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ACHIEVEMENT MOTIVATION AND INTELLIGENCE TEST SCORES: A TEST OF THE YERKES-DODSON HYPOTHESIS

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The old Yerkes-Dodson hypothesis of an inverted U-shaped relationship between strength of motivation and level of performance is tested for intelligence test scores. Resultant Achievement motive is measured with the Mehrabian-scales. Four motive groups (quartiles) are formed. Intelligence is measured with Drenth's "Test voor Niet-Verbale Abstractie" (non-verbal abstraction) in a neutral and in a high ego-involvement condition. The latter condition is supposed to arouse the achievement-related motives strongly. As hypothesized the most highly motivated group in the high ego-involvement condition performs significantly lower than the less highly motivated subject group. In the neutral condition an inverted U-shaped relationship is neither expected nor found. Secondary analyses using the data from all eight subject groups correspond with the hypothesis. Important practical implications are discussed.

INTRODUCTION

Based on the evidence from his research on the behavioral effects of individual differences in achievement-oriented motives, Atkinson (1974b, p. 395) challenges the assumptions implicitly made by most test psychologists that ... "the level of motivation is either optimal for everyone being tested, or constant, or only negligibly different among all individuals at the time of performance", and that reliable differences in test scores must be attributed solely to individual differences in the measured ability or aptitude. Atkinson argues that any test score is derived from the performance of an individual with his or her ability or aptitude in a condition that arouses most probably achievement-oriented motives but usually offers also other (intrinsic and extrinsic) incentives. Individual differences in test scores reflect not only differences in true ability but also situationally aroused differences in strength of motivation while taking the test. Individual differences in motives (personality dispositions) that are aroused by the test situation will affect the test performance and will be reflected in the test scores. As any other achievement, test scores are the result of an interaction between aptitudes and motivation.

In his conceptual analysis of how motivation affects test performance Atkinson (1974a) assumes that this effect is mediated by the effect of motivational variables on the efficiency with which the test is performed. Test scores are considered to be the product of "true ability" and "efficiency of test performance". The efficiency varies

from 0.00 to 1.00 and expresses to what degree true ability is expressed in the performance. The nature of the relationship between strength of motivation and efficiency of performance, and hence also test scores, depends on the nature of the task. It is usually assumed that this relationship is linear or monotonic increasing, as evidenced by the general use of linear product-moment correlations when correlating motivational measures and performance criteria (e.g. Klinger, 1966).

Atkinson (1974a,b; Atkinson & Birch, 1978, p. 148) hypothesizes however that this relationship may not be monotonic but can be described best by an inverted U-shaped curve. This assumption is based on the much older "Yerkes-Dodson Law". Yerkes and Dodson (1908) found that mice learned more easily to make a visual discrimination between a white and a black box when they were moderately motivated to do so than when they are either more or less motivated. Strength of motivation was operationalized in intensity of electric shocks (aversive stimulation or negative motivation). The second part of the Yerkes-Dodson Law holds that the optimal level of motivation varies with the difficulty of the task : it would be lower for difficult tasks and higher for more easy tasks. The first part of the Yerkes-Dodson Law has been confirmed repeatedly in studies using a broad variety of motivational measures and performance criteria (see McClelland, 1951; Hebb, 1955; Broadhurst, 1957; 1959; Jones, 1961; Duffy, 1962; Cofer and Appley, 1964; de Bonis, 1965; 1969). Lewin (1938), Easterbrook (1959) and Broen and Storms (1961), among others, offer theoretical explanations for the inverted U-shaped relationship between strength of motivation and level of test performance.

Atkinson's reanalyses (Atkinson, 1974a) of some earlier studies of the behavioral effects of individual differences in achievement-oriented motives (Entin, 1968; Smith, 1966; Horner, 1968; Reitman, 1960; Atkinson & O'Connor, 1966) show indeed a nonmonotonic or curvilinear relationship between strength of achievement motivation and task performance : the most highly motivated subjects perform less well than less strongly (more optimally) motivated subjects. Very highly motivated subjects perform less efficiently while taking the test because of their too strong motivation and they have therefore their true ability or aptitude underestimated by their test scores.

The criterion measures in all these studies were rather simple and unimportant two or three steps arithmetic tests or anagram performances. The same nonmonotonic relationship should however hold also for intelligence tests or aptitude tests in general. The practical implications of such a relationship could be of great importance when selection of, for example, students or job applicants is based on such test scores (Atkinson, 1974a; Lens, 1975; Atkinson *et al.* 1976). Atkinson (1974b, p. 211) concludes his summary of evidence for the curvilinear relationship available in the achievement motivation literature with the exclamation : "What if it had been an intelligence test". Very highly motivated subjects performing inefficiently while taking a test would possibly not be selected because their test scores are

lower than those of subjects with an equal ability but a more optimal level of motivation during the test (more efficient test performance). In the cumulative achievements, however, the subjects are selected for (e.g. university studies or a professional career) the higher motivated subjects would achieve more than the less motivated subjects, mostly because they would spend much more of their time in this endeavour and hence reach higher levels of performance. Time spent in an activity is a monotonic increasing function of total strength of motivation for that activity, assuming number and strength of motivation for alternative activities being constant (Atkinson, 1974b). Total strength of motivation to perform an achievement related task is the algebraic sum of the positive tendency to achieve success, the negative tendency to avoid failure and all extrinsic tendencies to achieve success and avoid failure. The extrinsic motivational component is assumed to be equal for all subjects, as usually done in achievement motivation research.

The origin of this empirical research is Atkinson's exclamation cited above. Its goal is to test the hypothesis of a nonmonotonic relationship (inverted U-shaped) between strength of achievement motivation and the level of performance in an intelligence test as dependent measure.

METHOD

SUBJECTS

The subjects were 229 first year students in Psychology or Educational Sciences at the University of Leuven (94 males and 135 females). They were tested in groups of about 20 subjects each. Groups were formed on the basis of the alphabetical list of all first year students. Only the first letter of the subject's last name determined to which group he or she belonged. All subjects were tested for achievement-related motives and intelligence (in that order) within one session. Both tests were introduced to the subjects as completely independent.

ASSESSMENT OF ACHIEVEMENT MOTIVE

Strength of Achievement motive was measured with the Mehrabian male and female scales of the tendency to achieve (Mehrabian, 1968; 1969)[1]. The original items of the test were of course translated in Dutch, the mother tongue of the subjects. The Mehrabian scales are developed as a substitute for the measure of need Achievement based on the Thematic Apperception Technique (McClelland *et al.*, 1953) mostly because scoring T.A.T.-stories for n Achievement requires considerable training and is very time consuming. The male and the

[1] Mehrabian and Bank (1978) recently revised the Mehrabian scales to obtain a single and broad based measure that would be equally applicable to both sexes.

female scales contain each 26 items, formulated positively or negatively. The subject must express on 9-point scales to what extend he or she agrees with the statement in each item ($+4$ = very strong agreement; -4 = very strong disagreement). Agreement or disagreement with an item expresses a behavioral disposition differentiating high versus low achievers. The content of the items is closely related to Atkinson's Theory of Achievement Motivation (Atkinson & Feather, 1966; Atkinson & Birch, 1978). The male and the female scale correlate significantly negative with the Test Anxiety Questionnaire (Mandler & Sarason, 1952) and significantly positive with the T.A.T.-n Achievement scores. Mehrabian (1968) reports ten week test-retest product-moment correlation coefficients of 0.78 for the male scale and 0.72 for the female scale. He also reports significant correlations with performance criteria. The distribution of all 229 achievement motive scores was devided into quartiles: High = $\geq +17$; Medium-High = $+16 - -5$; Medium-Low = $+4 - -6$; Low = ≤ -7.

DEPENDENT MEASURE

Intelligence was measured with Drenth's "Test voor Niet-Verbale Abstractie" (Test for Non-Verbal Abstraction) (Drenth, 1965). This paper-and-pencil test measures the ability to see relations in patterns of abstract figures and gives a good estimation of general intelligence relatively independently of verbal or numerical ability. Drenth's test is intended for higher levels of intelligence where many other intelligence tests do not discriminate between subjects. The test consists of 40 problems to be solved within a time limit of 20 minutes. Each of these 40 problems consists of 10 figures. The first four figures are alike in some aspect that the subject must detect to be able to indicate which two of the remaining six figures do also have that same characteristic. The subject is given one example and four training items. No one of the 229 subjects in this study could solve all 40 problems correctly within the allowed 20 minute time period. Drenth (1965) reports a three month test-retest reliability of 0.81 and a split-half reliability of 0.89. The test correlates highly with other non verbal tests (e.g. D.A.T.-analogies). Its correlation with verbal tests is rather low.

Intelligence was measured in a neutral and in a high ego-involvement condition for different subjects. In the neutral condition (N = 79) the test was introduced to the subjects as a new test that psychologists were developing and of which was not yet known exactly what it measured and what value it had. These instructions were intended not to arouse the achievement motivation strongly. In the high ego-involvement condition (N = 150) however the test was introduced as a very valuable instrument for measuring higher levels of intelligence and as highly predictive for academic achievements. These instructions were supposed to arouse the achievement-oriented motives strongly. The range of strength of achievement motivation (situationally aroused

achievement motive dispositions) is much broader in the high ego-involvement condition than in the neutral condition. The low motive group (test anxiety stronger than n Achievement) is more relaxed, less negatively achievement motivated and hence having a stronger total positive motivation to achieve in the neutral than in the high ego-involvement condition. The positively achievement motivated subjects (n Achievement stronger than Test Anxiety) are more strongly motivated in the high ego-involvement condition than in the less motive arousing neutral condition in which achievement related motives are not aroused by the instructions but solely by the nature of the tasks to be solved.

HYPOTHESIS

Testing the hypothesis of a nonmonotonic or inverted U-shaped relationship between strength of achievement motivation and intelligence test scores requires test scores from subjectgroups with strength of motivation varying from lower to higher than the optimal level of motivation. As explained above the strong arousal of achievement-oriented motives in the high ego-involvement condition is intended to create such a broad motivational range. The main hypothesis tested in this study is that of an inverted U-shaped relationship between strength of achievement motivation and intelligence test scores in the high ego-involvement condition. We hypothesize for the high ego-involvement condition a significant linear and a significant quadratic trend component. Expecting a significant linear trend component is based on the reasonable assumption that even in the high ego-involvement condition only the most highly motivated group(s) is (are) beyond the optimal level. We also expect a significant lower mean intelligence test score in the high motive group than in "a" less highly motivated subgroup in the same high ego-involvement condition. It can be the medium-high or the medium-low subgroup that scores significantly higher than the high-motive group because we do not know where on the motivational continuum the most optimal level of motivation is situated for the used criterion test.

In the neutral condition achievement-oriented motives are not intentionally aroused by the instructions but nevertheless we must assume that the very nature of the problems to be solved arouses to a certain degree achievement-oriented motive dispositions in the subjects. Chances are much lower that the optimal level of motivation will be surpassed by many subjects to an important extend. We therefore expect only a significant linear trend component in the neutral condition.

Within each experimental condition we have four different levels of strength of achievement motivation corresponding to the four motive groups. The weak and strong situational arousal of the achievement oriented motives as measured by the Mehrabian scales creates eight different motivational groups. Not knowing the relative importance

or effect of individual differences in achievement-oriented motives in comparison with the situational arousal of these motives on the strength of achievement motivation, we cannot rankorder all eight groups on a motivational continuum. We do, for example, not know if the medium-high motive group in the high ego-involvement condition is stronger or less strongly motivated to achieve than the high motive group in the neutral condition. But starting with the strongest motivated group (high motive group in the high ego-involvement condition) we can form different rankorderings of six motivational groups to study in secondary analyses the same hypothesis of curvilinearity.

RESULTS

Table 1 gives the mean intelligence test scores for each of the four motive groups in the two experimental conditions.

TAB. 1. MEAN INTELLIGENCE TEST SCORES OF FOUR MOTIVE GROUPS IN A NEUTRAL AND IN A HIGH EGO-INVOLVEMENT CONDITION

motive group	condition		row mean
	neutral	high ego involvement	
high	25.29	23.95	24.29
	(n = 14)	(n = 41)	(n = 55)
medium-high	27.45	27.19	27.28
	(n = 20)	(n = 37)	(n = 57)
medium-low	24.42	24.21	24.30
	(n = 26)	(n = 34)	(n = 60)
low	26.79	23.63	24.68
	(n = 19)	(n = 38)	(n = 57)
column mean	25.91	24.73	25.14
	(n = 79)	(n = 150)	(n = 229)

Motive groups (quartiles) were formed on the basis of all 229 subjects' scores on the Mehrabian scales. This explains why for each experimental condition separately the number of subjects is not equal or even approximately equal in the four motive groups. Chi-square analysis shows that there is no significant association between motive level and experimental condition (Chi-square = 4.10; df. = 3; p = .25).

In the high ego-involvement condition the mean-intelligence test scores of the four motive groups are distributed as hypothesized. One-way Analysis of Variance shows a significant effect of motivation ($F = 2.96$; $df = 3/146$; $p < .05$). The difference between the mean intelligence test score of the high motive group (23.95) and the medium-high motive group (27.19) is highly significant in the expected direction, using the error term from the analysis of variance ($t = 2.44$; $df = 146$; $p < .01$). An orthogonal-polynomial trend analysis (Hays, 1973[2],

p. 687-691) shows a non significant linear trend and a significant quadratic trend component. The deviation from the quadratic trend component is also significant (see Table 2).

TAB. 2. ORTHOGONAL-POLYNOMIAL TREND ANALYSIS FOR THE HIGH EGO-INVOLVEMENT CONDITION

source	SS	df	MS	F	P
between	303.81	3	101.27	2.96	.05
linear	30.27	1	30.27	0.89	N.S.
quadratic	136.25	1	136.25	3.99	.05
cubic	137.29	1	137.29	4.02	.05
error	4991.98	146	34.19		
totals	5295.79	149			

The hypothesis of a curvilinear (inverted U-shaped curve) relationship between strength of achievement motivation and intelligence test scores can be maintained for the high ego-involvement condition in which the subjects' characteristic achievement-oriented motives (n Achievement and Test Anxiety) are strongly aroused. The most highly motivated group performs significantly lower in an intelligence test than a group of subjects with a less intense degree of achievement motivation. Contrary to our hypothesis we do not find a significant linear trend component.

In the neutral condition achievement-oriented motives were not intentionally aroused by the test instructions but probably to a lower degree by the nature of the tasks to be solved. The one-way Analysis of Variance shows no significant differences between the mean intelli-

TAB. 3. ORTHOGONAL-POLYNOMIAL TREND ANALYSIS FOR THE NEUTRAL CONDITION

source	SS	df	MS	F	p
between	125.07	3	41.69	0.88	N.S.
linear	1.79	1	1.79	0.04	N.S.
quadratic	0.21	1	0.21	0.004	N.S.
cubic	123.07	1	123.07	6.61	N.S.
error	3543.31	75	47.24		
totals	3668.38	78			

gence test scores of the four motive groups in this condition (see Table 3). In a performance condition in which achievement-oriented motives are not strongly aroused test scores and strength of achievement motivation are unrelated. Neither the linear trend component nor the quadratic are statistically significant. Inspection of Table 1 shows however also in the neutral condition a performance decrement in the high motive group, corresponding with a curvilinear trend. The

relatively high mean score of the low motive group (higher than for the medium-low motive group) cannot be explained.

SECONDARY ANALYSES

The two way Analysis of Variance does not show a significant main effect of condition ($F = 1.87$; $df = 1/221$) nor an interaction effect of condition and motive groups ($F = 0.642$; $df = 3/221$) but only a significant main effect of motive group ($F = 2.765$; $df = 3/221$; $p < .03$). We see in Table 1 that for all four motive groups the mean intelligence test scores are somewhat higher in the neutral than in the high ego-involvement condition, especially so for the high and for the low motive groups. The direction of the difference for the high motive group is in correspondence with the hypothesis of an inverted U-shaped relationship between strength of motivation and level of test performance. The high motive group in the neutral condition is less strongly motivated than the high motive group in the high ego-involvement condition. In both groups the strength of achievement motivation is assumed to be higher than the optimal level but less so in the neutral than in the high ego-involvement condition. The high motive group in the neutral condition performs less inefficiently than the high motive group in the high ego-involvement condition and therefore reaches higher test scores. For both low motive groups strength of motivation must be assumed to be lower than optimal so that we should find in this range of the motivational continuum a linear relationship between strength of motivation and intelligence test scores. The data (see Table 1) do confirm this expectation. As explained, the total strength of motivation to perform well should be higher in the neutral than the high ego-involvement condition for these negatively achievement motivated subjects. The total sum of the negative achievement motivation and the positive extrinsic motivation, assumed to be equal for all subjects, is higher in the neutral than in the ego-involvement condition.

The interaction between personality characteristics (achievement motives) and situational arousal of the achievement motives in two degrees creates eight motivational levels. For reasons explained on p. 54 we can, starting with the strongest motivated group, make two rank-orderings of six motive groups on the achievement motivation continuum. In both rank-orderings (see Table 4) of six groups of subjects from low to high strength of achievement motivation, the mean intelligence test scores decrease at the higher end of the motivational continuum. The most optimal level of motivation seems to be realized somewhere in the motivational range of the medium-high motive group working in a neutral condition, at least as far as our data show. Only the low motive group in the neutral condition disturbes twice the perfect inverted U-shaped relationship between motivation and test performance.

The highest mean intelligence test score (27.45) is obtained by the

medium-high motive group in the neutral condition. The most highly motivated group (high motive group in the ego-involvement condition) scores 23.95. The difference between these two mean scores is statistically significant when we use the error term from the two-way Analysis of Variance ($t = 2.06$; $df = 221$; $p < .025$ one-tailed).

In both rank-orderings the motivational group falling between the most highly motivated group and the group with the highest mean intelligence test score (high/neutral and medium-high/ego-involvement;

TAB. 4. MEAN INTELLIGENCE TEST SCORES OF SIX GROUPS OF SUBJECTS RANKORDERED FOR STRENGTH OF ACHIEVEMENT MOTIVATION FROM LOW TO HIGH (N = neutral; E.I. = high ego-involvement).

otive group	low/E.I.	low/N	medium-low/N	medium-high/N	high/N	high/E.I.
ean test score	23.63	26.79	24.42	27.45	25.29	23.95
otive group	low/E.I.	low/N	medium-low/N	medium-high/N	medium-high/E.I.	high/E.I.
ean test score	23.63	26.79	24.42	27.45	27.19	23.95

see Table 4) has a mean intelligence test score between that of those two groups, confirming a decrease in intelligence test scores with increasing strength of achievement motivation.

SUMMARY AND CONCLUSIONS

Because of the important practical consequences of Atkinson's hypothesis of a curvilinear relationship between strength of motivation and test scores, we tested this hypothesis which is based on the Yerkes-Dodson Law, using an intelligence test as performance criterion. In the high ego-involvement condition, intended to create a broad motivational continuum from low to very high, the hypothesis could be maintained. The quadratic trend component was significant. The most highly motivated subgroup did perform significantly lower on the intelligence test than a group of less motivated subjects. Contrary to our expectations the linear trend component was not significant. Secondary analyses in which data of the two experimental conditions were combined gave additional evidence of an inverted U-shaped relationship between strength of achievement motivation and intelligence test scores.

We consider the evidence discussed here strong enough to test the same hypothesis in an important real life situation where subjects (e.g. students) are selected for cumulative achievements (e.g. university studies) on the basis of test scores. Because of the great importance of such a selection for the subjects, it will be no problem to create very high levels of achievement motivation. Confirming the same hypothesis would allow us to follow students who did less well on the test because of a much too strong total motivation to do well on the tests but still well enough to be selected and to compare their

later cumulative achievements (academic records) with those of students who were less motivated while taking the test (more optimal) and who scored higher on the tests. This would enable us to test Atkinson's theoretical assumption that these very highly motivated subjects do perform better in cumulative achievements than the less motivated subjects who did better on the selection tests. Finally, this study would enable us to see if performance decrement due to a too strong motivation can be so great that those most highly motivated subjects will not be selected because of their rather low test scores which underestimate their true aptitudes.

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