DOCUMENT RESUME

ED 377 452 CS 011 914

AUTHOR	Rickman, David L.; Groth, Kenneth M.
TITLE	Factors Affecting Verbal and Nonverbal Fluency Measures in Nonpatients: A Neuropsychological Approach.
PUB DATE	[94]
NOTE	30p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Age Differences; *Cognitive Processes; Correlation; Educational Background; Higher Education; *Language Fluency; Language Research; *Neuropsychology; Sex Differences
IDENTIFIERS	T Test

ABSTRACT

A study examined the relative contributions of age, sex, and education to verbal and nonverbal fluency in a normal population. Sixty-seven subjects aged 12 to 71 years performed paper-and-pencil tasks proven to be dependent on the right and left hemispheric modalities of the frontal lobes. Multiple t-tests were applied to determine whether differences existed between male and female performances, in addition to comparing intra-subject verbal and nonverbal scores. Pearson Product-Moment correlation coefficients were calculated to investigate any educational or age-related effects, in addition to further examining interaction between verbal and nonverbal fluency scores. Results indicated that verbal fluency correlates significantly with its nonverbal analogue, design fluency, and that education is related to both abilities. Age and sex differences, however, failed to reveal any effect on these performances. It would be of interest, however, to distinguish between higher performance as a result of higher education or higher performance as a result of higher verbal intelligence. (Contains three tables and four figures of data; contains 18 references.) (Author/SR)

Factors Affecting Verbal and Nonverbal Fluency Measures in Nonpatients: A Neuropsychological Approach

David L. Rickman

Kenneth M. Groth

Wayne State University

Running Head: FACTORS AFFECTING FLUENCY MEASURES IN NONPATIENTS

Abstract

The present study was conducted to examine the relative contributions of age, sex, and education to verbal and nonverbal fluency in a normal population. Sixty-seven subjects aged 12 to 71 years performed paper-and-pencil tasks proven to be dependent on the right and left hemispheric modalities of the frontal lobes. Multiple *t*-tests were applied to determine whether differences existed between male and female performances, in addition to comparing intra-subject verbal and nonverbal scores. Pearson Product-Moment correlation coefficients were calculated to investigate any educational or age-related effects, in addition to further examining interaction between verbal and nonverbal fluency scores. Results indicate that verbal fluency correlates significantly with its nonverbal analogue, design fluency, and that education is related to both abilities. Age and sex differences, however, failed to reveal any effect on these performances.

Factors Affecting Verbal and Nonverbal Fluency Measures in Nonpatients: A Neuropsychological Approach

In 1971 Hans-Lukas Teuber, perhaps one of the most eminent neuroscientists of the modern era, argued that the "what" and "how" questions in neuropsychology are still largely unsolved, that is, that we do not yet know what various frontal-lobe dysfunctions signify in terms of normal function, or how cognitive processes within the frontal-lobes can be understood without basing conclusions on data obtained from studies of abnormal function.

Luria (1962, 1973) asserts that the cerebral organization of mental activity can be better understood through analysis of how mental activity is altered in different local brain lesions. Most research in brain function over the past few decades has utilized this approach in locating areas of the brain involved in specific processes. The basic tenet of this approach is that if cognitive deficits exist in a lesioned individual, location of those specific processes/abilities can thus be indicated through comparison with nonlesioned or control subjects. Subjects are usually, but not always, matched for age, sex, handedness, and education in order to control the impact of these variables on between-group comparisons. The present study realizes the importance of this method in determining location of specific cognitive processes within the brain, however, the need for more normative studies is emphasized. The effort to establish effects of individual differences, if any, is not strongly represented in the literature, indeed, the "how" and "what" - in addition to the "where" and "when" - of normal frontal lobe function must be explored. This is the perspective taken in the present study, in which nonpatient individuals were tested in an effort to investigate the effects of individual differences on verbal and nonverbal fluency.

Jones-Gotman and Milner (1977) developed a nonverbal fluency task they considered to be analogous to the Thurstone Word Fluency Test, except theirs is a measure of abilities thought to be dependent on modalities of the right hemisphere rather than the left. They predicted that performance on a design fluency task - the creation of nonsense drawings - would be more adversely affected by lesions in the right hemisphere rather than those localized in the left. In earlier studies, Milner (1964, 1974) demonstrated selective deficits in left-frontal lesioned patients in word fluency, and concluded that verbal fluency reflects processes specific to the left hemisphere. She then investigated the ability of right-frontal lesioned patients to produce nonsense drawings, and found this task to be the nonverbal analogue to word fluency, that is, that right-frontal lesioned patients showed deficits in the ability to spontaneously produce nonsense drawings. This study was clinical in its scope, and it served to further substantiate previous findings (Reed and Reitan, 1963; Zangwill, 1964; Griffith and Davidson, 1966; Perret, 1974) that evidenced lateralization of verbal and nonverbal functions.

Specific factors influencing a normal individual's verbal and nonverbal fluency, however, must be realized. Milner's research has successfully located regions of the brain involved in these functions, however, individual differences in the ability to produce nonsense drawings and/or to recall words beginning with a specific letter are yet undetermined. This topic remains, for the most part, ignored in the literature, and serves as the focal point of the present study. Several issues are thus raised: 1) How are verbal fluency - and its nonverbal analogue, design fluency - affected by age-related factors?; 2) Are verbal and/or nonverbal fluency influenced by such factors as education or sex?; or, perhaps most important, 3) Is there significant relationship between these two fluency skills, even though they are hemispherically differentiated?

In a recent study of normal subjects aged 50 to 89 years, Axelrod (1990) found significant relationship between scores on the vocabulary section of the WAIS-R and design fluency, thereby suggesting cross-modality similarities in hemispherical functioning. In his sample, however, sex and education were found to have no significant effect on either design fluency or vocabulary scores.* This indicates that while verbal knowledge - or even overall intelligence (the vocabulary section correlates strongly - r=0.81 - to full IQ on the WAIS-R) - is related to fluency measures, other individual differences fail to predict these abilities for this particular age group. The Axelrod study did, however, reveal progressive age-related decline in frontal lobe functioning (e.g., IQ scores, problem-solving) among his subjects - albeit miniscule - suggesting that age might play a role in these higher cortical processes to some extent.

*B.N. Axelrod (personal communication, October 7, 1990)

Other studies (Warrington, James, and Kinsbourne, 1966; Borkowski, Benton, and Spreen, 1967; Perret, 1974) have not revealed individual differences in measures of verbal and nonverbal fluency simply because they focused not on these variables but instead on location and severity of lesion in their respective patient samples. While providing valuable information regarding anatomical involvement, they offer little insight in terms of what specific individual differences, if any, influence these processes. The present study focuses on this area of neglect in the literature, and hence, introduces the following hypotheses: 1) that design fluency measures will correlate significantly with word fluency measures, thereby substantiating previous findings that cross-modal similarities exist for these functions; 2) that factors such as sex and education bear no relationship to verbal and nonverbal fluency; and 3) that both design and word fluency will show age-related decline among older subjects.

Method

Subjects

The sample comprised 67 subjects - 30 male and 37 female - ranging from ages 12 to 71 years (M = 35.74, SD = 13.46). All participated in the study on a voluntary basis, and informed consent was obtained from each using a procedure approved by the educational psychology department of Wayne State University. A demographics questionnaire was completed by each subject before testing, in an effort to screen for any relevant anomalies (e.g., severe organic brain damage, chronic mental illness). Upon recognition of any severe frontal-lobe dysfunction and/or substance abuse, the respective subject's responses were eliminated from the data analyses, and in turn, the results of the study.

Test Materials and Procedure

Each subject was asked to complete the entire testing sequence: 1) a demographics/medical history questionnaire; 2) a verbal (word) fluency test; and 3) a nonverbal (design) fluency test. A brief explanation of each of these instruments follows:

1) The demographics questionnaire

The demographics questionnaire consisted of inquiries directed toward obtaining information (e.g., age, education, mental and physical health) relevant to the proposed hypotheses outlined earlier. Each subject was instructed to complete this questionnaire prior to beginning the testing sequence. In the event that any disqualifying conditions were indicated, a note was made by the examiner on the protocol and the subject's responses were eliminated from the study. This process served to limit the scope of the study to nonpatients, thereby establishing normative data required to meet the goals of this research.

2) The Word Fluency Test

In an effort to assess each subject's verbal fluency, a variation of the Thurstone Word Fluency Test (Thurstone and Thurstone, 1943) was utilized. Test materials consisted of paper and pencil, and each subject was instructed to write or to say, first, as many English-language words as they could think of starting with the letters "S" and "C" in two respective five-minute trials. The second condition required the subjects to write or say as many four-letter English-language words as they could think of - this time beginning with the letters "F" and "P" to minimize the role of memory - in two respective four-minute trials. The letters used in both conditions have been classified as easy (Borkowski et al., 1967) based on mean number of associations, however, this study is the first to use a fixed (four-letter) verbal condition as an analogue tc the fixed design fluency task. At the end of each timed trial, the examiner said "stop", and any word left unfinished was rejected from the total output for this test.

3) The Design Fluency Test

In addition to the two aforementioned instruments, each subject completed a nonverbal fluency task developed by Jones-Gotman et al. (1977). The Design Fluency Test (DFT) is comprised of two conditions: 1) a free condition, and 2) a fixed (four line) condition. In the free condition, each subject was required to invent drawings representing neither actual objects nor anything derived from such objects. Before beginning the test, each subject was given two examples of allowable drawings, in addition to illustrations of those that would be disqualified. They were then instructed to make as many different nonsense drawings as they could in 5 minutes, during which reprimands were provided by the examiner in the event of the first scribble or nameable response. These reprimands were in the form of warnings such as, "Remember, you are not allowed to scribble", or "That's nameable. It's a hexagon" (for example).

The fixed condition differed from the free condition in that subjects were asked to create drawings existing of exactly four lines. The examiner provided two examples of allowable drawings during the instruction phase, and explained to the subject the definition of a line: a circle would be counted as one line, a sharp angle two lines, and so forth. Subjects were then told that all drawings were to contain lines that could be counted without ambiguity, that is, to make them distinct so the examiner could differentiate any one line from the other three. Warnings such as those in the free condition were given upon any subject's failure to follow the rules for allowable drawings, in addition to reprimands given when the wrong number of lines were used. Each subject was given four minutes to complete this task.

After the experiment, each subject's verbal and nonverbal fluency response sheets were coded and then separated from the demographics questionnaires, copied on a Xerox machine, and scored individually. Finding the total output for each subject's word fluency was uncomplicated - a Webster's New Collegiate Dictionary (1981) was used in some instances - however, great care was taken to separate perseverative responses from the total output. Output for both free and fixed conditions represent averages derived from each, that is, "S" and "C" responses were averaged, thus providing an individual's free word fluency score across two common letters, and "F" and "P" responses were averaged to provide the fixed word fluency score. Scoring the DFT was more complicated, requiring the establishment of standard criteria by which nonsense drawings were judged. The authors accomplished this by scoring four different protocols each, independently from one another. A comparison was made afterward, in order to establish interscorer reliability. Any discrepancy between the two scorers' methods was discussed, and agreement was reached on specific scoring criteria to be used on each protocol thereafter.

Results

All 67 subjects completed every task. Only one subject was eliminated from the study due to a history of alcoholism. Examination of the demographics questionnaires revealed that most levels of education beyond the 12th grade were well represented. Figure 1

Insert Figure 1 about here

---

illustrates the percentage distribution of all subjects by age, sex, handedness, and years of education. Upon viewing Figure 1 it is evident that the ratio of right-handed to left-handed subjects is approximately 4.5:1, therefore it was decided that any analyses regarding handedness would be excluded from this study because left-handed cases were too few. The number of males to females, however, is fairly equal (males: $n = 30$, females: $n = 37$).

Relatively few subjects listed unallowable words or drew objects that could be named. The mean numbers of perseverative responses on the DFT approximate those reported by Jones-Gotman et al. (1977) - free design $M = 2.9$, fixed design $M = 3.8$ - and appear to be very low in the verbal conditions (free verbal $M = 0.95$, fixed verbal $M = 0.37$). A complete analysis regarding perseverative responses and their interaction with all variables, however, is beyond the scope of this study.

The mean output scores, standard deviations, and t-scores across all subjects as a function of fluency task are shown in Table 1.

Insert Table 1 about here

Significant difference between performance on the free verbal (M = 33.95, SD = 10.95) and the free design tests (M = 14.70, SD = 7.05) was found to exist ($t = 4.9$, $p < .01$). When comparing performances on fixed (four-letter and four-line) conditions, however, it was found that the difference between verbal (M = 16.32, SD = 6.01) and nonverbal (M = 14.47, SD = 5.86) scores were not significant. It must be stated that this difference is a likely reflection of the nature of each test; it is simply easier for subjects to produce words beginning with a specified letter than to produce meaningless drawings with no restriction of lines, thus necessitating a correlational analysis of inter-test performances among subjects.

The effect of sex on verbal and nonverbal fluency was analyzed by using a separate variance estimate t-test, due to a larger female sample size. Table 2 shows the mean output scores, standard deviations,

---

Insert Table 2 about here

---

and t-scores as a function of sex. No significant differences exist at the .01 level between the sexes for any of the verbal or nonverbal tests. This suggests that gender does not discriminate between high and low verbal or nonverbal fluency.

Pearson Product-Moment correlational analysis reveals moderate to strong inter-test association. In fact, all but two inter-test correlations among all subjects yielded significance at the .01 level. Table 3 shows these associations, in addition to the relationship

Insert Table 3 about here

between output scores, age, and education. Free and fixed verbal output scores show the strongest inter-test correlation (r = .79, $p < .001$). Other significant inter-test correlations exist between free and fixed design (r = .70, $p < .001$), free verbal and free design (r = .33, $p < .01$), fixed verbal and fixed design (r = .33, $p < .01$), and free verbal and fixed design (r = .42, $p < .001$). The only inter-test correlation failing to show significant interaction is between fixed verbal and free design (r = .14, p = .138). A graphic representation of these data is provided in Figure 2. It is particularly interesting that the

Insert Figure 2 about here

correlations between the free and fixed conditions are exactly the same, suggesting equal interaction between verbal and nonverbal fluency abilities. It appears that increased performance on the verbal fluency tasks generally indicates a concomitant increase in nonverbal (design) fluency. Age, however, fails to show relationship to performance on any of the four tests (free r = .09, fixed verbal r = .04, free design

r = .07, fixed design r = .05), thus indicating minimal impact of this variable upon these hemispherically differentiated functions.

Educational factors appear to interact significantly with performances on all fluency tests. Graphic illustration of the data contained in Table 3 regarding the effect of education is provided in Figures 3 and 4. These scatter plots show loose clustering of the

Insert Figures 3 and 4 about here

scores around the regression lines, however, tests of correlation reveal that as scores on each test increase, the number of years spent in school for each subject tends to increase in linear fashion. The highest correlation exists between years in education and fixed verbal scores (r = .61, $p < .01$). Significant interactions also exist between education and free verbal scores (r = .44, $p < .01$), fixed verbal scores (r = .49, $p < .01$), and free design performances (r = .41, $p < .01$).

Disc sion

The aim of this experiment, to determine the effects of age, sex, and education on verbal and nonverbal (design) fluency, has been realized. It has been established that significant correlations exist between verbal and design fluency scores, thereby suggesting that despite their hemispheric localization, these functions appear to interact with one another. In turn, it is indicated that the design fluency task is indeed the nonverbal analogue to verbal fluency, thus substantiating the claim of Jones-Gotman and Milner (1977).

The hypothesis that sex bears no relationship to verbal and nonverbal fluency has been rejected in the present study. Performances were not significantly different on any tests as a function of sex. This finding contradicts previous research (Bolla, Lindgren, Bonaccorsky, and Bleecker, 1990; Veroff, 1980) that reported higher performance on word fluency tasks among females. It is possible, however, that the previous studies employed less stringent techniques for matching males and females on education, thereby making accurate interpretation difficult to attain.

Performances on all tests used in the present study were not found to decline with age. While these results agree with Bolla et al. (1990), they fail to substantiate previous findings (Axelrod, 1990) associating age with progressive decline in frontal lobe function. The present study involved a younger population than the Axelrod study, however.* It is possible that in order to determine the effect of age on verbal and design fluency, a wider age range than 12 to 71 years must be used. In a study of 20 to 59 year olds, Cauthen (1978) found no significant differences in verbal fluency across decade age ranges, thus supporting the premise that exclusion of individuals over 70 years of age might result in nonsignificant differences.

The hypothesis that education would not interact with verbal or nonverbal fluency performances has also been rejected as a result of the data gathered in this study. Significant correlations between all fluency measures and years of education were revealed, thereby indicating an existing interaction. Although this was the first study

*B.N. Axelrod (personal communication, April 15, 1991) to examine the effects of education on design fluency, previous research (Gade et al., 1985) regarding education and verbal fluency has failed to yield significant correlations between the two measures. The present study contradicts this research, finding significant interaction between education and free and fixed verbal fluency measures, in addition to both nonverbal fluency conditions. Bolla et al. (1990) stress that special attention to verbal intelligence as opposed to educational level appears to be critical in developing norms for an elderly population. Higher levels of formal education were the exception rather than the rule in their sample of older individuals. Due to the relative youth of the subjects in the present study, this is not a concern, nevertheless, it would be interesting to distinguish between higher performances as a result of higher education or higher performance as a result of higher verbal intelligence. It has been suggested that those with higher verbal intelligence probably employ more effective recall strategies, have better organization skills, have a broader knowledge of vocabulary, and greater semantic linguistic facility at their disposal (Bolla et al., 1990). While it is yet unknown what role these skills would play on visual tasks such as the DFT, it is probable that interaction would exist.

References

Bolla, K.I., Lindgren, N., Bonaccorsy, C., and Bleecker, M. (1990). Predictors of verbal fluency (FAS) in the healthy elderly. Journal of Clinical Psychology. 46, 623-628.

Borkowski, J.G., Benton, A.L., and Spreen, O. (1967). Word fluency and brain damage. Neuropsychologia 5, 395-402.

Cauthen, N.R. (1978). Verbal fluency: Normative data. Journal of Clinical Psychology 34, 126-129.

Gade, A., Lykke, E., Mortensen, H., Vaesen, H., Jonsson, A., and Udesen, H. (1985). Predictors of cognitive performance: Age, education, and intelligence. Paper presented at the Eighth European Conference of the International Neuropsychological Society, Copenhagen.

Griffith, H., and Davidson M. (1966). Long-term changes in intellect and behavior after hemispherectomy. Journal of Neurology, Neurosurgery, and Psychiatry 29, 571-568.

Jones-Gotman, M. and Milner, B. (1977). Design fluency: The invention of nonsense drawings after focal-cortical lesions. Neuropsychologia 15, 653-674.

Luria, A.R. (1973). The working brain. New York: Basic Books Inc.

Luria, A.R. (1980). Higher cortical functions in man. (B. Haigh, Trans.). New York: Basic Books, Inc. (Original work published 1962).

Milner, B. (1964). Some effects of frontal lobectomy in man. In J.M. Warren and K. Eckert (Eds.), The frontal granular cortex and behavior. (pp. 313-334). New York: McGraw-Hill.

Milner, B. (1974). Hemispheric specialization: Scope and limits. In F. Schmidt and F. Worden (Eds.), The neurosciences: Third study program (pp. 75-89). Boston: M.I.T. Press.

Perret, E. (1974). The left frontal lobe of man and the suppression of habitual responses in verbal categorical behaviour. Neuropsychologia 12, 323-330.

Reed, H.B.C. Jr., and Reitan, R.M. (1963). Intelligence test performances of brain damaged subjects with lateralized motor deficits. Journal of Consulting Psychology 27, 102-106.

Teuber, H.L. (1972). Unity and diversity of frontal lobe functions. Acta Neurobiologica Experimentalis 32, 615-656.

Thurstone, L., and Thurstone, T. (1943). The Chicago Tests of Primary Mental Abilities. Chicago: Science Research Associates.

Veroff, A. (1980). The neuropsychology of aging: Qualitative analysis of visual reproductions. Psychological Research 41, 249-268.

Warrington, E.K., James, M. and Kinsbourne, M. (1966). Drawing disability in relation to laterality of cerebral lesion. Brain 89, 53-82.

Webster's New Collegiate Dictionary. (1981). Springfield, MA: G. & C. Merriam Co.

Zangwill, O.L. (1966). Psychological deficits associated with frontal lobe lesions. International Journal of Neurology 5, 395-402.

Acknowledgements

We wish to express our gratitude toward all subjects who participated in this study. Special thanks to Dr. Bradley Axelrod, Veteran's Administration Hospital, Allen Park, MI, for his inspiration, and Dr. Schlomo Sawilowsky, Wayne State University, for taking time out of his busy schedule to assist in data analysis.

Table 1

Mean Output Scores, Standard Deviations, and t-Scores Across All Subjects as a Function of Fluency Task

Fluency Task				
Free Verbal (n = 67)		Free Design (n = 67)		
M	SD	M	SD	t (df)
33.95	10.95	14.70	7.05	4.9* (66)
Fixed Verbal		Fixed Design		
M	SD	M	SD	t (df)
16.32	6.01	14.47	5.86	2.25 (66)

*$p < .01$

Table 2

Mean Output Scores, Standard Deviations, and t-Scores as a Function of Sex

	Group					
	Male (n = 30)		Female (n = 37)			
Fluency Task	M	SD	M	SD	t	(df)
Free Verbal	31.25	10.94	36.14	10.61	1.84*	(61.36)
Free Design	13.30	5.58	15.92	7.93	1.58*	(63.84)
Fixed Verbal	15.57	6.06	16.93	6.00	0.92*	(61.88)
Fixed Design	13.70	5.53	15.11	6.12	0.99*	(64.18)

*p > .01

Table

Correlations Between Age, Education, Verbal Fluency (Free and Fixed Conditions), and Design Fluency (Free and Fixed Conditions)

	Fixed Design	Free Design	Fixed Verbal	Free Verbal	Education	Age
Age	.05	.07	.04	.09		
Education	.61*	.41*	.49*	.44*		
Free Verbal	.42*	.33*	.79*	——	.44*	.09
Fixed Verbal	.33*	.14	——	.79*	.49*	.04
Free Design	.70*	——	.14	.33*	.41*	.07
Fixed Design	——	.70*	.33*	.42*	.61*	.05

*$p < .01$

Figure Caption

Figure 1. Percentage distribution of subjects by age, sex, handedness, and years of education.

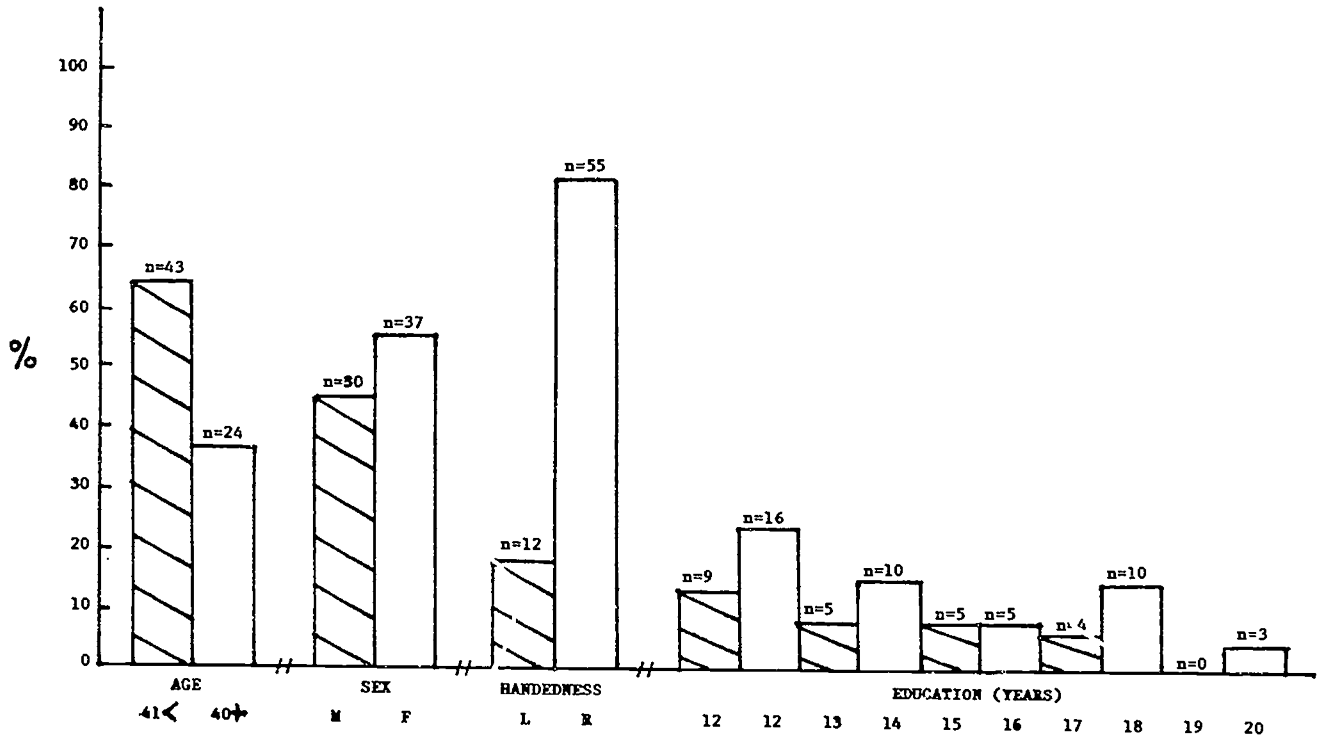
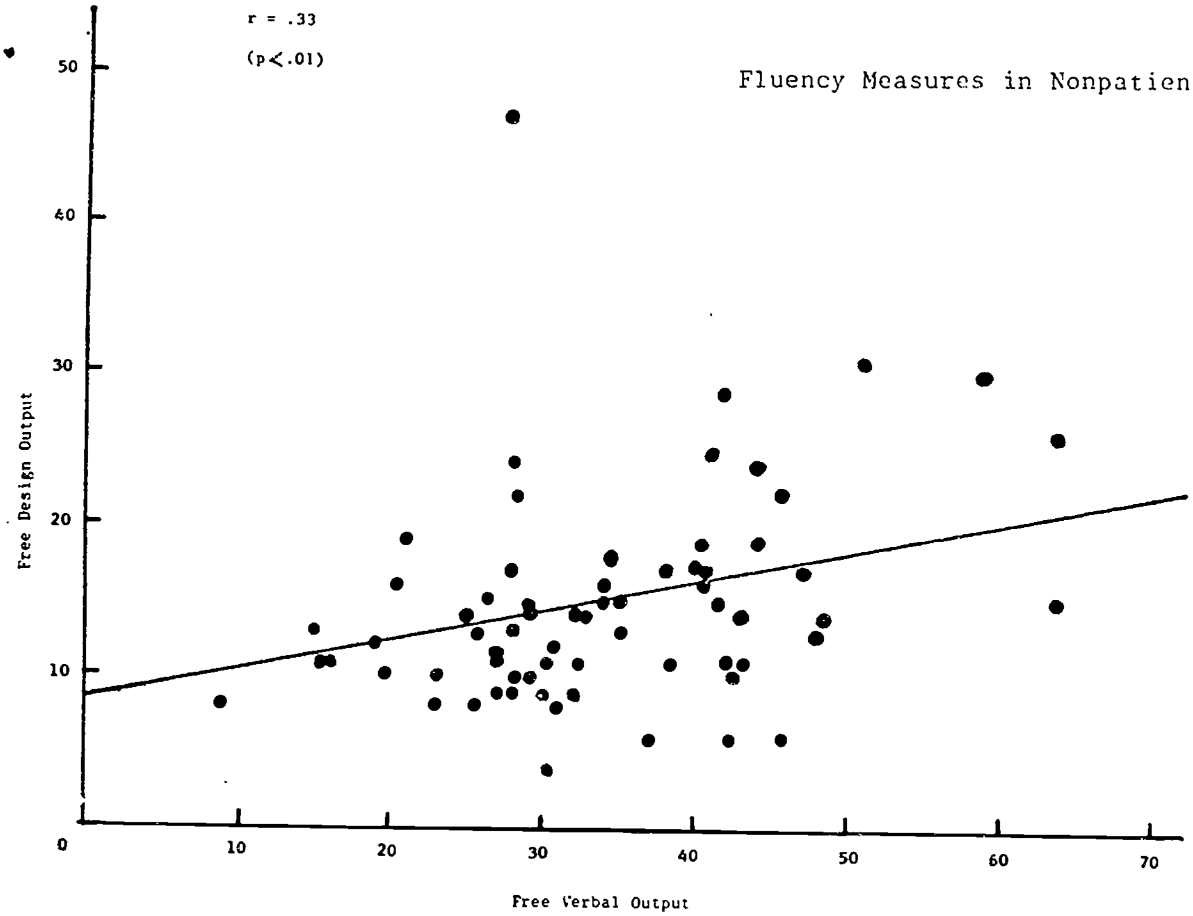

%
100
90
80
70
60
50
40
30
20
10
0
n=43
n=24
n=30
n=37
n=12
n=55
n=9
n=16
n=5
n=10
n=5
n=5
n=10
n=0
n=3
AGE
41<
40+
SEX
M
F
HANDEDNESS
L
R
EDUCATION (YEARS)
12
12
13
14
15
16
17
18
19
20

Figure Caption

Figure 2. Correlations between verbal fluency output scores (free and fixed conditions) and design fluency output scores (free and fixed conditions).


r = .33
(p<.01)
Free Design Output
Free Verbal Output
0
10
20
30
40
50
60
70

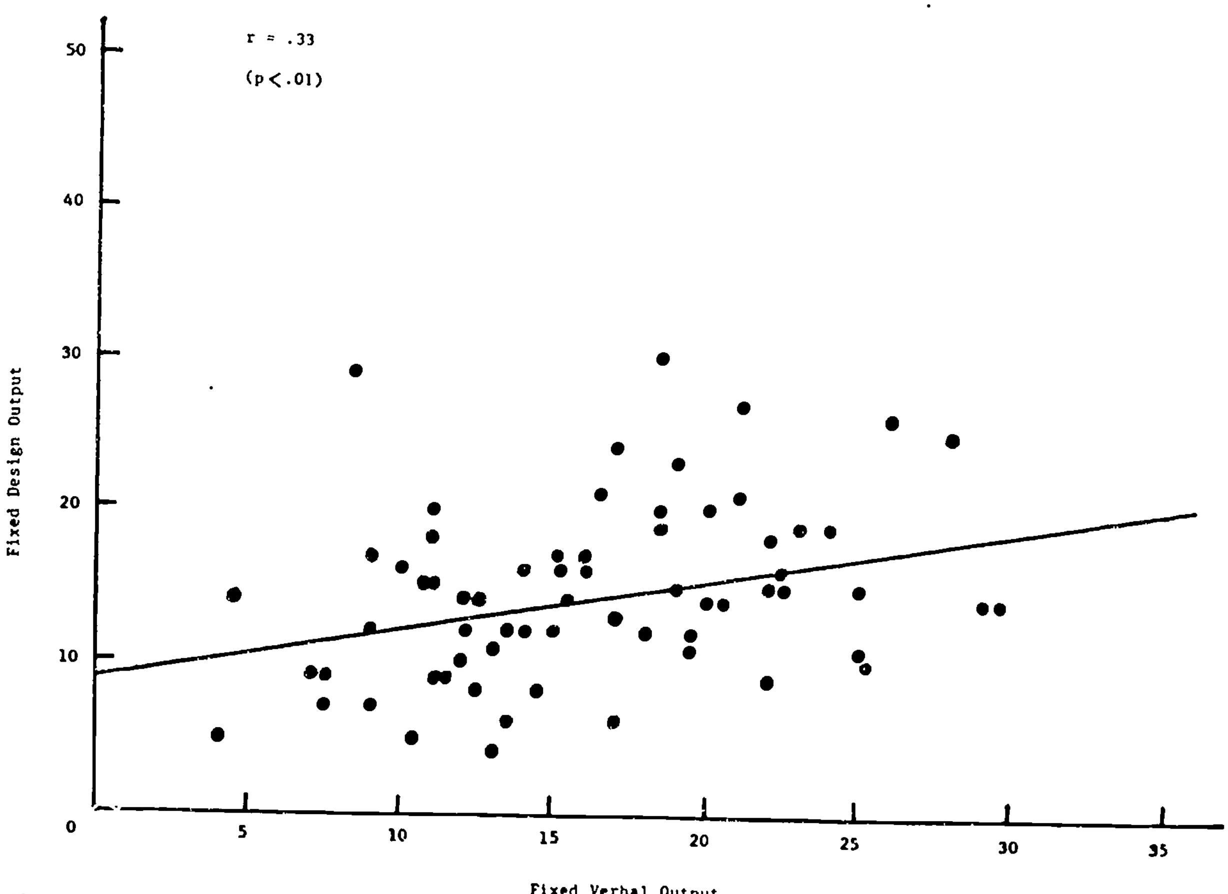
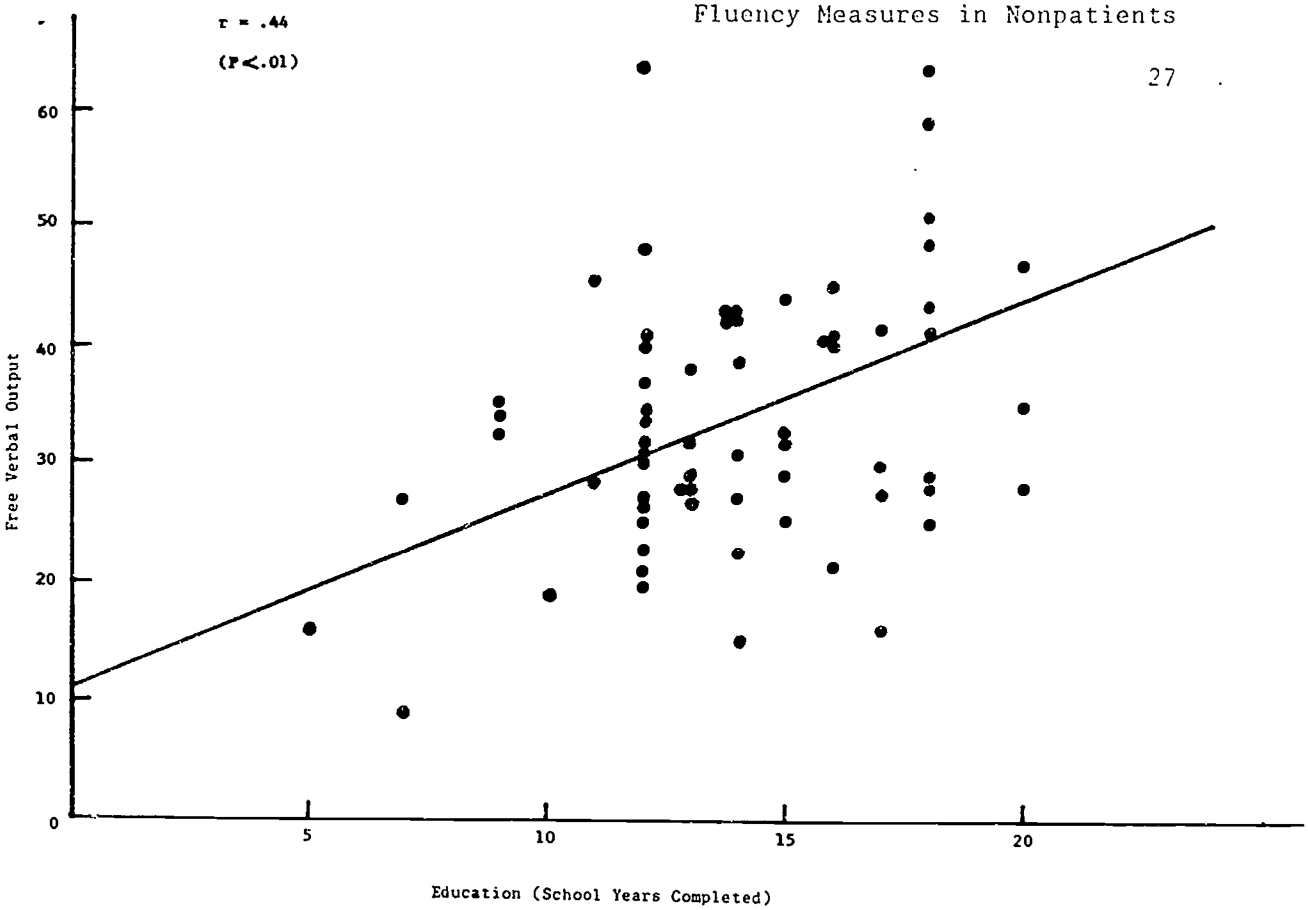

r = .33
(p<.01)
Fixed Design Output
Fixed Verbal Output
0
5
10
15
20
25
30
35

Figure Caption

Figure 3. Correlations between verbal fluency output scores (free and fixed conditions) and education.


r = .44
(P<.01)
Free Verbal Output
0
10
20
30
40
50
60
5
10
15
20
Education (School Years Completed)

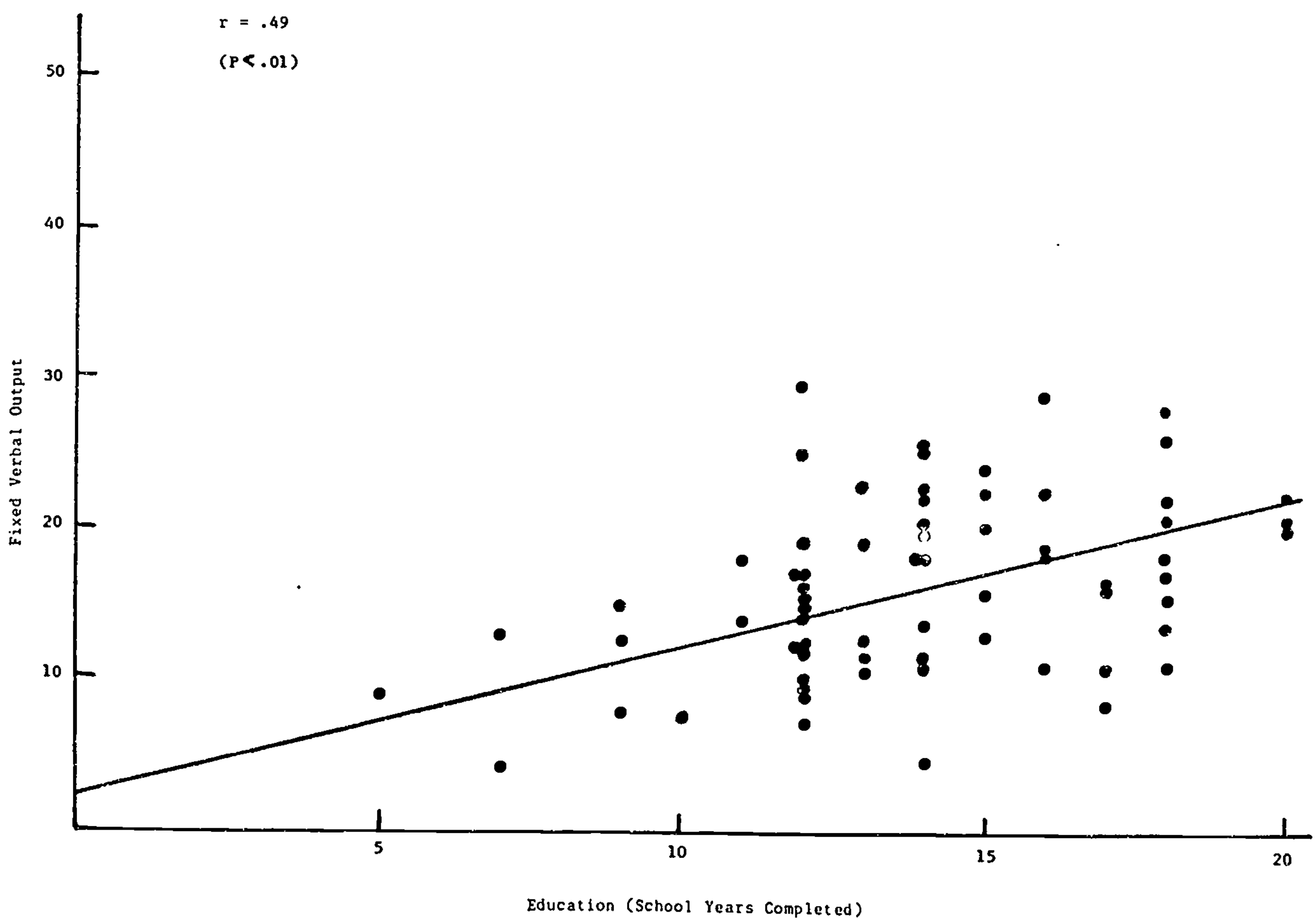
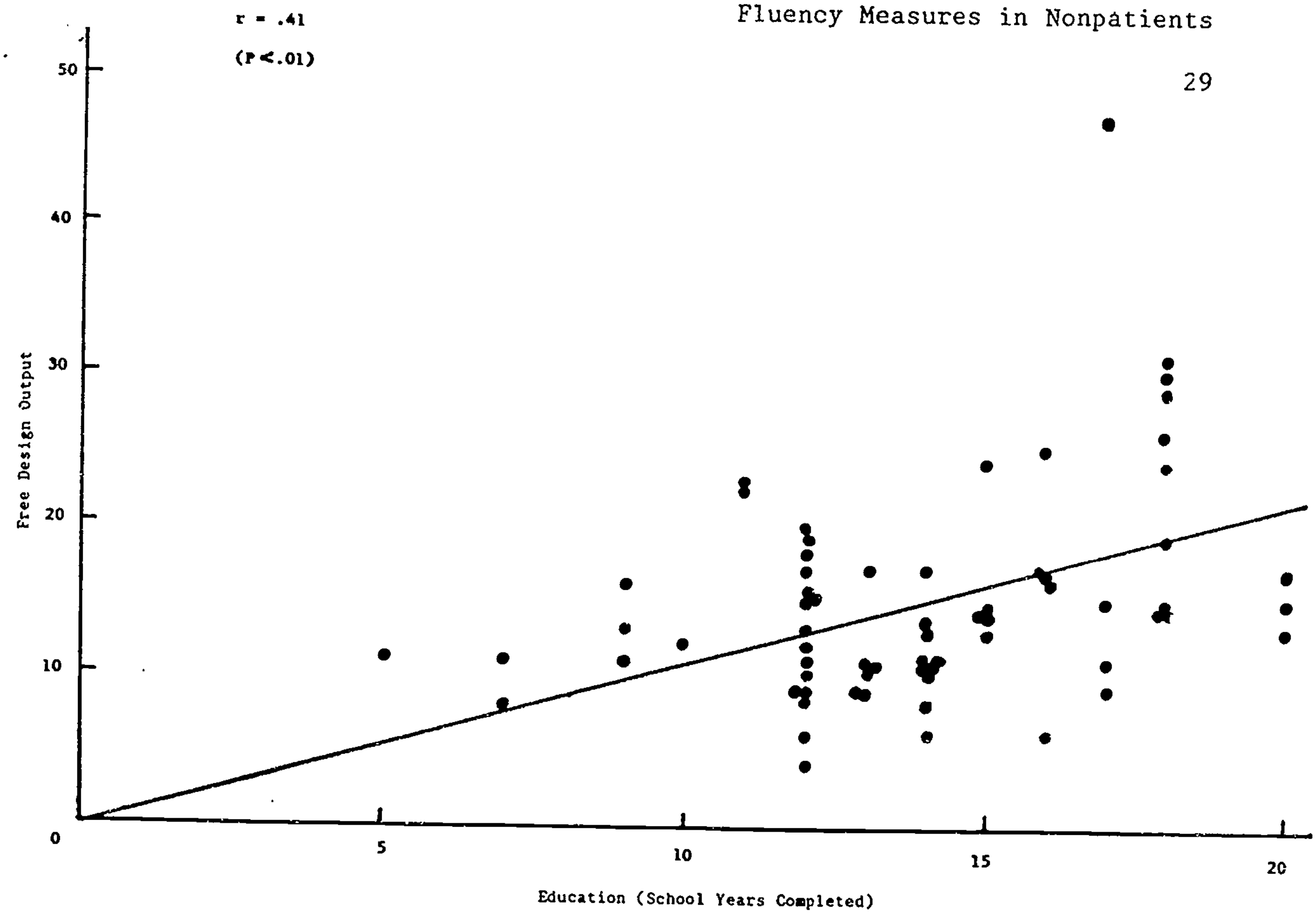
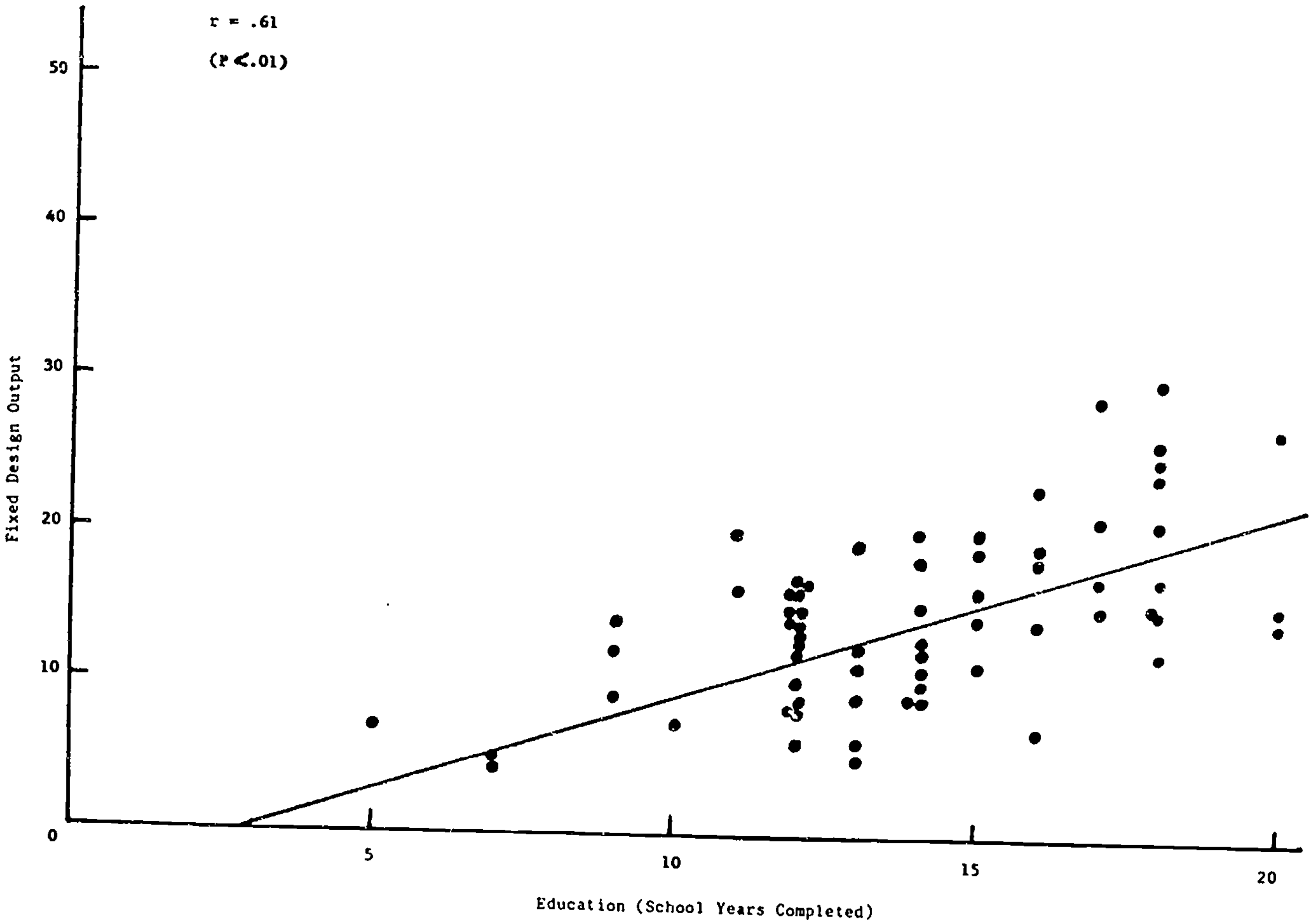

r = .49
(P<.01)
Fixed Verbal Output
10
20
30
40
50
5
10
15
20
Education (School Years Completed)

Figure Caption

<u>Figure 4</u>. Correlations between design fluency output scores (free and fixed conditions) and education.


r = .41
(P<.01)
50
40
30
20
10
0
Free Design Output
5
10
15
20
Education (School Years Completed)


r = .61
(P<.01)
50
40
30
20
10
0
Fixed Design Output
5
10
15
20
Education (School Years Completed)