

Running Head: Normals on the LNNB

Performance of Normal Adults on the Luria-Nebraska Neuropsychological Battery, Form I

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Abstract

To examine three problems in the interpretation of the Luria-Nebraska Neuropsychological Battery (LNNB), the normal participants from four different studies were pooled to form a sample of 241 LNNB profiles. The first problem addressed was the LNNB's false positive rate. All five yes/no decision rules were applied simultaneously. Each individual rule had a 0-8% false positive rate: combining the rules in four different ways increased the false positive rate by 0-6%. When divided into over and under 65 year-old groups, each rule applied to the younger group had a 0-5% false positive rate: combining them increased the rate to 6-8%. When applying the rules to the older group, each rule had a 0-27% false positive rate: combining all rules but the one with the highest error rate produced a false positive rate of 27%. The false positive rate for the entire sample was 12%. To solve the second problem of interpretation, making qualitative item analyses easier, the difficulty level (i.e., percentage of normals missing the item) for each item was calculated. The third problem was the LNNB's malingering formula's accuracy. The formula was applied to the sample: as expected, the normal profiles had an inaccuracy rate of 26%. The few mildly impaired profiles had a 6% inaccuracy rate. When applied to the entire sample of normals and using the appropriate interpretive guidelines, the formula had a false positive rate of 1%.

Performance of normal adults on the Luria-Nebraska Neuropsychological Battery, Form I

David Faust (Faust, 1996; Faust, Ziskin & Hiers, 1991) has argued that the forensic use of the Luria-Nebraska Neuropsychological Battery (LNNB) should be challenged during cross-examination by a) calling into question its false positive rate, b) citing the requirement that a qualitative item analysis be done in addition to the quantitative analysis, and c) describing its susceptibility to being faked. The answers to these challenges require studies be done on a large group of normal people.

The LNNB, like many neuropsychological tests, was originally normed on a large sample of normal people. Unfortunately, the original normative sample has been lost (C. Golden, personal communication, 1992). To solve the three challenges posed by Faust, the present authors pooled the data from four LNNB studies (Conley, 1985; Puente, Brinkley & King, 1990; Roecker, House & Graybill, 1992; Rogers, 1983) that collected profiles from normal adults. The three challenges are presented as three different studies.

Experiment 1

The first problem concerns the false positive rate (FPR) of the LNNB Form I. Faust (1996; Faust et al., 1991) has argued that any neuropsychologist presenting abnormal test results in a forensic setting should be queried on the FPR of that test. For both the LNNB and Halstead-Reitan Battery (HRB), the answer to such a question is complicated by the diversity of established rules for the differentiation of normals from people with true neuropsychological deficits, henceforth referred to as "decision rules." The LNNB's rules are defined in Table 1, with the validation and cross-validation studies that used normals summarized in Table 2.

 Insert Tables 1 & 2 About Here

The first manual (Golden, Hammeke & Purisch, 1980) recommended using the "2 Point Rule," which has a cross-validated FPR of 17% (Golden, Moses, Graber & Berg, 1981b). The cross-validation used 60 normals (see Table 2 for demographic means and standard deviations). A

formula to estimate the premorbid level of functioning was introduced, and labeled the "Critical Level" (CL). The 2 Point Rule used the age and education formula defined in Table 1.

Other studies' samples have yielded lower FPRs for the 2 Point Rule. One sample of 40 hospitalized normals yielded an FPR of 12.5% (Berg & Golden, 1981) and another sample of 25 medical outpatients yielded an FPR of 8% (Johnson, 1982; Johnson, Moses & Bryant, 1984). A sample of 20 normals yielded an FPR of 5% (Newman, 1984; Newman & Sweet, 1986). One sample of 14 older normals had an FPR of 7% (Spitzform, 1982), and another ($N = 78$) yielded an FPR of 8% (MacInnes et al., 1983).

However, the second manual (Golden, Purisch & Hammeke, 1985) recommended the use of four other rules, as well as an alternative method of calculating the CL (defined in Table 1). This alternative CL formula has not yet been used in any study of LNNB false positives, although one study (Roecker et al., 1992) refers to this formula.

The FPR for the "3 Point Rule" was initially established as 27% (Sawicki & Golden, 1984). This study used 135 medical patients and the age x education CL formula. However, 23% of these Ss were taking CNS depressants at the time of testing, which might have elevated their LNNB scores. This possibility suggests (but certainly does not prove) that the 3 Point Rule FPR is only 4%. The study also did not use the alternative CL rule recommended by the 1985 manual.

Other, smaller studies have also reported the 3 Point Rule's FPR, but found lower FPRs. A sample of 104 normals yielded an FPR of 9% (Roecker et al., 1992). However, the sample was purposefully bimodal, with younger and older groups. When the normals over age 65 were eliminated, the remaining 52 normals (age range 18-30) yielded an FPR of 4%. In another study, a sample of 15 normals (only an age mean of about 36 years was reported) yielded an FPR of 0% (Ayers, 1987; Ayers, Abrams, Newell & Friedrich, 1987). The sample of 60 normals described previously (Golden et al., 1981b) was reanalyzed (Moses & Maruish, 1989) to yield an FPR of 7%. The sample of 20 normals described previously yielded an FPR of 0% (Newman, 1984; Newman & Sweet, 1986).

The effect of age extremes on the 3 Point Rule's FPR has also been studied. The 3 Point Rule's FPR in a subsample of 28 adolescent ($N = 31$; age range 13-17 years) normals was 10% (Lewis, Hutchens & Garland, 1993), again only using the age x education CL. A sample of 52 older (age range 65-85) normals yielded an FPR of 13.5% (Roecker et al., 1992). Combining the 5 smaller samples (counting Roecker et al.'s sample as one) produces a sample with an N of 227, age range of 13-85, and a 3 Point Rule FPR of 7%.

The FPR for the "30 Point Rule" was initially established at 23% (Sawicki & Golden, 1984). This study used the same 135 normals used to validate the 3 Point Rule, and the FPR is exactly that of the normals taking CNS depressants at the time of the testing. The 104 normals described previously (Roecker et al., 1992) yielded an FPR of 20% for the combined sample, 8% for the younger sample, and 33% for the older sample. A subsample of the adolescents described previously ($n = 23$) yielded a 30 Point Rule FPR of 26% (Lewis et al., 1993).

The "2 Point L1-L8 Rule" described in the manual (Golden et al., 1985) used scales initially constructed using 77 normals with age $M = 41.3$ ($SD = 16.3$) and education $M = 11.9$ ($SD = 2.8$) (McKay & Golden, 1979). The subsample of 28 adolescents cited previously yielded an FPR of 10% (Lewis et al., 1993). The rule apparently has otherwise not been studied on normals.

The only study using the "30 Point L1-L8 rule" employed the sample of 31 normal adolescents described previously, and yielded an FPR of 0% (Lewis et al., 1993).

The Luria-Nebraska Impairment Index (LNII) has been normed (Johnson, 1982; Johnson et al., 1984) and reviewed (Moses & Maruish, 1989) as a way of describing the level of neuropsychological impairment, akin to the HRB's Average Impairment Rating (Russell, 1984; Russell, Neuringer & Goldstein, 1970). The LNII was normed on 101 neurological patients and 62 controls. The cross-validated FPR was 16%, using the sample of 25 medical patients described previously.

The 1985 manual recommends the combined use of the 3 Point, 30 Point, 2 Point L1-L8, and 30 Point L1-L8 Rules, using the lower of the two numbers produced by the two CL methods (the "Manual Rule"). However, the effect on the FPR of using this combination has never been

studied. Likewise, no study has yet determined the effect on the FPR of adding the LNII to the Manual Rule (the "5 R Rule"). The rules might be additive, so the FPR rises five-fold, or one rule might be so sensitive it provides a ceiling effect. Given the small sample sizes and lack of cross-validation samples for every rule, the FPR of the Manual and 5 R Rules are unknown, as are the effects of advanced age. To solve this problem, we applied the various decision rules to the current combined normal sample of 241.

Method

Participants. Participants were screened for each study with careful interviews. None were accepted for inclusion if they had any history of neurological insult or violence, were in poor health or substance detoxification, or on any CNS depressant medication.

The total number of participants was 241. The University of North Carolina at Wilmington provided 104 participants, 104 came from rural midwestern communities, 18 came from Metropolitan Correctional Center San Diego, and 15 came from Oklahoma State University. The combined group had an age range of 17-84 ($M = 33.22$, $SD = 21.68$). Their education had a range of 6-18 ($M = 12.84$, $SD = 2.2$). The distributions of age and education are not even: Figures 1 and 2 present the distributions for these variables. Figure 3 presents the scattergram of age by education. Note the over-representation of young college students, and the complete lack of Ss between 45 and 64. The sample is clearly bimodal, with the younger group's ($n = 189$) age range being 17-44 ($M = 22.19$, $SD = 4.8$), and an education range of 6-18 ($M = 13.4$, $SD = 1.7$). The older group's ($n = 52$) age range is 65-84 ($M = 74.17$, $SD = 5.96$), with education range of 8-16 ($M = 10.91$, $SD = 2.66$). Although the n is the same, the older group is not exactly the same participants as in Roecker et al.

 Insert Figures 1, 2, & 3 about here

Materials & Procedure. The LNNB Form I was administered and scored using the standard instructions (Golden et al., 1980; Golden et al., 1985), and the decision rules defined in Table 1 were applied.

Results & Discussion

Table 3 presents the distribution of the decision rules and the effect of combining them into the Manual and 5 R Rules. Table 4 presents the correlation of the Rules' outcomes with age and education by group. Given the Rules' highly significant correlations with age and clearly bimodal sample distribution, the Rules' FPRs in Table 3 are also reported for the two age groups. No S had an LNII above 2.

 Insert Tables 3 & 4 about here

For the combined sample, using the Manual Rule adds 3% to the FPR of the next highest rule, the 30 Point Rule. Using the 5 R Rule adds 6% to the FPR of the 30 Point Rule.

With an FPR of 27%, using the 30 Point Rule with patients over 64 would seem to be a source of error. Not using it with the older group (making the 30 Point Rule's FPR for the older group 0%) reduces the combined group's 30 Point FPR to 2%, the Manual Rule's FPR to 8% (3% over the other rules' FPRs), and the 5 R Rule's FPR to 12% (5% over the LNII). The older group's Manual Rule FPR falls to 17% (4% over the 3 Point Rule's FPR), and the 5 R Rule's FPR falls to 27% (10% over the LNII). The CL, however calculated, clearly does not completely control for advanced age. The judicious use of Table 3 should enable clinicians and researchers to minimize incorrect conclusions when using the LNNB.

Experiment 2

The second problem concerns the difficulty level of each item. Advocates of the Lurian method (Akhutina & Tsvetkova, 1983; Christensen, 1975; Golden et al., 1980; Golden et al., 1985) argue that each item should be considered in context. The 1985 manual's Appendix D provides "Item Difficulty" coefficients with which to judge the emphasis to be placed on a patient's

impaired performance on any given item. While the coefficients were calculated using 161 normals, the demographics of these normals are not reported, and nothing is known of the effects of age upon the coefficients. More importantly, the coefficients are simply the average score. The manual notes that this combines 1 and 2 scores, making it impossible to determine how each of the 161 Ss scored.

In addition, some coefficients are unreasonably high. For example, Item 2 has a difficulty level of .79! This item is a very simple one, designed to provide a basal level of simple movement by which to judge later measures of motoric praxis (Christensen, 1975). To obtain a difficulty level of .79, 40-80% of the 161 Ss would have had to miss the item. Contrary to Appendix D, most LNNB item difficulty coefficients should approach 0 (Puente et al., 1990) in normals.

Method and Results

To gain clarity, item Difficulty Levels (DL: the percentage of Ss getting an item score greater than 0) were calculated using the present sample. Table 5 presents the percentage of Ss missing each item, separated by score (1, 2, or either) and age group (younger, older, combined).

 Insert Table 5 About Here

Discussion

In general, the item DLs are well below those of provided in the 1985 manual. For example, Item 2's DL is a quarter that of the manual's. As expected, the younger group missed fewer items than the older group. The range of the DLs for the combined group is 0-55; the range for the younger group is 0-44 (Item 108's DL of 50 for the younger group is an anomaly, caused by an overly strict scorer. This item should be regarded as having DLs of 0); the range for the older group is 0-100. Not surprisingly, the older group especially had trouble with timed speed and mobility items (e.g., Items 1-2, 21-23, 33, 85); the greatest DL difference (79%) between the two subgroups is Item 21, a timed coordination task.

Some items were missed by both groups. For example, Item 36 ("Draw a circle") was missed by 29% of the younger group and 87% of the older group, although later, similar items (38, 40, 42, 44, 46) have lower levels. Some items are at face difficult, and sometimes the DLs reflect it (e.g., Items 89, 179, 184, 196, 266), sometimes not (e.g., Items 140, 151, 268). The most difficult item for both subgroups is Item 171.

Authorities in the Lurian method and the LNNB disagree on the difficulty of individual items. Christensen warns that Items 97-99 "are not always easily performed even by healthy subjects" (Christensen, 1975, p. 74). However, the 1985 manual (Golden et al., 1985, p. 139) describes Item 99 as "a very simple task," with normals "rarely" getting a score greater than one. In this study, Item 99 produced DLs of 23 (younger), 72 (older), and 32 (combined). In the younger group, 14% obtained a score greater than one.

Golden and colleagues (Golden et al., 1981a; Golden et al., 1982) consider the items in Table 4 marked with an * to be "so simple that no normal person would be expected to miss them under ordinary conditions;" (Golden et al., 1982, p. 148) "all are quite simple and would not usually be missed by a normal individual." (Golden et al., 1982, p. 149). In the present study, only Item 10 receives a DL of 0; the other 16 items have DL ranges of .52-16 (younger), 0-87 (older), and .41-30 (combined), excluding Item 108. Item 85 would seem to have been unexpectedly difficult for the current sample.

Inclusion of the DL of missed items can enhance a report or testimony. Table 5 can be used to add miss rates expressed in percentages. For example, Item 22, an alternate tapping task, is rarely missed by the younger group (DL = 4%). Serial 7s (Item 221) is a commonly used task in mental status exams; 84% of the current sample could get at least 4 calculations in 30 seconds, and only 2% of the combined group failed it completely, compared to 38% of the older group. A perhaps better task to note is the untimed learning of a seven-word list (Item 223); 95% of the older group (100% of the younger group) could learn this list within five trials with less than 9 errors.

Users of the Screening Test for the LNNB (Golden, 1987) should note the DLs of the 15 items used in that test (Items 22, 23, 33, 59, 176, 205, 208, 209, 219, 221, 222, 223, 227, 230,

256. Not surprisingly, these items are fairly easy for the younger group, with a DL range of .52-15.

Experiment 3

The need for detecting malingered neuropsychological protocols has been well documented (Faust, 1996; Heaton, Smith, Lehman & Vogt, 1978; Rogers, Harrell & Liff, 1993). The need was addressed with an empirically derived LNNB formula that has a cross-validated hit rate of 91%, with 17% false negative rate and 7% false positive rate (McKinzey, Podd, Krehbiel, Mensch & Trombka, in press). However, these rates were obtained by eliminating participants who generated normal profiles. In the cross-validation, the Ss were either 51 normals asked to fake the LNNB or 202 patients referred for neuropsychological evaluation. Of the latter, 50 (25%) had an LNII of one (normal). Of that 50, 9 (18%) had a formula result of malingering. However, this rate might be higher or lower in a diversified sample of true normals. In addition, nothing is known of the effect of age. Especially interesting is the formula's performance on the current sample's false positives. The purpose of the third experiment was to test the utility of the formula by examining how well it differentiates between the false positive and true negative profiles obtained from the current sample.

Method & Results

The same sample and materials previously described were used. The malingering formula was applied to the 241 participants. The 5 R Modified Rule was used to determine impairment.

Table 6 presents the distribution of the malingering formula and 5 R Modified Rule outcome by age groups. When the malingering formula result was dummy coded (Fake = -1, Not Fake = 1), the correlation of the result and age was significant ($r = .21$, $p = .0009$). The correlation of the faking formula result and education was not significant ($r = -.07$, $p = .2675$).

Insert Table 6 about here

Discussion

When applied to normal profiles, the formula is fairly inaccurate (13-28% inaccuracy rate, depending on group). However, the formula is accurate (0-13% inaccuracy rate, depending on group) when applied to abnormal profiles of people presumed to be normal. Of 29 normals having at least one decision rule positive (i.e., using the 5 R Modified Rule) only 2 (7%) had a faking formula result of malingering, 1% of the entire sample. This is consistent with the formula's cross-validation study (McKinzey et al., in press). Of 202 people who had been referred for neuropsychological evaluation (cross-validation sample), 10 (5%) had a faking formula result of malingering, a 5 R Modified Rule result of positive, and an LNII of less than 5, and were therefore misclassified. The current results support the interpretive guideline that a formula outcome of "malingering" should not be considered in a normal LNNB profile.

Summary

Faust's three challenges can now be answered in great detail. Empirically studied FPRs can be cited for the rules used and estimates sharpened for specific age groups. Qualitative item analyses can be done more easily, defended with specific numbers, and explained with item examples. The patient's motivation to fake the LNNB can be assessed with a formula unlikely to produce a false positive outcome in a normal person. This is the only study done to address these heretofore troublesome challenges.

Of course, as Figure 3 shows, this sample is clearly imperfect. It has many empty age by education cells, most notably those of ages 45-64. We hope this sample will a) be enlarged by the addition of Ss from studies using controls with demographics not included in this sample and b) despite its imperfections, be used by other qualified researchers who need a large sample of "normals" to compare to an experimental group. The data is on computer disk and in an easily shared format; contact the corresponding author for details.

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Table 1

LNNB Decision Rules

The profile is abnormal if:

2 Point (Golden et al., 1980): any 2 of the C1-S1 (excepting C7-9) scales are over the CL (using the age * education formula only).

3 Point (Golden et al., 1985): any three of the C1-S1 are over the CL.

30 Point (Golden et al., 1985): the highest of C1-S1 (excepting C7 and C9) is 30 T points over the lowest of C1-S1 (regardless of CL).

2 Point L1-L8 (Golden et al., 1985): any 2 of L1-L8 are over the CL.

30 Point L1-L8 (Golden et al., 1985): the highest of L1-L8 is 30 T points over the lowest of L1-L8 (regardless of CL).

LNII (Johnson, 1982; Johnson et al., 1984): the Luria-Nebraska Impairment Index (LNII) is 2 or more (using the age * education formula only).

Manual Rule: any one (or more) of the 3 Point, 30 Point, 2 Point L1-L8, or 30 Point L1-L8 is met, using the CL.

5 R Rule: any one (or more) of the 3 Point, 30 Point, 2 Point L1-L8, 30 Point L1-L8, or LNII rules is met (each rule uses the appropriate CL formula).

Note. The Critical Level (CL) is the lower of two numbers (Golden et al., 1985): (1) 25 + the T score of the lowest C1-S1 scale or (2) the maximum of 45 or $(68.8 + (.214 * \text{age}) - (1.47 * \text{education}))$.

Table 2
Summary of LNNB False Positive Studies

Study	N	Age \bar{M} (SD)	Education \bar{M} (SD)	Rule	FPR %
(Ayers, 1987; Ayers et al., 1987)	15	36		3 Point	0
(Berg & Golden, 1981)	40	41.1 (16.3)	11.8 (2.7)	2 Point	12.5
(Golden et al., 1981b);	60	43.2 (15.4)	13 (2.9)	2 Point	17
(Moses & Maruish, 1989)				3 Point	7
(Johnson, 1982; Johnson et al.,	25	37.6 (14.6)	16.6 (3.5)	2 Point	8
1984)				LNII	16
(Lewis et al., 1993)	31	range 13-17		3 Point	10
		15 (1.1)		30 Point	26
				2 Point L	10
				30 Point L	0
(MacInnes et al., 1983)	78	range 60-88, 72.2 (6.4)	12.9 (2.9)	2 Point	8
(Newman, 1984; Newman &	20	range 19-54,	14.4 (2.35)	2 Point	5
Sweet, 1986)		30.85 (11.24)		3 Point	0
(Roecker et al., 1992)	104			3 Point	9
				30 Point	20
	52	range 18-30, 24.9 (3.44)	range 8-18, 14.2 (1.92)	3 Point	4
				30 Point	8
	52	range 65-85, 73.29 (6.22)	range 8-18, 10.9 (2.65)	3 Point	13.5
				30 Point	33
(Sawicki & Golden, 1984)	135	46.8 (16.49)	12.5 (2.94)	3 Point	27
				30 Point	23
(Spitzform, 1982)	14	range 65-83, 71.4 (4.8)	range 10-15 11.92 (1.2)	2 Point	7

Table 3

False Positive Rates of Each Decision Rule by Group

False Positive Rates Percentages of Each Group

Rule	Younger	Older	Combined
3 Point	3	13	5
30 Point	3	27	8
2 Point L1-L8	3	12	5
30 Point L1-L8	0	0	0
LNII	5	17	7
Manual	6	31	11
5 R	8	36	14
Manual Modified	6	17	8
5 R Modified	8	27	12

Note. Combined $N = 241$; Younger $n = 189$, Older $n = 52$. Percentages are rounded. The last two rules eliminate the 30 Point Rule from consideration when used with the Older group. No S had an LNII above 2.

Table 4

Correlation of Each Decision Rule with Age and Education by Group

Rule	Age					
	Younger		Older		Combined	
	Correlation	Significance	Correlation	Significance	Correlation	Significance
3 Point	.06	.396	.25	.0699	.23	.003
30 Point	.03	.7046	.244	.0819	.39	<.0001
2 Point L1-L8	.08	.2238	.244	.0808	.19	.0033
30 Point L1-L8	0		0		0	
LNII	.05	.4676	.06	.6717	.2	<.0014
Manual	.04	.5674	.28	.0465	.35	<.0001
5 R	.03	.65	.196	.1649	.35	<.0001
Manual Modified	.04	.5674	.31	.0231	.2	.0018
5 R Modified	.03	.6507	.15	.3033	.25	<.0001
Rule	Education					
	Younger		Older		Combined	
	Correlation	Significance	Correlation	Significance	Correlation	Significance
3 Point	.06	.4113	-.098	.491	-.1	.1
30 Point	-.167	.0213	.052	.7154	-.21	.001
2 Point L1-L8	.083	.254	.152	.2845	.03	.6926
30 Point L1-L8	0		0		0	
LNII	.182	.0123	.133	.3501	.05	.4419
Manual	-.09	.2125	.07	.6297	-.17	.0098
5 R	-.028	.7038	.054	.7055	-.15	.02
Manual Modified	-.09	.2125	.01	.9234	-.12	.0586
5 R Modified	-.03	.7038	.12	.3998	-.08	.1978

Note. Combined $N = 241$; Younger $n = 189$, Older $n = 52$. Each rule is dummy coded so that

Normal = -1 and Abnormal = 1.

Table 5

Item Difficulty Percentages

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
1	2.58	1.03	3.61	21.28	0	21.28	6.22	.83	7.05
2	5.67	1.55	7.22	23.4	0	23.4	9.13	1.24	10.37
3	6.19	1.03	7.22	4.26	0	4.26	5.81	.83	6.64
4	5.15	1.03	6.19	8.51	0	8.51	5.81	.83	6.64
5	0	1.03	1.03	0	0	0	0	.83	.83
6	0	0	0	0	0	0	0	0	0
7	0	4.64	4.64	0	8.51	8.51	0	5.39	5.39
8*	0	2.58	2.58	0	6.38	6.38	0	3.32	3.32
9*	0	.52	.52	0	0	0	0	.41	.41
10*	0	0	0	0	0	0	0	0	0
11	0	3.09	3.09	0	2.13	2.13	0	2.9	2.9
12	0	1.03	1.03	0	0	0	0	.83	.83
13	0	4.12	4.12	0	19.15	19.15	0	7.05	7.05
14	0	4.12	4.12	0	21.28	21.28	0	7.47	7.47
15	0	2.06	2.06	0	4.26	4.26	0	2.49	2.49
16	0	1.03	1.03	0	4.26	4.26	0	1.66	1.66
17	0	8.76	8.76	0	31.91	31.91	0	13.28	13.28
18	0	4.12	4.12	0	31.91	31.91	0	9.54	9.54
19	0	0	0	0	0	0	0	0	0
20	0	.52	.52	0	2.13	2.13	0	.83	.83
21	4.64	3.09	7.73	29.79	57.45	87.23	9.54	13.69	23.24
22	2.58	1.55	4.12	40.43	14.89	55.32	9.96	4.15	14.11
23	12.37	0	12.37	76.6	8.51	85.11	24.9	1.66	26.56
24	0	6.19	6.19	0	8.51	8.51	0	6.64	6.64
25	0	6.19	6.19	0	31.91	31.91	0	11.2	11.2
26	0	1.55	1.55	0	0	0	0	1.24	1.24
27	0	4.12	4.12	0	4.26	4.26	0	4.15	4.15
28	0	10.31	10.31	0	2.13	2.13	0	8.71	8.71
29	0	5.15	5.15	0	0	0	0	4.15	4.15
30	0	9.79	9.79	0	12.77	12.77	0	10.37	10.37
31	0	4.64	4.64	0	12.77	12.77	0	6.22	6.22
32	0	6.19	6.19	0	8.51	8.51	0	6.64	6.64
33	9.79	0	9.79	59.57	19.15	78.72	19.5	3.73	23.24
34	0	6.19	6.19	0	0	0	0	4.98	4.98
35	0	7.73	7.73	0	0	0	0	6.22	6.22
36	22.16	7.22	29.38	42.55	44.68	87.23	26.14	14.52	40.66
37	11.34	1.03	12.37	6.38	2.13	8.51	10.37	1.24	11.62
38	18.56	5.15	23.71	27.66	21.28	48.94	20.33	8.3	28.63
39	4.64	1.55	6.19	19.15	10.64	29.79	7.47	3.32	10.79
40	15.46	2.06	17.53	23.4	10.64	34.04	17.01	3.73	20.75
41	10.31	1.03	11.34	19.15	21.28	40.43	12.03	4.98	17.01
42	21.13	3.61	24.74	59.57	21.28	80.85	28.63	7.05	35.68
43	7.73	1.03	8.76	21.28	8.51	29.79	10.37	2.49	12.86
44	18.04	2.06	20.1	36.17	14.89	51.06	21.58	4.56	26.14
45	20.62	.52	21.13	53.19	12.77	65.96	26.97	2.9	29.88
46	13.4	1.55	14.95	19.15	6.38	25.53	14.52	2.49	17.01
47	12.89	1.55	14.43	40.43	17.02	57.45	18.26	4.56	22.82

(table continues)

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
48	1.55	1.55	3.09	2.13	10.64	12.77	1.66	3.32	4.98
49	3.61	0	3.61	4.26	0	4.26	3.73	0	3.73
50	4.64	1.55	6.19	8.51	0	8.51	5.39	1.24	6.64
51	9.28	1.55	10.82	40.43	6.38	46.81	15.35	2.49	17.84
52	5.67	.52	6.19	25.53	0	25.53	9.54	.41	9.96
53	7.73	4.12	11.86	17.02	14.89	31.91	9.54	6.22	15.77
54	9.79	1.55	11.34	48.94	19.15	68.09	17.43	4.98	22.41
55	13.92	1.55	15.46	31.91	6.38	38.3	17.43	2.49	19.92
56	0	12.37	12.37	0	17.02	17.02	0	13.28	13.28
57	0	7.73	7.73	0	19.15	19.15	0	9.96	9.96
58	2.58	1.03	3.61	6.38	2.13	8.51	3.32	1.24	4.56
59	6.7	1.03	7.73	10.64	2.13	12.77	7.47	1.24	8.71
60	14.43	4.12	18.56	17.02	6.38	23.4	14.94	4.56	19.5
61	13.4	4.12	17.53	31.91	8.51	40.43	17.01	4.98	21.99
62	21.65	.52	22.16	76.6	0	76.6	32.37	.41	32.78
63	12.89	4.64	17.53	23.4	21.28	44.68	14.94	7.88	22.82
64*	6.19	.52	6.7	6.38	0	6.38	6.22	.41	6.64
65	4.64	.52	5.15	8.51	2.13	10.64	5.39	.83	6.22
66	10.82	2.06	12.89	40.43	17.02	57.45	16.6	4.98	21.58
67	5.15	4.12	9.28	23.4	10.64	34.04	8.71	5.39	14.11
68	8.76	1.03	9.79	25.53	4.26	29.79	12.03	1.66	13.69
69	7.22	2.06	9.28	14.89	4.26	19.15	8.71	2.49	11.2
70	3.61	2.58	6.19	36.17	10.64	46.81	9.96	4.15	14.11
71	5.67	1.55	7.22	34.04	21.28	55.32	11.2	5.39	16.6
72	3.09	1.03	4.12	0	0	0	2.49	.83	3.32
73	.52	1.03	1.55	0	0	0	.41	.83	1.24
74	9.28	1.55	10.82	12.77	0	12.77	9.96	1.24	11.2
75	3.61	.52	4.12	21.28	2.13	23.4	7.05	.83	7.88
76	0	6.19	6.19	0	21.28	21.28	0	9.13	9.13
77	0	5.67	5.67	0	14.89	14.89	0	7.47	7.47
78	0	11.86	11.86	0	40.43	40.43	0	17.43	17.43
79*	0	11.86	11.86	0	29.79	29.79	0	15.35	15.35
80	0	2.58	2.58	0	4.26	4.26	0	2.9	2.9
81	0	3.09	3.09	0	6.38	6.38	0	3.73	3.73
82*	5.15	1.55	6.7	19.15	6.38	25.53	7.88	2.49	10.37
83*	10.31	.52	10.82	51.06	2.13	53.19	18.26	.83	19.09
84	4.12	1.55	5.67	14.89	6.38	21.28	6.22	2.49	8.71
85*	15.98	.52	16.49	82.98	4.26	87.23	29.05	1.24	30.29
86	1.55	.52	2.06	4.26	0	4.26	2.07	.41	2.49
87	4.12	1.03	5.15	14.89	4.26	19.15	6.22	1.66	7.88
88	15.98	5.15	21.13	29.79	46.81	76.6	18.67	13.28	31.95
89	21.65	10.31	31.96	25.53	72.34	97.87	22.41	22.41	44.81
90	4.12	1.03	5.15	23.4	0	23.4	7.88	.83	8.71
91	6.7	1.55	8.25	23.4	0	23.4	9.96	1.24	11.2
92	8.76	3.09	11.86	40.43	17.02	57.45	14.94	5.81	20.75
93	39.69	1.55	41.24	55.32	44.68	100	42.74	9.96	52.7
94	23.2	.52	23.71	55.32	10.64	65.96	29.46	2.49	31.95
95	23.2	8.25	31.44	31.91	53.19	85.11	24.9	17.01	41.91
96	5.67	2.06	7.73	12.77	2.13	14.89	7.05	2.07	9.13
97	29.38	4.64	34.02	55.32	17.02	72.34	34.44	7.05	41.49
98	12.37	3.61	15.98	27.66	12.77	40.43	15.35	5.39	20.75

(table continues)

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
99	8.25	14.43	22.68	21.28	51.06	72.34	10.79	21.58	32.37
100	.52	.52	1.03	10.64	0	10.64	2.49	.41	2.9
101*	.52	0	.52	8.51	0	8.51	2.07	0	2.07
102*	3.09	1.03	4.12	19.15	2.13	21.28	6.22	1.24	7.47
103*	1.55	1.03	2.58	21.28	2.13	23.4	5.39	1.24	6.64
104	1.03	0	1.03	25.53	4.26	29.79	5.81	.83	6.64
105	1.55	.52	2.06	8.51	4.26	12.77	2.9	1.24	4.15
106	1.55	2.58	4.12	0	8.51	8.51	1.24	3.73	4.98
107	0	2.58	2.58	0	8.51	8.51	0	3.73	3.73
108*	36.6	13.4	50	0	0	0	29.46	10.79	40.25
109	0	10.82	10.82	0	34.04	34.04	0	15.35	15.35
110	2.06	3.61	5.67	4.26	0	4.26	2.49	2.9	5.39
111	13.4	1.55	14.95	27.66	0	27.66	16.18	1.24	17.43
112	5.15	.52	5.67	10.64	4.26	14.89	6.22	1.24	7.47
113	2.06	0	2.06	10.64	0	10.64	3.73	0	3.73
114	0	4.64	4.64	0	0	0	0	3.73	3.73
115	0	3.09	3.09	0	0	0	0	2.49	2.49
116	0	5.67	5.67	0	21.28	21.28	0	8.71	8.71
117	0	5.15	5.15	0	23.4	23.4	0	8.71	8.71
118	0	3.61	3.61	0	0	0	0	2.9	2.9
119	0	1.03	1.03	0	6.38	6.38	0	2.07	2.07
120	0	0	0	0	6.38	6.38	0	1.24	1.24
121	0	0	0	0	0	0	0	0	0
122	0	18.04	18.04	0	63.83	63.83	0	26.97	26.97
123	0	3.09	3.09	0	8.51	8.51	0	4.15	4.15
124	0	3.09	3.09	0	2.13	2.13	0	2.9	2.9
125	0	2.06	2.06	0	21.28	21.28	0	5.81	5.81
126	0	0	0	0	6.38	6.38	0	1.24	1.24
127	11.34	1.55	12.89	34.04	0	34.04	15.77	1.24	17.01
128	0	15.46	15.46	0	53.19	53.19	0	22.82	22.82
129	0	2.58	2.58	0	12.77	12.77	0	4.56	4.56
130	0	5.15	5.15	0	38.3	38.3	0	11.62	11.62
131	0	8.76	8.76	0	55.32	55.32	0	17.84	17.84
132	13.92	6.19	20.1	27.66	38.3	65.96	16.6	12.45	29.05
133	1.03	0	1.03	2.13	0	2.13	1.24	0	1.24
134	4.12	0	4.12	31.91	6.38	38.3	9.54	1.24	10.79
135	1.55	0	1.55	14.89	2.13	17.02	4.15	.41	4.56
136	2.06	.52	2.58	12.77	0	12.77	4.15	.41	4.56
137	1.55	0	1.55	14.89	0	14.89	4.15	0	4.15
138	6.7	1.03	7.73	36.17	0	36.17	12.45	.83	13.28
139	0	3.61	3.61	0	14.89	14.89	0	5.81	5.81
140	0	4.64	4.64	0	14.89	14.89	0	6.64	6.64
141	0	2.06	2.06	0	25.53	25.53	0	6.64	6.64
142	5.15	0	5.15	2.13	0	2.13	4.56	0	4.56
143	4.12	0	4.12	8.51	2.13	10.64	4.98	.41	5.39
144	4.12	0	4.12	12.77	0	12.77	5.81	0	5.81
145	0	1.55	1.55	0	4.26	4.26	0	2.07	2.07
146	3.09	1.55	4.64	0	0	0	2.49	1.24	3.73
147	2.06	0	2.06	2.13	0	2.13	2.07	0	2.07
148	4.64	0	4.64	23.4	0	23.4	8.3	0	8.3
149	8.76	2.58	11.34	44.68	10.64	55.32	15.77	4.15	19.92

(table continues)

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
150	0	3.09	3.09	0	0	0	0	2.49	2.49
151	0	9.79	9.79	0	21.28	21.28	0	12.03	12.03
152	0	6.19	6.19	0	2.13	2.13	0	5.39	5.39
153	0	3.61	3.61	0	0	0	0	2.9	2.9
154	0	5.67	5.67	0	0	0	0	4.56	4.56
155	22.16	4.12	26.29	59.57	17.02	76.6	29.46	6.64	36.1
156	10.82	1.03	11.86	36.17	4.26	40.43	15.77	1.66	17.43
157*	7.22	1.55	8.76	34.04	21.28	55.32	12.45	5.39	17.84
158	3.61	0	3.61	25.53	2.13	27.66	7.88	.41	8.3
159	4.12	.52	4.64	4.26	2.13	6.38	4.15	.83	4.98
160	0	2.58	2.58	0	4.26	4.26	0	2.9	2.9
161	0	2.06	2.06	0	6.38	6.38	0	2.9	2.9
162*	0	1.55	1.55	0	10.64	10.64	0	3.32	3.32
163	0	1.55	1.55	0	4.26	4.26	0	2.07	2.07
164	8.76	2.06	10.82	21.28	17.02	38.3	11.2	4.98	16.18
165	15.98	2.06	18.04	38.3	19.15	57.45	20.33	5.39	25.73
166	2.06	0	2.06	6.38	2.13	8.51	2.9	.41	3.32
167	6.7	1.55	8.25	19.15	17.02	36.17	9.13	4.56	13.69
168	6.19	3.09	9.28	23.4	17.02	40.43	9.54	5.81	15.35
169	18.56	6.19	24.74	42.55	8.51	51.06	23.24	6.64	29.88
170	28.35	0	28.35	63.83	2.13	65.96	35.27	.41	35.68
171	41.24	3.09	44.33	68.09	31.91	100	46.47	8.71	55.19
172	0	11.86	11.86	0	38.3	38.3	0	17.01	17.01
173	0	10.82	10.82	0	51.06	51.06	0	18.67	18.67
174	0	12.89	12.89	0	51.06	51.06	0	20.33	20.33
175	14.43	2.58	17.01	34.04	6.38	40.43	18.26	3.32	21.58
176	4.12	2.06	6.19	17.02	2.13	19.15	6.64	2.07	8.71
177	1.55	0	1.55	2.13	2.13	4.26	1.66	.41	2.07
178*	4.64	0	4.64	4.26	2.13	6.38	4.56	.41	4.98
179	0	30.41	30.41	0	76.6	76.6	0	39.42	39.42
180	0	1.55	1.55	0	0	0	0	1.24	1.24
181	0	1.03	1.03	0	2.13	2.13	0	1.24	1.24
182	1.03	3.61	4.64	4.26	10.64	14.89	1.66	4.98	6.64
183	14.43	1.55	15.98	12.77	0	12.77	14.11	1.24	15.35
184	24.23	19.59	43.81	46.81	51.06	97.87	28.63	25.73	54.36
185*	11.86	3.09	14.95	23.4	4.26	27.66	14.11	3.32	17.43
186	30.41	1.03	31.44	63.83	4.26	68.09	36.93	1.66	38.59
187	2.58	3.09	5.67	10.64	25.53	36.17	4.15	7.47	11.62
188	13.4	5.15	18.56	14.89	2.13	17.02	13.69	4.56	18.26
189	2.58	.52	3.09	10.64	0	10.64	4.15	.41	4.56
190	2.06	.52	2.58	0	0	0	1.66	.41	2.07
191	0	5.15	5.15	0	0	0	0	4.15	4.15
192	6.19	3.61	9.79	14.89	4.26	19.15	7.88	3.73	11.62
193	2.06	0	2.06	0	0	0	1.66	0	1.66
194	1.03	0	1.03	2.13	0	2.13	1.24	0	1.24
195	2.06	0	2.06	23.4	4.26	27.66	6.22	.83	7.05
196	22.16	15.98	38.14	34.04	63.83	97.87	24.48	25.31	49.79
197	3.09	1.55	4.64	8.51	0	8.51	4.15	1.24	5.39
198	3.09	0	3.09	6.38	0	6.38	3.73	0	3.73
199	18.56	1.55	20.1	44.68	2.13	46.81	23.65	1.66	25.31
200	11.86	1.55	13.4	55.32	0	55.32	20.33	1.24	21.58

(table continues)

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
201	0	.52	.52	0	0	0	0	.41	.41
202	7.73	6.19	13.92	17.02	40.43	57.45	9.54	12.86	22.41
203	.52	.52	1.03	0	0	0	.41	.41	.83
204	.52	0	.52	6.38	0	6.38	1.66	0	1.66
205	1.03	0	1.03	0	0	0	.83	0	.83
206	1.03	0	1.03	0	0	0	.83	0	.83
207	5.15	1.55	6.7	6.38	6.38	12.77	5.39	2.49	7.88
208	.52	0	.52	0	0	0	.41	0	.41
209	0	.52	.52	0	0	0	0	.41	.41
210	0	0	0	0	0	0	0	0	0
211	0	0	0	0	0	0	0	0	0
212	7.22	.52	7.73	14.89	0	14.89	8.71	.41	9.13
213	1.55	0	1.55	2.13	2.13	4.26	1.66	.41	2.07
214	0	0	0	0	2.13	2.13	0	.41	.41
215	7.73	1.55	9.28	19.15	8.51	27.66	9.96	2.9	12.86
216	0	3.09	3.09	0	2.13	2.13	0	2.9	2.9
217	0	8.76	8.76	0	14.89	14.89	0	9.96	9.96
218	3.09	.52	3.61	48.94	10.64	59.57	12.03	2.49	14.52
219	3.61	0	3.61	17.02	2.13	19.15	6.22	.41	6.64
220	0	5.67	5.67	0	14.89	14.89	0	7.47	7.47
221	10.31	.52	10.82	31.91	6.38	38.3	14.52	1.66	16.18
222	14.95	.52	15.46	25.53	14.89	40.43	17.01	3.32	20.33
223	5.67	0	5.67	40.43	4.26	44.68	12.45	.83	13.28
224	15.46	.52	15.98	57.45	4.26	61.7	23.65	1.24	24.9
225	0	3.09	3.09	0	23.4	23.4	0	7.05	7.05
226	0	10.82	10.82	0	51.06	51.06	0	18.67	18.67
227*	4.12	0	4.12	51.06	23.4	74.47	13.28	4.56	17.84
228	0	5.67	5.67	0	38.3	38.3	0	12.03	12.03
229	22.68	10.31	32.99	23.4	74.47	97.87	22.82	22.82	45.64
230	1.03	.52	1.55	12.77	2.13	14.89	3.32	.83	4.15
231	14.43	7.22	21.65	42.55	21.28	63.83	19.92	9.96	29.88
232	19.07	1.03	20.1	63.83	12.77	76.6	27.8	3.32	31.12
233	11.34	.52	11.86	36.17	2.13	38.3	16.18	.83	17.01
234	5.15	4.12	9.28	17.02	36.17	53.19	7.47	10.37	17.84
235	5.15	1.03	6.19	10.64	61.7	72.34	6.22	12.86	19.09
236	12.37	6.19	18.56	31.91	40.43	72.34	16.18	12.86	29.05
237	10.82	11.34	22.16	55.32	12.77	68.09	19.5	11.62	31.12
238	3.09	15.98	19.07	4.26	72.34	76.6	3.32	26.97	30.29
239	12.89	5.67	18.56	17.02	55.32	72.34	13.69	15.35	29.05
240	0	18.56	18.56	0	51.06	51.06	0	24.9	24.9
241	15.98	6.19	22.16	27.66	31.91	59.57	18.26	11.2	29.46
242	0	28.35	28.35	0	87.23	87.23	0	39.83	39.83
243	0	30.93	30.93	0	100	100	0	44.4	44.4
244	20.1	2.58	22.68	57.45	8.51	65.96	27.39	3.73	31.12
245	24.74	14.43	39.18	46.81	34.04	80.85	29.05	18.26	47.3
246	7.22	2.58	9.79	29.79	17.02	46.81	11.62	5.39	17.01
247	6.7	2.06	8.76	23.4	8.51	31.91	9.96	3.32	13.28
248	35.05	6.19	41.24	74.47	17.02	91.49	42.74	8.3	51.04
249	31.96	8.25	40.21	38.3	59.57	97.87	33.2	18.26	51.45
250	25.77	7.22	32.99	68.09	27.66	95.74	34.02	11.2	45.23
251	0	5.67	5.67	0	8.51	8.51	0	6.22	6.22

(table continues)

Item #	Younger			Older			Combined		
	=1	=2	Total (DL)	=1	=2	Total (DL)	=1	=2	Total (DL)
252	0	4.12	4.12	0	10.64	10.64	0	5.39	5.39
253	0	2.06	2.06	0	6.38	6.38	0	2.9	2.9
254	6.7	1.55	8.25	25.53	10.64	36.17	10.37	3.32	13.69
255	0	.52	.52	0	0	0	0	.41	.41
256	13.4	.52	13.92	34.04	12.77	46.81	17.43	2.9	20.33
257	0	1.55	1.55	0	4.26	4.26	0	2.07	2.07
258	0	0	0	0	2.13	2.13	0	.41	.41
259	3.09	2.58	5.67	4.26	8.51	12.77	3.32	3.73	7.05
260	0	0	0	0	0	0	0	0	0
261	1.55	1.03	2.58	2.13	0	2.13	1.66	.83	2.49
262	0	6.19	6.19	0	44.68	44.68	0	13.69	13.69
263	12.37	11.86	24.23	14.89	31.91	46.81	12.86	15.77	28.63
264	0	31.44	31.44	0	40.43	40.43	0	33.2	33.2
265	34.02	8.76	42.78	70.21	2.13	72.34	41.08	7.47	48.55
266	0	24.23	24.23	0	57.45	57.45	0	30.71	30.71
267	22.16	17.01	39.18	38.3	31.91	70.21	25.31	19.92	45.23
268	0	7.73	7.73	0	34.04	34.04	0	12.86	12.86
269	16.49	2.06	18.56	36.17	12.77	48.94	20.33	4.15	24.48

Note. Combined $N = 241$; Younger $n = 189$, Older $n = 52$.

DL = the total percentage of Ss in the group getting an item score greater than 0.

* marks items previous research considered very simple.

(table continues)

Table 6

Distribution of the Malingering Formula Results by Group and 5 R Modified Rule Outcome

Formula Result	Combined	
	5 R Modified Rule Result	
	Normal \underline{n} (%)	Abnormal \underline{n} (%)
Malingered	53 (25)	2 (7)
Not Malingered	159 (75)	27 (93)
Totals of column	212 (100)	29 (100)

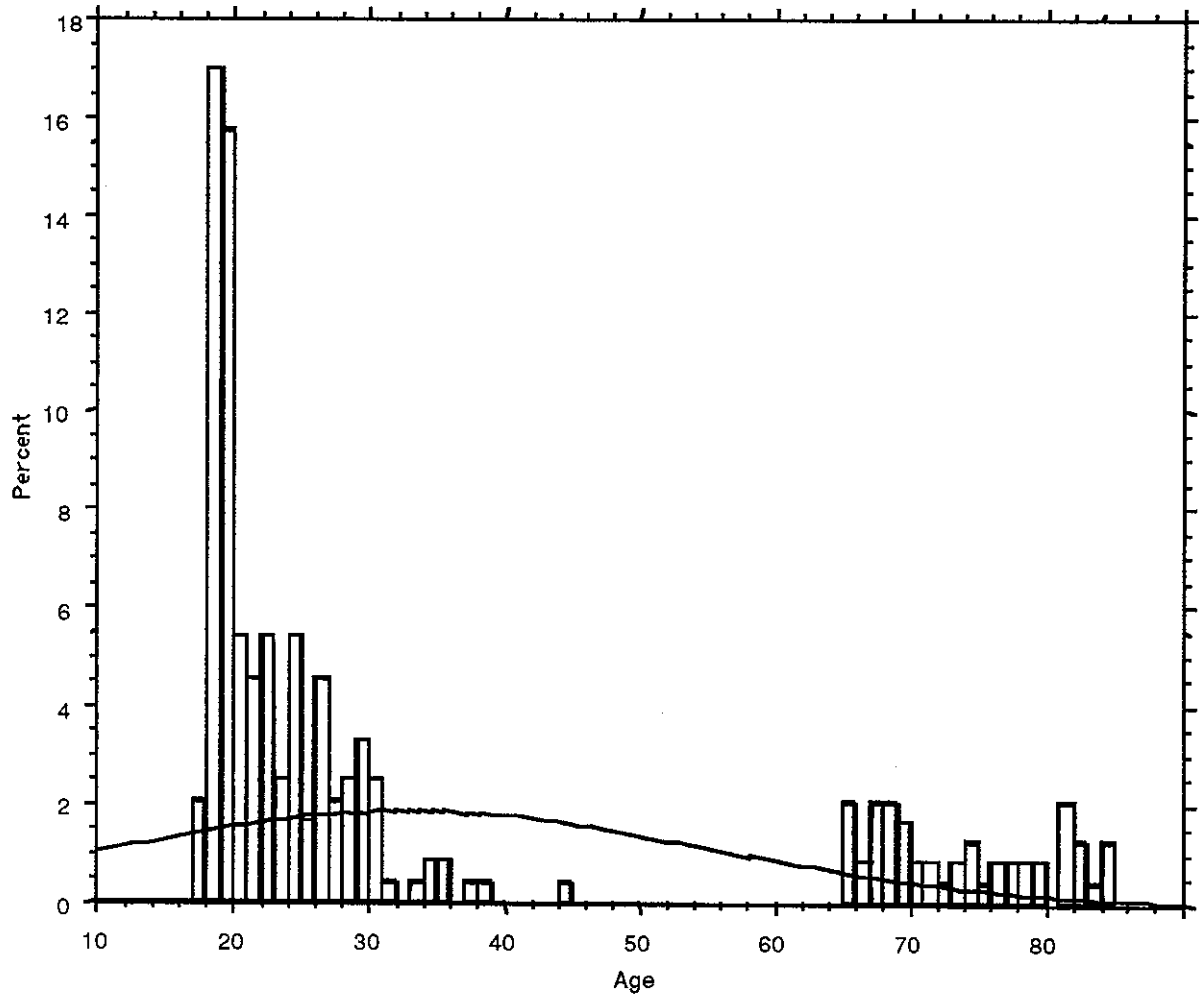
Formula Result	Younger	
	5 R Modified Rule Result	
	Normal \underline{n} (%)	Abnormal \underline{n} (%)
Malingered	48 (28)	2 (13)
Not Malingered	126 (72)	13 (87)
Totals of column	174 (100)	15 (100)

Formula Result	Older	
	5 R Modified Rule Result	
	Normal \underline{n} (%)	Abnormal \underline{n} (%)
Malingered	5 (13)	0 (0)
Not Malingered	33 (87)	14 (100)
Totals of column	38 (100)	14 (100)

Note. Combined \underline{N} = 241; Younger \underline{n} = 189, Older \underline{n} = 52. Percentages are rounded. The empirically derived formula compares a group of simple items with a group of more complex ones. The items were included in the formula based on their correlation with the scores obtained by experimental malingerers or patients referred for neuropsychological assessment.

Figure 1

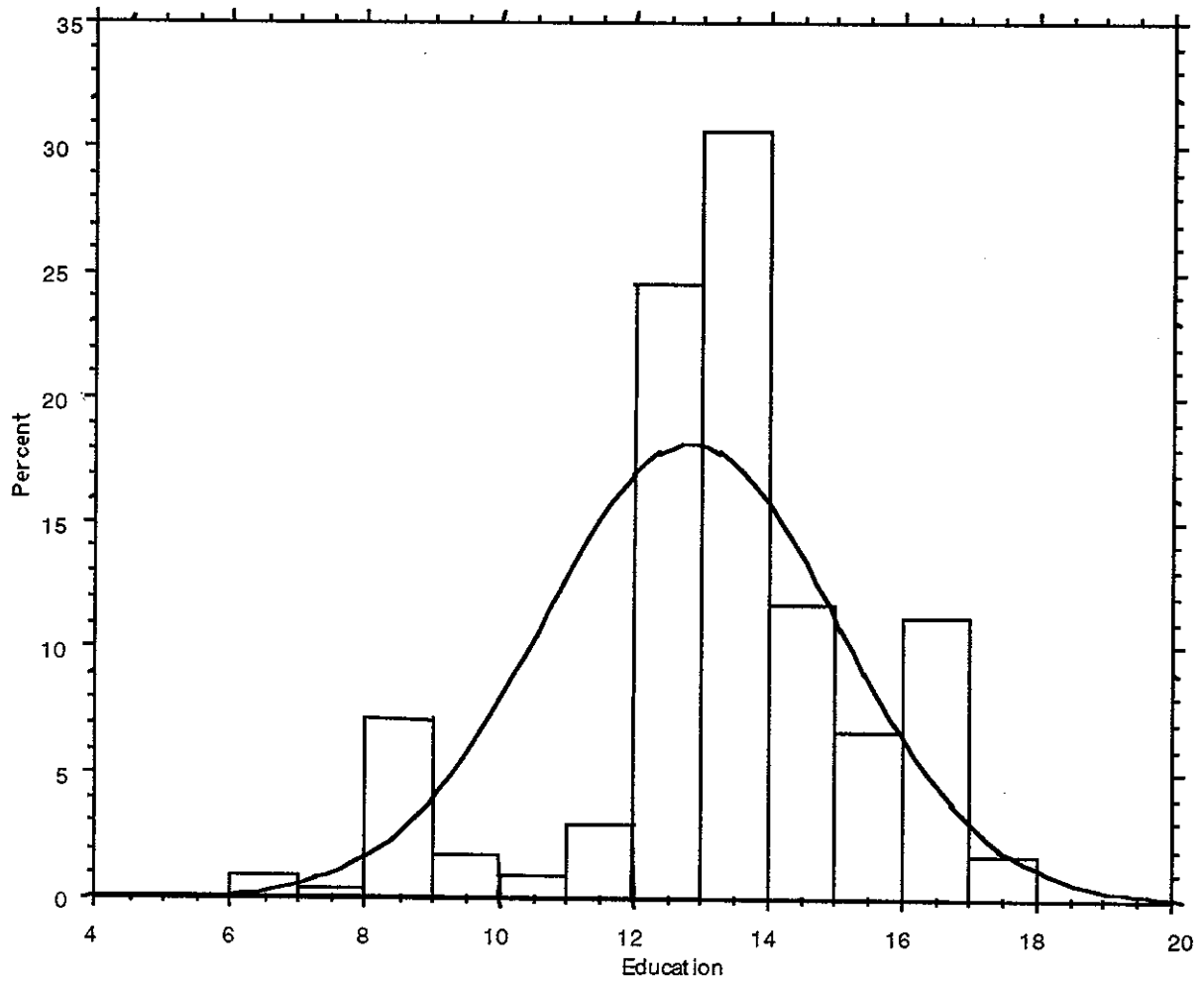
Distribution of Age



Note. N = 241. The curved line represents a normal distribution of the same mean & standard deviation.

Figure 2

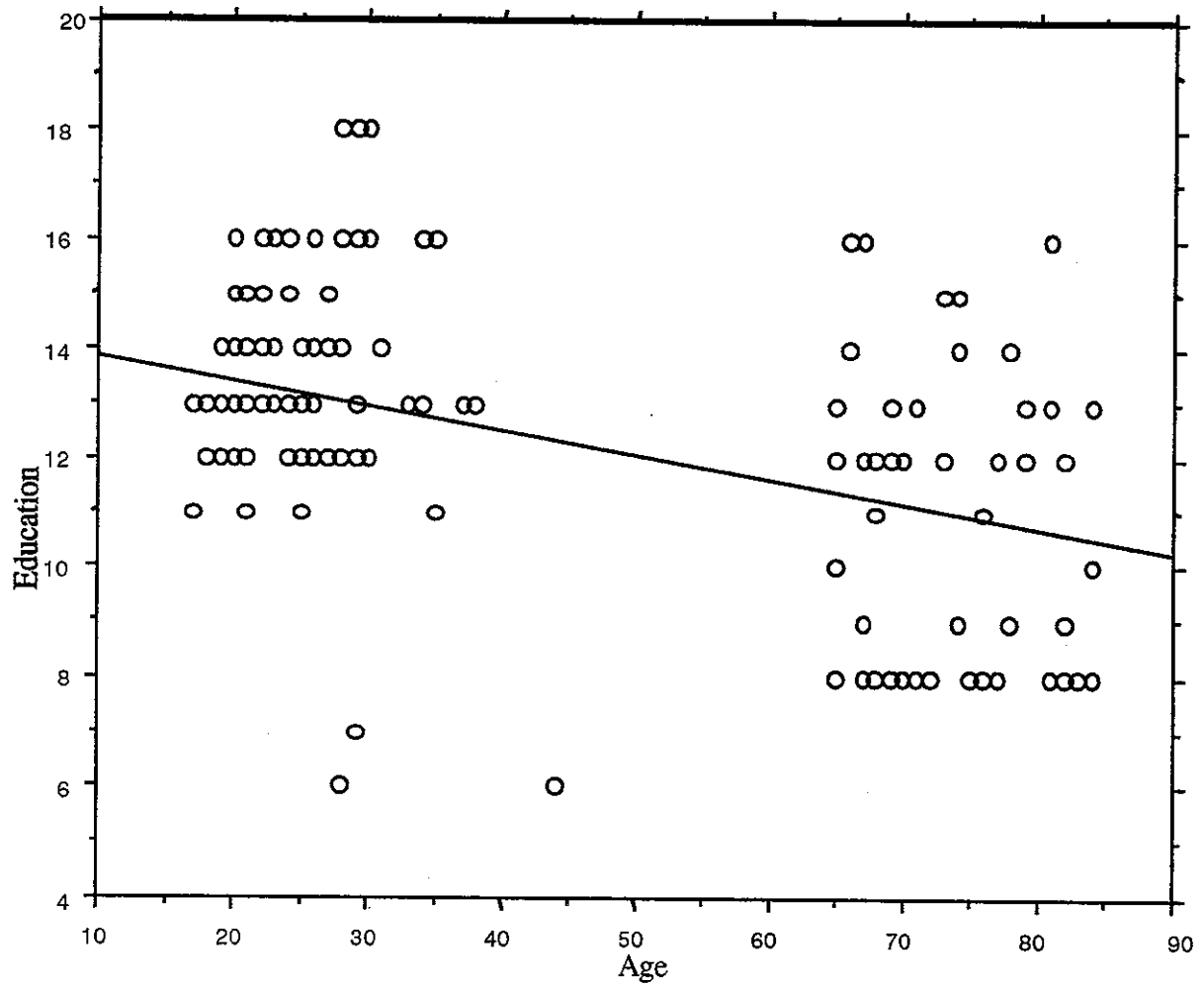
Distribution of Education



Note. $N = 241$. The curved line represents a normal distribution of the same mean & standard deviation.

Figure 3

Scattergram of Age and Education, with Regression Line



Note. $N = 241$.