY- STAFFORD, KENNETH R.

ARIZONA STATE UNIV., TEMPE

REPORT NUMBER CRP-2944   PUB DATE 31 AUG 66

REPORT NUMBER BR-5-0609

GRANT OEG-6-10-0121

EDRS PRICE MF-$0.09 HC-$1.64 41P.

DESCRIPTORS- *PROBLEM SOLVING, LINGUISTICS, LANGUAGE LABORATORIES, *LANGUAGE SKILLS, *NAVAHO, *BILINGUAL STUDENTS, *TASK PERFORMANCE, SEMANTICS, COMMUNICATIONS, TEMPE, ARIZONA

THIS RESEARCH ATTEMPTED TO RELATE PROBLEM-SOLVING BEHAVIOR TO LANGUAGE BY FINDING RELATIONSHIPS BETWEEN (1) PROBLEM SOLVING AND LANGUAGE TYPE AND (2) PROBLEM SOLVING AND CATEGORIES OF BILINGUALISM. ENGLISH-SPEAKING MONOLINGUAL AND TYPES OF BILINGUAL NAVAHO EIGHTH-GRADE PUPILS WERE COMPARED ON PROBLEM-SOLVING TASKS. IQ AND READING COMPREHENSION WERE CONTROLLED. FINDINGS INDICATED THAT THE COMPOUND BILINGUALS DID LESS WELL THAN COORDINATE BILINGUALS AND ENGLISH-SPEAKING MONOLINGUALS, BUT THAT THERE WAS NO DIFFERENCE BETWEEN THE COORDINATE BILINGUALS AND THE MONOLINGUALS. DIFFERENCES WERE EXPLAINED IN TERMS OF OSGOOD'S TWO-STAGE MEDIATION MODEL AND INTERFERENCE. IMPLICATIONS FOR THE LANGUAGE TRAINING OF BILINGUALS WERE MENTIONED. (GD)

ED010291

PROBLEM SOLVING AS A FUNCTION OF LANGUAGE

Kenneth R. Stafford

Final Report
Cooperative Research Project Number 2944
Research Branch
Grant Number OE 6-10-012

The Research Reported Herein Was Supported
by a Grant from the
United States Department of Health, Education, and Welfare
Office of Education

Department of Counseling and Educational Psychology
Arizona State University
Tempe, Arizona

August 31, 1966

ACKNOWLEDGMENTS

I am indebted to the participating faculty and staff, Mr. William Martin, Superintendent, and Mr. Stanley Van Keuren, counselor, of the Ft. Defiance-Window Rock Public School System. Similarly, gratitude is extended to the participating faculty and staff and Mr. Joseph Matthews, Superintendent, of the Chinle Public School System. Their cooperation is sincerely appreciated.

Dr. Joel Benedict and his staff at the Arizona State University Audio-Visual Center were most helpful with instrumentation.

Punch card data decks were prepared in the Testing Service at Arizona State University, and statistical analyses were done in the University Computer Center.

Mr. David Phillips, the graduate research assistant on this project, deserves thanks for his varied assistance, ranging from battling snow on an Indian reservation to administering tests and processing data. Dr. Irving Stout gave valuable, time-saving assistance regarding initial contacts with officials, for which I am grateful.

My wife contributed by making tables, figures, and typing - and by bearing with the whole thing.

TABLE OF CONTENTS

Problem Solving as a Function of Language

I. Overview.

Contemporary interest in the linguistic relativity hypothesis traces largely to the descriptive-speculative work of Whorf (1939), who broadly suggested that cognitive behavior of individuals is determined by the language system they use. Only recently have psychologists begun to move beyond anthropological descriptions to controlled experimentation. In an extension of the Brown and Lenneberg (1954) codability study, Lenneberg and Roberts (1956) found that differences in codability of colors between Zuni and English produced differences in recognition and memory of colors for speakers of these languages. Carroll and Casagrande (1958) explained differences in classificatory behavior between Navaho speakers and English speakers in terms of Navaho grammar. Suci (1960), in one of the many cross-cultural semantic differential studies, found that the three commonly detected factors (evaluation, potency, activity) accounted for only 39% of the total variance, not the usual 66%. Additional factors are apparently involved when Navahos interact with their environment. The present investigation was conceived and motivated in this context.

It was the task of this project to relate problem-solving behavior to language. This was to be done by finding relationships between (1) problem solving and language type, and (2) problem solving and categories of bilingualism. Navaho and English were the languages chosen. With the assumption that solutions to problems used involve mediational processes, the following experimental hypotheses were made: (1) Since - it was assumed - Navaho evolved largely as a thing-based, nature-based language, in contrast to Indo-European idea-based languages, Navaho-speaking individuals will not do as well as English-speaking persons on tasks placing great demand on encoding and manipulation of encodings. (2) Bilinguals who encode and manipulate equally well in both languages will experience greater interference than monolinguals or bilinguals dominant in one language, which will reduce problem-solving efficiency.

These hypotheses were to be tested by presenting problems to four groups of Navaho subjects presumably alike except for the independent variable, language: namely - Navaho speaking; English speaking; bilinguals who learned Navaho and English in the same context, i.e., at home before starting school; and bilinguals who learned Navaho and English in different contexts, i.e., English after starting school. Subjects were to be drawn from the eighth grade level in public schools at Ft. Defiance and Chinle, both on the Navaho Reservation in Northern Arizona. The study was to begin in Ft. Defiance and was to be replicated in Chinle.

Only three of the experimental Navaho groups were available at Ft. Defiance: English speaking, compound bilinguals, and coordinate bilinguals. Only two were found at Chinle: compound and coordinate bilinguals. It was not feasible to select extramural 14 - 16 year old

Navaho-speaking Navahos since the language variable might be confounded with other cultural-educational-intellectual variables. For the Navaho-English comparison, an attempt was made to select 6 - 8 year Navaho-speaking and English-speaking Navahos from the Ft. Defiance-Window Rock Schools. This met with failure since gaining reliable data with the experimental apparatus from 6-year-old Navaho-speaking Navahos was most impractical - even with the aid of a native interpreter known by the subjects.

Five problems were to be used with the experimental groups, based upon previous exploratory work with Navahos at Phoenix Indian School. Problem number 5 proved to be too difficult for the subjects at hand; it was eliminated. Because of a mechanical failure, problem number 2 was given to approximately one-half of the Ft. Defiance compound and coordinate groups.

In addition to the separation made dependent upon when English was learned, another was made according to whether bilingual subjects used both languages or only a single language to solve the experimental problems. This was done by simply asking each subject, upon completion of all problems, which language or languages, if either, he used while doing the task.

With these modifications the study proceeded.

II. Problem.

In a psycholinguistic theory of bilingualism, Ervin and Osgood (1954) speculated that the kind of bilingual system developed by a bilingual is related to whether the two languages were learned in associated or disassociated contexts. Two languages learned by an individual in the same context constitutes a compound system. Learning Navaho and English simultaneously is an example of this. Two languages learned by an individual in different contexts constitutes a coordinate system. Learning English in school after having mastered Navaho during pre-school years at home is an example of this. For compound bilinguals, cross-linguistic learning should be essentially the same, merely being two different ways of encoding the same referential meanings. For coordinate bilinguals, the referential meanings encoded in the two languages should differ markedly. It follows that there should be a greater amount of interference between languages in the case of the compound bilingual, reducing the efficiency of cognitive behavior.

Evidence of meaning similarities and differences for compound and coordinate bilinguals respectively was obtained by Lambert, Havelka, and Crosby (1958). Semantic differential profiles for word equivalents in French and English showed greater divergence in meaning for the French-English coordinate bilinguals than for the compound bilinguals. This was replicated by Stafford and Van Keuren (1966) using Navaho-English compound and coordinate bilinguals, with much smaller profile differences, however.

In a retroactive inhibition experiment, Lambert, Havelka, and Crosby (1958) found that compound French-English bilinguals benefited (on relearning a series of English words) from an interpolated list of French equivalents, whereas the coordinate bilinguals did not. This supports the Ervin-Osgood theory that there is greater chance for interference in compound bilingual systems. Lambert and Jakobovits (1960) provided additional support for the probability of interference in the case of compound bilinguals. They found compound bilinguals to exhibit greater cross-linguistic semantic satiation effects; that is, there was more transfer of semantic satiation effects from language to language among compound bilinguals than among coordinate bilinguals.

These studies have related types of bilingualism to meaning similarities and differences, transfer effects, and semantic satiation effects. In further exploring the implications of the Ervin-Osgood theory, it should be of interest to investigate the relationship between complex mental processes, such as problem solving, and kinds of bilingualism, as well as monolingualism (where there should be no interference effects).

The present study tested three experimental hypotheses.

(1.) Performance on problem-solving tasks will be poorer for compound bilingual groups than for either the monolingual or coordinate bilingual groups. That is, compound bilinguals will solve fewer problems and require more trials in their efforts to get solutions.

(2.) Performance on problem-solving tasks will be poorer for the coordinate bilingual groups than for the English-speaking monolinguals. Coordinate bilinguals will solve fewer problems and require more trials to get solutions.

(3.) Performance on problem-solving tasks will be poorer for bilinguals using both languages for solutions than for bilinguals using only one language for solutions. Bilinguals using two languages will solve fewer problems and require more trials for solutions.

III. Method.

Apparatus. In testing the hypotheses of this experiment, it was necessary to devise problems which required of subjects encoding, storage of encodings, and manipulation of encodings. An automated, portable problem-presenting apparatus* was developed for this purpose. It was designed so that problems should be equally fair to English-speaking, bilingual, and non-English-speaking Navahos; that problem difficulty could be systematically varied; and that the exact number of trials to criterion (solution) could be determined. On the face of the device (see Fig. 1) is a screen divided into quadrants; beside each quadrant is a control button to be operated by the subject; above the screen is a signal or reward light. A square and a triangle are flashed on the screen in separate quadrants. The subject presses a button. If it is the correct one, the reward light flashes. Each time a button is pressed the figures change position. Ten consecutive reward light flashes were construed as a solution; 100 trials were allowed for each problem before presenting another.

The experimental task consisted of four progressively more difficult problems, the relative difficulty of which was determined empirically by ascertaining the number of problem solutions and trials

---

*Built by American Atomics Corporation, Tucson, Arizona

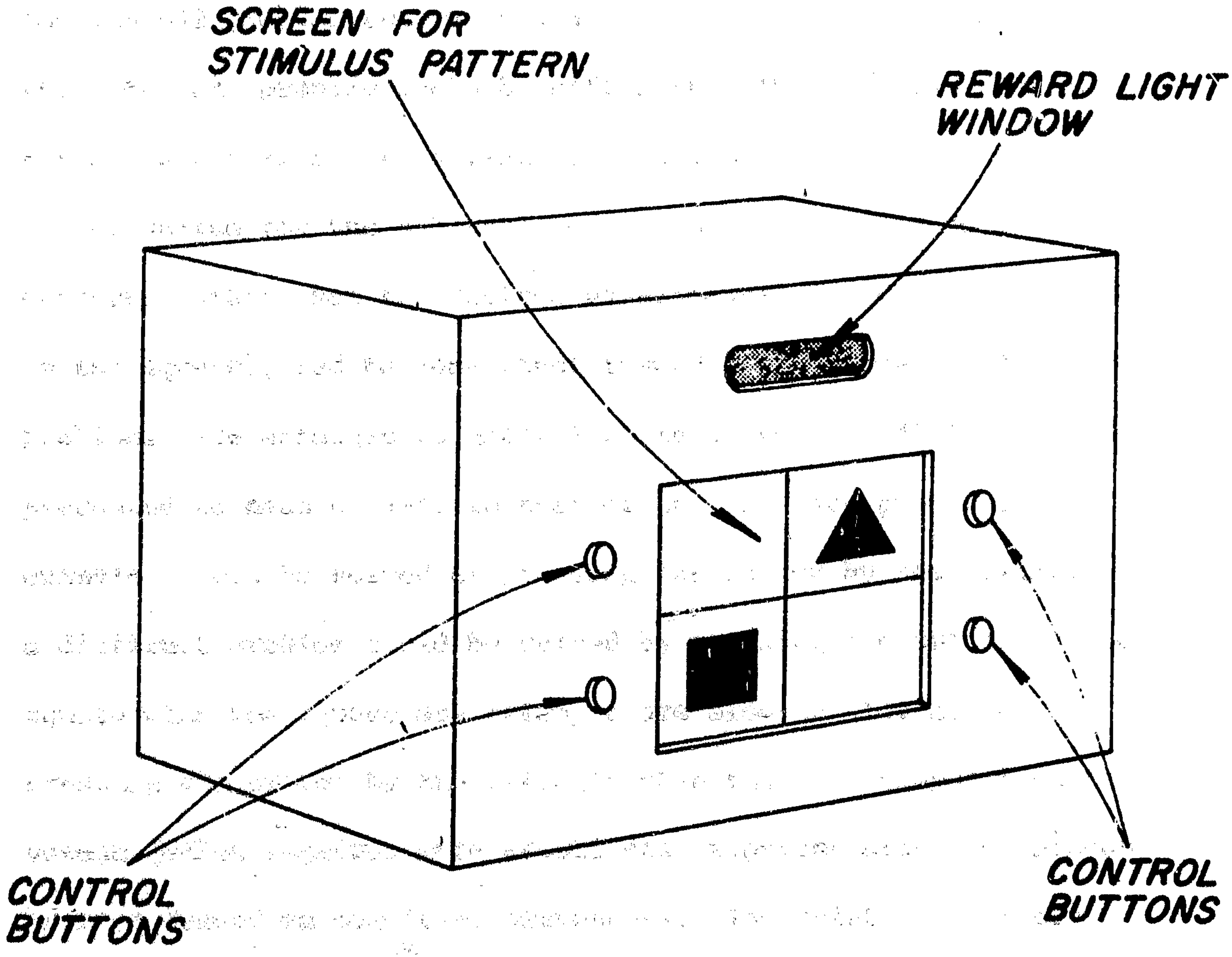


Figure 1. Schematic diagram of the problem-presenting apparatus

to criterion occuring in a preliminary test of similar subjects. Each problem was in a film cartridge designed for the device and each problem was visibly but easily placed in the machine by the experimenter in full view of the subject. The subject not only saw the old problem removed and a new one replaced, but was told that the next problem would be different. The stimulus configurations on the film strips (which, of course, appeared on the screen of the device for the subject) were randomly arranged so that no patterns, other than the desired experimental pattern (e.g., button by the square), led to consistent reward light flashes. The problems were arranged in order from least to most difficult and presented to each subject in that order. An easy problem, for example, could be solved by pressing the button by the triangle; a difficult problem could be solved by pressing the button by the square when the square and triangle are side by side and by pressing the button by the triangle when they are diagonal on the screen (which requires more complicated representation and places greater demand on cognitive processes). The solution of every problem involved pressing a button contiguous to a figure; the solution of every problem was different. The subject was required to discover these facts for himself and thus each succeeding problem made an increased demand on his memory and reason.

The problems were given to each subject individually under standardized conditions in a familiar setting in their school. Directions were given verbally in English, and a demonstration problem was used as an illustration of what was expected. The demonstration problem (similar to but much simpler than the four experimental problems) was placed in the machine, the experimenter methodically pressed buttons to show the subject how the configurations changed on the screen, then how pressing certain buttons caused the reward light to flash. The subject then was allowed to do this, continuing until he was able to get a light flash every time a button was pressed. When complete understanding of the task was assured, the first experimental problem was presented.

In order of presentation the problems were:

Demonstration problem: The button by the square (Only the square appeared on the screen.)

Problem #1: The button by the triangle (On this and all subsequent problems a square and a triangle appeared on the screen.)

Problem #2: The button by the figure on the lower half of the screen.

Problem #3: The button by the square when on the right side of the screen; the button by the triangle when on the left side of the screen.

Problem #4: The button by the square when figures are side by side on the screen; the button by the triangle when figures are diagonal on the screen.

The method employed in determining <u>single</u> and <u>both</u> language solutions among bilinguals merely involved the somewhat subjective expedient of asking them, upon completion of the session, which language or languages, if either, they used in attempting solutions. This was done at Chinle only.

Population. The subjects were chosen from eighth grade sections of Navaho pupils in the Ft. Defiance and Chinle Public Schools. This level provided the largest pool of homogeneous subjects - very probably more like each other, except for language, than eighth grade pupils in a large city public school. There was also some assurance at this level of sufficient mental maturity and adequate grasp of English to cope with the experimental situation. From the Ft. Defiance population, three groups were formed with the aid of a questionnaire which revealed the nature of English learning. Pupils who learned English and Navaho in the same context (simultaneously before starting to school) were placed in the compound bilingual group; those who learned English and Navaho in different contexts (Navaho at home during preschool years and English after starting to school) were placed in the coordinate bilingual group; and those who learned English only were placed in the monolingual group. From the Chinle population, two groups were formed by means of the same questionnaire - compound and coordinate bilingual groups. Means and standard deviations for age, IQ*, and reading comprehension#, plus sex distributions, for the population samples are given in Table 1.

---

*Non-Language section of the California Test of Mental Maturity.

#Reading Comprehension section of the SRA Achievement Battery.

TABLE 1
Sex Distributions, Means, and Standard Deviations for the Population Samples

	Sex		Age		IQ		Read. Comp.	
	M	F	M	SD	M	SD	M	SD
Ft. Defiance								
Compound	6	12	14.8	.60	[illegible]	10.7	5.1	1.5
Coordinate	13	11	14.9	.60	78	10.0	4.7	1.3
Monolingual	12	8	13.8	.67	98	17.2	6.4	2.2
Chinle								
Compound	9	14	14.7	.60	90.6	10.3	6.6	1.4
Coordinate	9	11	14.7	.59	85.9	10.8	6.6	1.3

IV. Results.

In relating independent and dependent variables, a Fisherian design was used, analysis of covariance and the t test. The independent variables were linguistic classifications: types of bilingualism, monolingualism, and whether single or both languages of a bilingual system were used. The dependent variables were total number of trials made in attempting solutions to all problems and percentage of problems solved. For example, if a subject failed to solve all four problems, a trial score of 400 was assigned; if a subject solved one of the four with 50 trials, he received a trial score of 350. If a subject solved three of the four problems, his problem score was .75; or two of three, .66.

In every analysis, IQ was the covariate. As a test of whether knowledge of English (reading comprehension scores) differed significantly for the experimental groups, an analysis of covariance (IQ covariate) was done with data from the combined Ft. Defiance-Chinle groups. No differences were evident.

The research strategy involved a replication (in order to make comparisons between highly homogeneous groups); pooling data from both population areas (to increase the power of statistical tests); and a comparison of bilinguals reaching solutions with either one language or both (to check for concordance between performance here and bilingual types). It was the belief of the experimenter that if a "concatenation of evidence" should emerge, the hypotheses would be strongly supported - even though the differences in many instances might not reach the conventional .01 and .05 levels.

Findings are presented in Table 2.

Inspection of Table 2 reveals that the first hypothesis was supported. Predicted directions of differences were born out in every case; only one of 10 tests showed no statistical significance (compound vs. English for problems, Ft. Defiance). The second hypothesis was not supported. There were direction reversals in two instances (coordinate vs. English for trials and problems, Ft. Defiance), one of which was statistically significant. Another comparison showed no significance (coordinate vs. English for problems, combined), however, the direction was as predicted. Two of 4 tests showed no significance; 2 of 4 revealed direction reversals - suggesting no differences at all between coordinate vs. English for these particular problem-solving situations. The third hypothesis was supported. Predicted directions of differences were verified, and differences were significant.

TABLE 2

F Ratios, t Ratios, Degrees of Freedom, Probability Limits (One-Tailed), and Direction of Differences for Trials and Problems for the Experimental Groups

	Total Trials	% Problems
Ft. Defiance (3 groups)	F=1.73 (2/58) .25=1.42, .10=2.39	F=1.66 (2/58) .25=1.42, .10=2.39
Compound vs Coordinate	Compound > Coordinate t=1.80 (40) .05=1.68, .02=2.02	Compound < Coordinate t=1.67 (40) .10=1.30, .05=1.68
Compound vs English	Compound > English t=.57 (36) .30=.53, .20=.85	Compound < English t=.103 (36) N.S.
Coordinate vs English	Coordinate < English t=1.14 (42) N.S. (Unpredicted direction, two-tailed test)	Coordinate > English t=1.46 (42) .20=1.30, .10=1.68 (Unpredicted direction, two-tailed test)
Chinle (2 groups)	F=.273 (1/40) .25=1.36	F=.439 (1/40) .25=1.36
Compound vs Coordinate	Compound > Coordinate t=.56 (41) .30=.53, .20=.85	Compound < Coordinate t=.75 (41) .30=.53, .20=.85
Combined (Ft. Defiance and Chinle, 3 groups)	F=5.183 (2/101) .01=4.79, .001=7.31	F=1.79 (2/101) .25=1.40, .10=2.35
Compound vs Coordinate	Compound > Coordinate t=1.386 (83) .10=1.29, .05=1.66	Compound < Coordinate t=1.66 (83) .05=1.66
Compound vs English	Compound > English t=3.208 (59) .01=2.66, .001=3.46	Compound < English t=1.42 (59) .10=1.30, .05=1.67
Coordinate vs English	Coordinate > English t=2.143 (62) .05=2.00, .02=2.39	Coordinate < English t=.146 (62) N.S.
Languages Used (Chinle Data)	F=1.633 (1/40) .25=1.36, .10=2.84	F=1.014 (1/40) .25=1.36
Single vs Both	Single < Both t=1.35 (41) .10=1.30, .05=1.68	Single > Both t=1.09 (41) .20=.85, .10=1.30

V. Discussion.

Basic to the Ervin-Osgood theory and the hypotheses formulated in this study is Osgood's (1953) two-stage mediation model. In sign ($\boxed{S}$) learning, it is suggested that a portion (r_m) of the total response (R_T) to a significate ($\dot{S}$) becomes associated with the formerly neutral sign. The r_m or meaning response is the occasion for self-stimulation (s_m), which can become associated selectively with instrumental acts (R_X). This is illustrated in Fig. 2. With this model, predicted differences can be illustrated for the monolingual, the coordinate bilingual, and the compound bilingual. The monolingual typically associates one sign with one significate and learns to respond instrumentally in a definite way. Fig. 2 shows this. No mediational interference would be expected. The coordinate bilingual, in learning languages in separate contexts, associates a word in one language ($\boxed{S_1}$) with a meaning response (r_{m_1}) in a certain context, and associates a word in another language ($\boxed{S_2}$) with a second meaning response (r_{m_2}) in a different context. Both r_{m_1} and r_{m_2} occasion s_{m_1} and s_{m_2}, which may become associated with two different instrumental acts. See Fig. 3. Little or no mediational interference would be expected since $\boxed{S_1}$ and $\boxed{S_2}$ elicite different meaning responses. The compound bilingual, in learning languages in the same context, associates the two sign equivalents ($\boxed{S}$ and $\boxed{S'}$) with essentially the same meaning responses (r_m and r'_m). Mediational interference would be expected in the interplay of languages, particularly

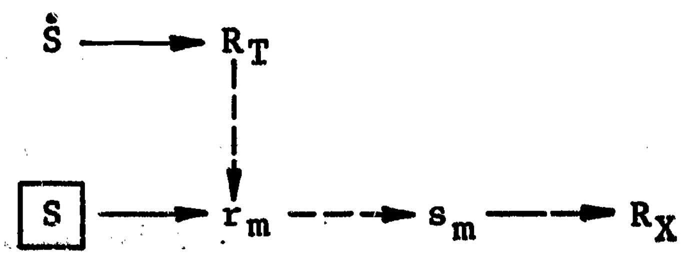


Figure 2. Two-stage mediation model

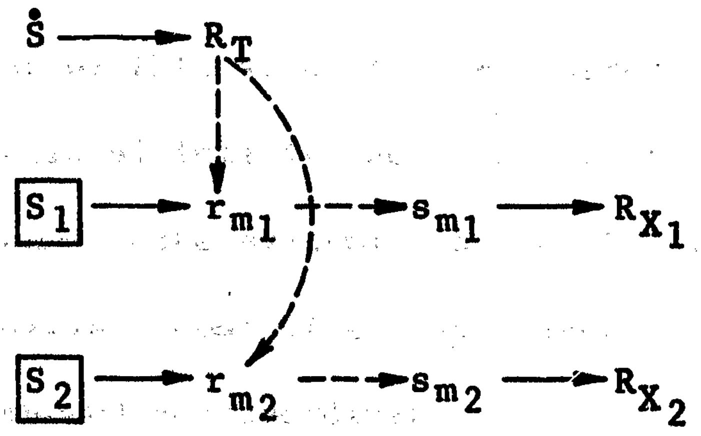


Figure 3. Two-stage mediation model related to coordinate bilingualism

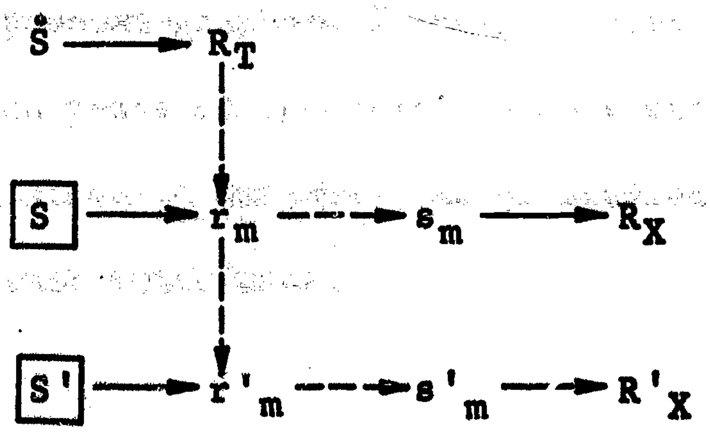


Figure 4. Two-stage mediation model related to compound bilingualism

in the case of complex problems where subtle behavior is involved.

These paradigms plus the concept of mediational interference provide an explanation of the findings of the present study. Apparently coordinate bilinguals tend to function with one language at a time. In the Chinle experiment the ratio of users of both languages to users of single languages among coordinate bilinguals was 1.5 to 1. Compound bilinguals, it seems, tend to function with two languages at a time. The ratio of users of both languages to users of single languages among compound bilinguals was 3.6 to 1.

An implication of this study is the desirability of minimizing the chances of mediational interference among bilinguals by emphasizing the development of coordinate systems. An important follow-up study would be to devise a controlled experiment in which Navaho bilinguals, both compound and coordinate, attending our conventional Reservation schools are compared with coordinate bilingual Navahos who have undergone a special language training program. Mediational interference should be avoided if Navaho-speaking children, upon entering a residential school, are exposed to suitable language-learning experiences: namely - common referents associated with English words, then word combinations which embody basic English syntax, and then, perhaps, phoneme-grapheme correspondances. It may well be that after one or two years of concentrated work with the English language, the other academic subjects can be studied without the handicap of mediational interference.

VI. Summary.

English-speaking monolingual and types of bilingual Navaho eighth grade pupils were compared on problem-solving tasks. IQ and reading comprehension were controlled. Predictions were made that compound bilinguals would require more trials in attempting to solve the experimental problems and solve fewer of them than would coordinate bilinguals, and also that coordinate bilinguals would do poorer than English-speaking monolinguals. Findings indicated that the compound bilinguals did less well than the other two groups, but that there was no difference between the coordinate bilinguals and the monolinguals. Differences were explained in terms of Osgood's two-stage mediation model and interference. Implications for the language training of bilinguals were mentioned.

APPENDIX A
RAW DATA, FT. DEFIANCE

COMPOUND

Sex	Age	IQ	Read.	Problems 1	Problems 2	Problems 3	Problems 4
F	15	107	4.5	1		49	81
F	16	73	3.1	32		-	38
F	15	70	5.0	28		-	-
F	15	70	4.4	2		14	-
F	15	89	3.8	52		30	-
F	14	74	3.8	93		-	24
F	14	75	6.4	2		-	-
M	15	80	4.9	2		97	55
F	14	91	5.5	1	-	31	90
M	16	91	4.0	4	5	-	-
F	14	97	5.9	18		-	-
F	15	79	5.5	1		-	-
M	15	65	4.6	2	24	-	-
M	15	80	5.5	26	87	-	77
F	14	69	5.5	1	50	31	-
M	15	81	2.9	4	15	-	82
F	15	80	7.6	3	71	31	28
M	15	87	9.5	3	54	37	-

COORDINATE

Sex	Age	IQ	Read.	Problems 1	Problems 2	Problems 3	Problems 4
F	15	80	4.0	1		14	78
F	15	81	6.0	2		37	54
F	15	81	4.5	2		-	-
F	15	71	4.4	9		35	88
F	15	56	4.0	5		32	29
M	16	59	3.3	2		90	87
F	15	75	6.1	20		-	-
F	15	75	5.0	1	75	92	36
F	15	62	3.2	24	48	18	78
F	15	80	3.1	2	95	25	-
F	14	75	4.0	1		-	-
M	14	91	4.0	37		-	-
M	16	88	7.4	2		57	3
M	16	78	4.0	8		-	89
M	15	84	3.5	9		59	-
M	15	54	5.4	1	-	37	79
M	15	81	3.9	10	-	99	-
M	15	81	4.0	1	-	72	93
M	14	82	5.0	2	84	49	95
M	14	72	4.9	10	-	46	56
M	14	104	5.5	2	40	71	-
F	15	84	8.4	4		-	25
M	15	83	3.9	7		52	17
M	14	99	6.4	2	92	20	30

ENGLISH

Sex	Age	IQ	Read.	Problems 1	Problems 2	Problems 3	Problems 4
M	15	76	5.4	8	46	-	-
M	15	75	3.5	2	15	-	40
F	14	96	5.0	1	48	59	-
F	14	97	4.0	23	-	77	90
M	14	79	4.5	1	-	-	-
F	14	78	6.4	58	59	81	6
F	13	100	4.2	28	36	11	20
F	13	109	7.3	1	27	52	11
F	13	95	8.7	2	87	-	-
M	13	119	7.2	3	57	35	78
M	14	86	5.3	4	80	-	-
M	15	94	3.8	2	98	52	19
M	14	106	7.1	1	47	-	-
M	14	83	6.0	7	43	38	-
M	14	90	3.5	42	88	82	80
F	13	150	10.5	2	99	-	-
M	14	102	9.0	2	15	80	98
M	14	109	10.5	2	-	45	-
M	13	106	6.7	3	29	-	-
F	13	110	10.1	1	26	98	30

RAW DATA, CHINLE

COMPOUND

Sex	Age	IQ	Read.	Problems 1	Problems 2	Problems 3	Problems 4	Manner of Thinking
F	15	76	4.5	40	-	-	-	Both
F	16	71	5.8	34	-	-	-	Both
F	14	91	7.2	15	-	-	-	Both
F	15	86	5.8	3	43	56	-	Both
F	15	78	7.0	73	-	-	-	Both
F	15	91	4.5	-	-	-	-	Both
M	14	95	5.8	3	23	71	72	English
F	16	73	6.7	33	51	-	-	Both
M	15	97	5.4	4	32	36	-	Navaho When Hard
M	15	99	5.3	-	-	-	-	Both
M	15	89	5.4	3	62	85	-	English
M	15	100	8.0	2	71	-	-	English
M	14	102	5.4	2	26	36	38	English
F	14	100	6.0	19	-	-	-	Both
F	15	93	6.8	1	-	-	-	Both
M	15	82	7.7	2	48	45	37	Navaho When Hard
F	14	94	8.0	1	45	-	-	Both
F	14	95	6.3	25	-	73	-	Both
M	14	82	7.9	8	15	-	-	Both
F	14	102	9.5	4	52	19	-	Both
F	14	106	6.6	3	-	-	-	Both
M	15	102	10.2	2	78	29	23	English
F	15	88	6.6	-	-	82	90	Both

COORDINATE

Sex	Age	IQ	Read.	Problems 1	Problems 2	Problems 3	Problems 4	Manner of Thinking
F	15	63	5.0	1	-	-	-	Both
F	14	77	7.4	10	-	65	-	Both
M	15	87	5.2	71	89	29	-	Both
F	15	85	8.0	.8	50	-	22	Navaho When Hard
F	16	81	6.5	1	70	-	-	English
M	14	75	4.0	27	92	-	-	Both
F	14	95	6.5	9	-	82	-	Both
M	15	81	5.2	3	-	-	-	English
F	15	76	6.5	3	46	-	-	Both
M	15	75	6.5	4	95	-	-	Both
M	14	104	4.9	7	69	-	-	English
F	14	102	7.1	4	33	-	-	Navaho When Hard
M	15	86	8.8	3	43	-	57	Navaho When Hard
M	14	101	7.5	3	26	47	-	Navaho When Hard
F	14	88	6.5	11	-	-	-	Both
F	15	81	6.8	1	96	41	-	Navaho When Hard
M	15	88	8.1	1	-	-	-	English
M	15	95	7.4	21	64	-	-	Navaho When Hard
F	15	82	6.5	3	68	-	87	Navaho When Hard
F	15	96	6.5	1	40	84	-	Navaho When Hard

APPENDIX B

Questionnaire Used to Determine Type of Bilingualism

Name ______________________, Age ____, Section ______________

Please answer each question by checking (✓) the one right place.

1. When did you learn to speak English? (check one)

   Before starting to school ____________

   After starting to school ____________

2. If you know Navaho, when did you learn to speak Navaho?

   Before starting to school ____________

   After starting to school ____________

3. Which language do you speak at home?

   Navaho ____________

   English ____________

   Both ____________

4. When you do your work in school, do you think in

   Navaho ____________

   English ____________

   Both ____________

5. When you think at your home, do you think in

   Navaho ____________

   English ____________

   Both ____________

6. When you read these questions, did you think at all in

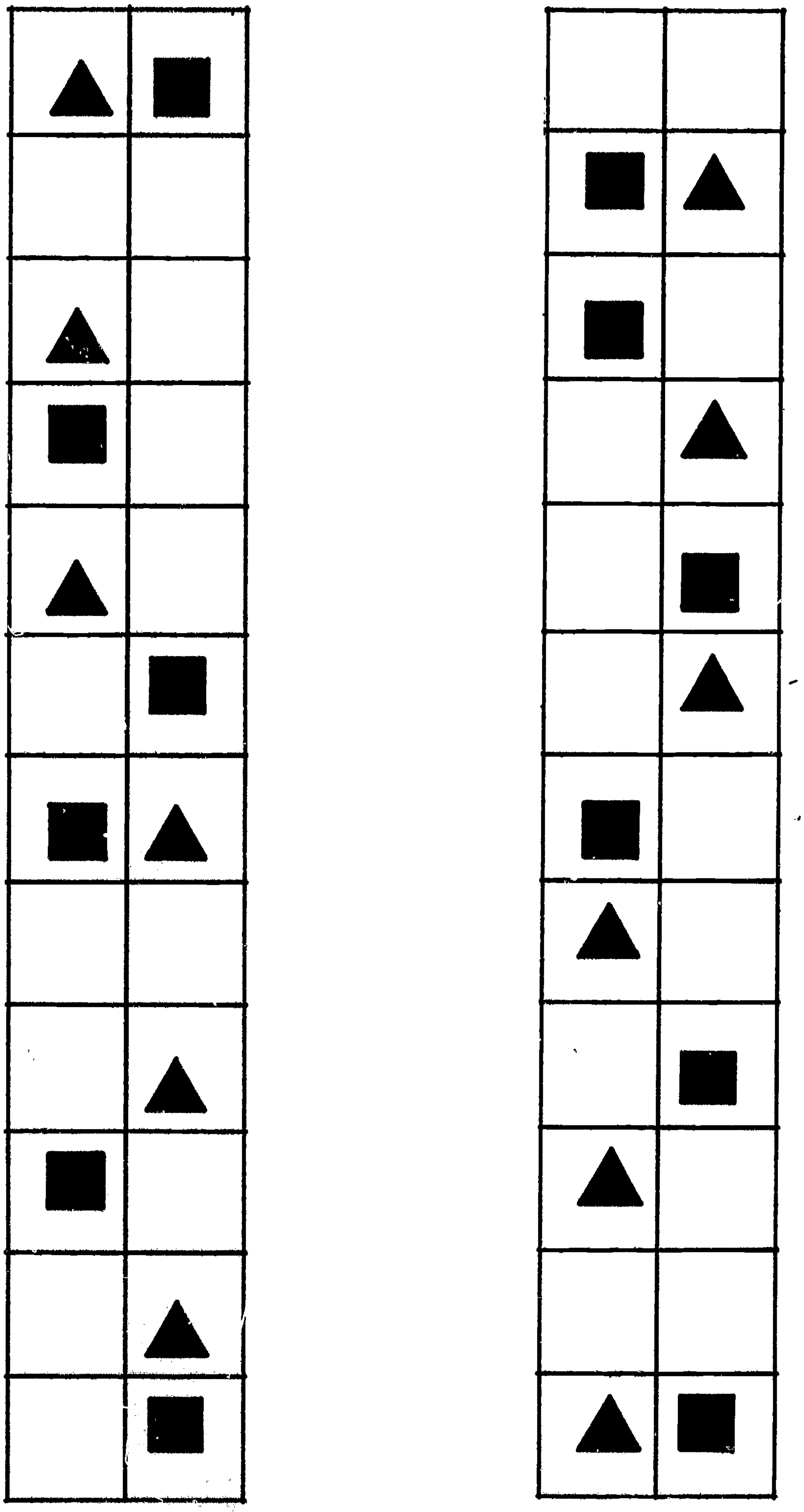
   Navaho ____________

   English ____________

   Both ____________

APPENDIX C

Sample Designs on Film Strips



APPENDIX D

Covariance Tables, Adjusted Means, and Standard Errors of Adjusted Means

ANALYSIS OF COVARIANCE TABLE

Total Number of Trials, Ft. Defiance Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	2	8608,3109				
ERROR (WITHIN)	59	146724,0278	159,0636	146564,9642	58	2526,9821
TREATMENT + ERROR (TOTAL)	61	155332,3387	23,6768	155308,6619	60	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				8743,6978	2	4371,8489

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(2, 58)= 1,730

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	170,5556	170,0345	12,0292
2	142,0833	141,2258	10,8154
3	158,7500	160,2460	12,7276

ANALYSIS OF COVARIANCE TABLE

% of Problems Solved, Ft. Defiance Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	2	2963.3055				
ERROR (WITHIN)	59	48062.1945	8.9858	48053.2086	58	828.5036
TREATMENT + ERROR (TOTAL)	61	51025.5000	221.5271	50803.9729	60	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				2750.7643	2	1375.3821

NULL HYPOTHESIS, NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(2, 58)= 1.660

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	68.2222	68.3461	6.8878
2	83.1667	83.3705	6.1928
3	69.7500	69.3940	7.2878

ANALYSIS OF COVARIANCE TABLE

Total Number of Trials, Chinle Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	1	15.0165				
ERROR (WITHIN)	41	210343.4022	19503.4569	190839.9453	40	4770.9986
TREATMENT + ERROR (TOTAL)	42	210358.4186	18216.2679	192142.1508	41	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				1302.2055	1	1302.2055

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(1, 40)= 0.273

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	265.4348	270.1585	14.5909
2	264.2500	258.8177	15.6770

ANALYSIS OF COVARIANCE TABLE

% of Problems Solved, Chinle Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	1	75.8658				
ERROR (WITHIN)	41	28441.5761	1425.8709	27015.7052	40	675.3926
TREATMENT + ERROR (TOTAL)	42	28517.4419	1205.4999	27311.9420	41	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				296.2368	1	296.2368

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(1, 40)= 0.439

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	51.0870	49.8097	5.4898
2	53.7500	55.2188	5.8984

ANALYSIS OF COVARIANCE TABLE

Total Number of Trials, Combined Samples, Ft. Defiance and Chinle

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	2	57448.5081				
ERROR (WITHIN)	102	610781.2063	4750.5004	606030.7059	101	6000.3040
TREATMENT + ERROR (TOTAL)	104	668229.7144	0.0001	668229.7143	103	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				62199.0084	2	31099.5042

NULL HYPOTHESIS, NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

$F(2, 101) = 5.183$

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	223.7805	223.8900	12.0981
2	197.6136	200.2213	12.0399
3	158.7500	152.7887	18.5715

ANALYSIS OF COVARIANCE TABLE

. % of Problems Solved, Combined Samples, Ft. Defiance and Chinle

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	2	3118.8967				
ERROR (WITHIN)	102	88908.6652	105.9209	88802.7443	101	879.2351
TREATMENT + ERROR (TOTAL)	104	92027.5619	76.6552	91950.9067	103	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				3148.1623	2	1574.0812

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(2, 101)= 1.790

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	58.6098	58.5934	4.6311
2	69.7955	69.4061	4.6088
3	69.7500	70.6402	7.1091

ANALYSIS OF COVARIANCE TABLE

Total Number of Trials, Single or Both Languages, Chinle Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	1	19960.8597				
ERROR (WITHIN)	41	190397.5590	6126.1674	184271.3915	40	4606.7848
TREATMENT + ERROR (TOTAL)	42	210358.4186	18562.1148	191796.3038	41	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				7524.9123	1	7524.9123

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(1, 40)= 1.633

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	232.1538	242.0105	20.6743
2	279.0667	274.7954	12.9336

ANALYSIS OF COVARIANCE TABLE

% of Problems Solved, Single or Both Languages, Chinle Samples

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	1	1581,5444				
ERROR (WITHIN)	41	26935,8974	353,1628	26582,7346	40	664,5684
TREATMENT + ERROR (TOTAL)	42	28517,4419	1260,5543	27256,8876	41	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				674,1530	1	674,1530

NULL HYPOTHESIS, NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES,

F(1, 40)= 1,014

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO,	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	61,5335	59,1719	7,8524
2	48,3333	49,3559	4,9124

ANALYSIS OF COVARIANCE TABLE

Reading Scores, Combined Samples, Ft. Defiance and Chinle

SOURCE	DF	YY	SUM-SQUARES (DUE)	SUM-SQUARES (ABOUT)	DF	MEAN-SQUARE
TREATMENT (BETWEEN)	2	10.5725				
ERROR (WITHIN)	102	320.3129	70.5252	249.7877	101	2.4731
TREATMENT + ERROR (TOTAL)	104	330.8853	80.2090	250.6763	103	
DIFFERENCE FOR TESTING ADJUSTED TREATMENT MEANS....				0.8887	2	0.4443

NULL HYPOTHESIS. NO DIFFERENCE AMONG TREATMENTS AFTER ADJUSTING WITH COVARIATES.

F(2, 101)= 0.180

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

TREATMENT NO.	TREATMENT MEAN	ADJUSTED MEAN	SE ADJUSTED MEAN
1	5.9707	5.9803	0.2456
2	5.5750	5.8951	0.2445
3	6.4350	5.7112	0.3769

REFERENCES

Brown, R. W., and Lenneberg, E. H. A study in language and cognition. *J. abnorm. soc. Psychol.*, 1954, 49, 454-462.

Carroll, J. B., and Casagrande, J. B. The function of language classifications in behavior. In Maccoby, Newcomb and Hartley (Eds.), *Readings in social psychology.* (3rd Ed.) New York: Holt, 1958. Pp. 18-31.

Ervin, S. M. and Osgood, C. E. Second language learning and bilingualism. In Osgood and Sebeok (Eds.), Psycholinguistics: A survey of theory and research problems. *J. abnorm. and soc. Psychol.*, 1954, 49, (4, Part 2), 139-146.

Lambert, W. E., Havelka, J., and Crosby, C. The influence of language-acquisition context on bilingualism. *J. abnorm. soc. Psychol.*, 1958, 56, 239-244.

Lambert, W. E., and Jakobovits, L. A. Verbal satiation and changes in the intensity of meaning. *J. exp. Psychol.*, 1960, 60,376-383.

Lenneberg, E. H., and Roberts, J. M. The language of experience: a study in methodology. Supplement to *Int. J. Amer. Ling.*, 1956, 22, No. 13.

Osgood, C. E. *Method and theory in experimental psychology.* New York: Oxford, 1953.

Stafford, K. R., and Van Keuren, S. R. Semantic differential profiles as related to monolingual-bilingual types. Unpublished paper, 1966.

Suci, G. J. A comparison of semantic structures in American Southwest culture groups. J. abnorm. soc. Psychol., 1960, 60, 25 - 30.

Whorf, B. L. Science and linguistics. Technol. Rev., 1939, 42, 229.