Achievement motivation and performance of scientists in research and development organizations

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The paper focuses on the development and application of an adult achievement motivation (AM) scale. A questionnaire was constructed and a pilot study was conducted to find the underlying dimensions of the AM construct. Principal component analysis of 206 samples indicated that 10 factors appeared relevant, which explained for 69% of the original variance. Cronbach Alpha values for the factors ranged from 0.55 to 0.87. The ten salient dimensions identified were: Task orientation, Perseverance, Anticipatory behaviour, Competitiveness, Test taking behaviour, Reaction to success/failure, Future orientation, Independence, Rigidity and Involvement. The questionnaire was administered to 222 scientists working in R&D organizations. Discriminant analysis was carried out using the Statistical Package for Social Sciences (SPSS) package. Results indicated that there exists a significant correlation between consistently good performance and AM.

Keywords: Achievement motivation, Scientist performance

Introduction

Scientific potential can be effectively utilized by identifying and selecting the best possible scientific talent to engage in research and development (R&D) activities, providing and maintaining an organizational climate that is conducive to innovative research performance, and maintaining high motivational levels that will entourage them to apply their talents and abilities. Achievement motivation (AM) is defined as a predisposition to strive for excellence. It can be expressed as a concern for excellence, a desire on the part of the person to perform in terms of a standard of excellence or to be successful in competitive situations. Persons dominated by this motive are generally active, work hard, set high goals, take challenging tasks, derive pleasure from doing difficult things and look for quality. They may have a standard in mind, with which they keep comparing themselves in accomplishing tasks.

The motive to work was initially conceptualized1 as a single factor manifested through a fantasy response to the Thematic Apperception Test (TAT)2. In the assessment of human motivation, testing instruments have attempted to isolate an individual's level of AM as first defined by Murray2 and further developed by McClelland et al3. Various testing formats have been employed with projective techniques receiving most consistent usage. However, projective techniques such as TAT appears to have serious practical problems and have continuously failed to answer the questions relating to reliability, validity and objectivity. While there are a number of objective measures of AM available, research has failed to identify any one particular instrument as equally effective or better than TAT4. TAT and other projective measures are still the only measures of AM widely used. However, given the limitations and criticisms of projective techniques (reliability, construct validity, objectivity and testability), one is compelled to consider the very real need to construct an objective self-report device capable of assessing the many dimensions of the AM construct.

Brief History of Achievement Motivation

Atkinson5 supported the need for an objective self-report device, and suggested that such a measure be based on the empirical findings of previous research that identifies causal factors influencing people to score high or low on need for achievement (nAch). Researchers using self-report measures of motivation have apparently done little substantial work on
theoretical variations of such self-descriptive motives in an attempt to discover how one happens to be a high or low scorer. Later, objective instruments having items on an a-priori or theoretical basis was developed and then determined the validity of the instrument on the basis of correlation with standard projective measures or designed achievement behaviour. A more appropriate tactic may be used to build a scale empirically selecting items that differentiate between people who perform a task with high AM. Factor analysis of objectively scored instruments initiated the construct of AM as having multiple factors. The four factors of the Helmreich & Spence model of AM were: 1) Desire to work hard; 2) To seek intellectual challenge; 3) To succeed in competitive situations; and 4) To avoid negative consequences of success.

A study on the motivational orientation, professional commitment and personality characteristics of administrators, engineers and scientists in R&D organizations reported that scientists, who were ‘highly committed’ to their profession, when compared to the ‘not-so-committed’ tended to be more interested in job content factors, perceived their organizational climate as being favourable, were high in AM and experienced less conflict with their supervisors. Banking personnel were utilized in studies as this occupation attracts individuals high in intrinsic need.

Another study focused on the discrepancy from goals and standards as primary determinants of motivation, uncertainty orientation, achievement-related motives, induced self-discrepancies and performance. Yet another study investigated AM in high achieving Latin women with the use of fear of success scale and an interview schedule to measure AM. Perhaps the most important aspect of a really strong achievement motive is that it makes its possessor very susceptible to appeals that he tries harder. Again, most people will put more effort into their work if they are challenged to do better or if some valid reason for exertion is pointed out to them. But an achievement-oriented (high AM) person is likely to outsmart all others in his zeal to improve his performance when he is challenged to do so.

An achievement-oriented person does not spurn tangible rewards and takes a special joy in winning and completing it successfully with a difficult standard. This means more to him than money or a public pat on the back. Higher the level of AM more likely is the person to rise to positions of greater power and responsibility. AM, which is related to managerial success, is the individual’s attitude towards risk. An achievement-oriented person prefers a moderate degree of risk precisely because his efforts, skills, and determination stand a reasonable chance of influencing the outcome. Most people have a natural preference for a particular degree of risk. Some are inclined towards a wild speculative gamble while others prefer a conservative approach that minimizes their exposure to losses. But individuals with a high degree of achievement drive fall almost uniformly in the middle. They like to take a moderate degree of risk which is big enough to offer some excitement and hope for a worthwhile gain but not so big that their own efforts would have less of an influence on the outcome than sheer luck. Achievement-oriented people work harder when they are complimented for their attitudes than when they are told about their efficiency.

A measure of AM was developed using stimulus items that reflected the results of those empirical studies whose findings differentiated among subjects with high or low AM. The purpose of this study is to construct an objective self-report measure of AM that is reliable and valid to administer for the scientists, who are held high on this intrinsic need. Therefore, the present study tries to determine whether achievement motive influences scientific productivity and innovativeness of scientists in public and private R&D organizations in India.

**Methodology**

**Part A: Measure of Achievement Motivation**

As a first step towards the construction of an objective, self-report measure of AM, a pool of forced-choice stimulus items was constructed to reflect the results of those empirical studies whose findings differentiated among subjects with high or low AM. The literature review resulted in 63 self-reported items, which were grouped into eight categorical headings as follows: Perseverance, Success probability, Personal characteristics, Task-orientation, Independence, Choice behaviour, Reaction to success/failure, and Accomplishments. The methodology followed to this point was planned to permit the greatest degree of content validity for each item as it related to the AM construct. Each stimulus item was then written in a forced-choice format following the pattern of a Likert type scale such as: “Success encourages me to attempt even
The 10 factors in order of contribution were: factors accounting for 69 percent of the original variance. Later, a normalized varimax rotation identified 10 nearly equal factor loadings for different factors and items revealed 13 factors with a few items having high loadings. Investigation of the initial PCA of the final normalized varimax procedure for rotation to simple structure. These 10 factors were then subjected to a PCA, which indicated that 10-13 factors appeared salient dimensions extracted from the PCA. This procedure indicated that 10-13 factors appeared relevant and thus normalized varimax rotations were computed. On the basis of these analyses, items were eliminated from the original set of 48. Elimination was contingent on the item's failure to load on any factor (loading < ± 0.33). A second run of PCA was conducted on the 8 items to safeguard the possible exclusion of salient factor(s). The PCA on the remaining 40 items indicated 10 viable dimensions accounting for 69 percent of the original variance (Table 1). These 10 factors were then subjected to a normalized varimax procedure for rotation to simple structure. Investigation of the initial PCA of the final items revealed 13 factors with a few items having nearly equal factor loading for different factors and later a normalized varimax rotation identified 10 factors accounting for 69 percent of the original variance. The 10 factors in order of contribution were:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Eigen value</th>
<th>Percent of variance</th>
<th>Cumulative % of variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task orientation</td>
<td>6.47</td>
<td>16.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Perseverance</td>
<td>3.81</td>
<td>9.5</td>
<td>25.7</td>
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<td>Anticipatory behaviour</td>
<td>3.45</td>
<td>8.6</td>
<td>34.4</td>
</tr>
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<td>Competitiveness</td>
<td>2.62</td>
<td>40.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Test taking behaviour</td>
<td>2.27</td>
<td>5.7</td>
<td>46.6</td>
</tr>
<tr>
<td>Reaction to success or failure</td>
<td>2.19</td>
<td>5.5</td>
<td>52.1</td>
</tr>
<tr>
<td>Future orientation</td>
<td>1.90</td>
<td>4.7</td>
<td>56.8</td>
</tr>
<tr>
<td>Independence</td>
<td>1.84</td>
<td>4.6</td>
<td>61.4</td>
</tr>
<tr>
<td>Rigidity</td>
<td>1.66</td>
<td>4.2</td>
<td>65.6</td>
</tr>
<tr>
<td>Involvement</td>
<td>1.38</td>
<td>3.5</td>
<td>69.0</td>
</tr>
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Table 1— Eigen values and percentage of variance accounted for by each factor

The final questionnaire containing 48 items were administered to 206 sample subjects comprising of students and working adults in the city of Chennai (India). The sample population consisted of males and females, and included college freshers through graduate students. Principal component analysis (PCA) was conducted using the Statistical Package for Social Sciences (SPSS) to initiate an investigation of the dimensionality of the 48 empirically keyed items. The scree-plot was then used to determine the salient dimensions extracted from the PCA. This procedure indicated that 10-13 factors appeared relevant and thus normalized varimax rotations were computed. On the basis of these analyses, items were eliminated from the original set of 48. Elimination was contingent on the item's failure to load on any factor (loading < ± 0.33). A second run of PCA was conducted on the 8 items to safeguard the possible exclusion of salient factor(s). The PCA on the remaining 40 items indicated 10 viable dimensions accounting for 69 percent of the original variance (Table 1). These 10 factors were then subjected to a normalized varimax procedure for rotation to simple structure. Investigation of the initial PCA of the final items revealed 13 factors with a few items having nearly equal factor loading for different factors and later a normalized varimax rotation identified 10 factors accounting for 69 percent of the original variance. The 10 factors in order of contribution were:

Task orientation, Perseverance, Anticipatory behaviour, Competitiveness, Test taking behaviour, Reaction to success or failure, Future orientation, Independence, Rigidity, and Involvement. Cronbach Alpha values for the factors ranged from 0.55 to 0.87 (Table 2). All the 10 orthogonally rotated factors were then logically explained as psychological constructs of AM as previously identified in the review of the literature.

**Description of Factors**

**Factor 1: Task Orientation (Items: 1, 4, 35, 37 and 38)**

Task Orientation is measured by 5 items, which account for 16.2 percent of the variance in the factor structure. The central theme of this factor focuses on the question "If given a choice of activities, what kind of activity or task would you choose?" The review of literature reflected a consistent pattern of subject response to this theoretical question depended upon the level of nAch possessed by the subject. A general pattern of response identified in the review of literature indicated that high nAch'ers will choose tasks of moderate difficulty where they have approx a 50/50 chance of success and failure, and low nAch'ers will typically choose either very difficult or very easy tasks. Subsequently, subjects scoring high on this factor choose activities selected by high nAch'ers and those subjects scoring low on this factor choose similar activities with those subjects of low nAch. A recent study found out that there is difficulty in measuring the results or impact of research when each research task is unique even though the task orientation is high.

**Factor 2: Perseverance (Items: 7, 10, 11, 17, 19 and 24)**

Perseverance is comprised of six items accounting for 9.5 percent of the variance in the factor structure. The items grouped on this factor reflect the persistence or determination of the subject to finish or complete tasks, problems, challenges, etc. This factor attempts to show the pattern of behaviour that subjects undergo after work or effort has been initiated on some task. Some studies have demonstrated the apparent difference in behaviour between high and low nAch'ers. It appears that subjects with high nAch, as opposed to subjects with low nAch, tend to work longer on problems or tasks but realize their limits sooner and will subsequently give up on fruitless efforts. The level of AM that an individual possesses appears to be related to the behaviour of the individual in the area of task...
perseverance. Consequently, a person scoring high on this factor tends to work on problems longer but will also concede when the task appears hopeless.

**Factor 3: Anticipatory Behaviour (Items: 9, 20, 23, 25 and 26)**

Anticipatory Behaviour is comprised of five items accounting for 8.6 percentage variance. In contrast to the factor future orientation (identified as the 7th factor), this factor inquires into the behaviour of the subject in preparation for something in the future as opposed to the temporal attitude of the future oriented subject. High amounts of active participation in future oriented activities in high nAchers was identified in the review of literature. A high score on this factor reflects high amount of anticipatory behaviour in the subject.

**Factor 4: Competitiveness (Items: 2, 15 and 40)**

Competitiveness is comprised of three items accounting for 6.5 percent variance. The factor centralizes on conditions or activities of competition that are preferred by the subject (I enjoy competing against the clock). The review of literature cited much of McClelland’s work, which demonstrated that subjects with high levels of nAch also have high levels of need for competition. The drawback in this factor is the small number of items that make up the factor. However, the pattern of content is quite evident and thus suggesting the need to develop additional items to assess this dimension.

**Factor 5: Test Taking Behaviour (Items: 12, 27, 31 and 36)**

In Test Taking Behaviour, the explained percentage of variance was found to be 5.7. The four items comprising this factor reflect the subject's behaviour during testing conditions. The factor focuses on the temporal aspects of testing behaviour. Researchers have identified that subjects with high need for achievement will take more time on problem solving tasks or school tests than subjects with low need for achievement. A high score on this factor would indicate that the individual is often the last person to complete a test taking more testing time than others.

**Factor 6: Reaction to Success or Failure (Items: 5, 32, 34 and 39)**

Reaction to Success or Failure is comprised of four items, which accounted for 5.5 percent of the variance. The factor's concern is with the subject's behaviour immediately following successful or unsuccessful completion of a task or problem. The four items inquire into the behaviour and reactions of the subject following these two possible antecedent events. Subjects with high need for achievement react differently to success or failure than do subjects with low nAch. For example, subjects with high nAch will generally attempt more difficult problems after success and less difficult ones following failure, whereas the reverse is typical for subjects with low nAch. Also, high nAch subjects tend to take short breaks in work after successful completion of one task. Scoring high on this factor indicates that the subject reacts in the same manner as do those subjects with high levels of AM.

**Factor 7: Future Orientation (Items: 3, 18 and 33)**

Future Orientation, following the pattern of results identified in the review of literature, reflects the temporal attitude of the subject. The literature has grouped a number of studies reflecting differences between high and low need achievers on such a dimension. Consistently, subjects with high nAch tend to be more future oriented and more concerned with the passing of time than do subjects low in nAch. Consequently, a high score on this scale reflects the future orientation of the subject differentiating him from those subjects low in nAch.

**Factor 8: Independence (Items: 8, 12 and 16)**

Independence comprises three items, which accounts for 4.6 percent of the variance. AM literature reports a greater preference for working alone, independently, among subjects with high nAch than among low nAch'ers. Consequently, a high score on this factor reflects a high preference for working alone or one could say for independence.

**Factor 9: Rigidity (Items: 14, 29 and 30)**

In Rigidity, the percentage of variance was 4.2. The three items inquire into the subject's need for security provided by consistency or stability. Subjects with high need for achievement appear, as seen in the literature, to be more flexible and adventurous in life activities than do subjects with low nAch. The literature also reports a concern or need for flexibility possessed by high nAch'ers. A high score on this factor reflects this need for flexibility and high adventurous behaviour.

**Factor 10: Involvement (Items: 6, 13, 21, and 28)**

Involvement is comprised of four items accounting for 3.5 percentage of variance in the factor structure. Items investigate the extent and breadth of subject
A recent study found that there are differences in expectation, values, attitudes and motivation of scientists and engineers from other employees (people element). AM literature reports that subjects with high nAch tend to get more actively involved in most tasks than do subjects with low nAch. The extent, breadth and depth of participation are greater for subjects with high nAch. Consequently, a high score on this factor reflects greater participation and involvement activity than does a low score.

Part B: Study of Scientists

For achieving the second objective of the study, a list of scientists working in public as well as private R&D organizations in India was prepared by using convenient sampling and by selecting addresses from the directory of R&D organizations in India. The test instruments comprising the AM questionnaire, a checklist for research performance indicators and a biographical data sheet were mailed to the scientists with a covering letter explaining the objectives of the study and a request to return the completed questionnaires. A total of 238 filled-in responses (response rate 34%) were received. Sixteen responses were found to be incomplete and therefore were eliminated leaving the final sample size at 222 subjects, whose responses were used in the analysis (Table 2).

Respondents were broadly classified (taking the 33rd and 66th percentile) into three groups of performance categories (high, medium and low) based on their responses to the checklist of research performance indicators (Table 3). Data analyses were carried out using SPSS. Mean and standard deviation for the three groups and sum of the squares between groups and within groups and the F-ratio performance were determined (Table 4). Further, t-values of three groups of performance were calculated (Table 5). A discriminant analysis was carried out to determine which AM factors are the best predictors of the level of performance (Table 6). Two variables, Anticipatory behaviour and Competition, were found to contribute significantly to the classification of the participants, and two more variables, Perseverance and Test-taking behaviour, were found to have maximum contribution to the correct classification of the participants. The classification rate (67.57%) is fairly high rate and it was also true even when the functions were developed with a fewer number of cases using a hold-out sample. The high-performance group was significantly different from the low-performance group on the dimension, Anticipatory behaviour. The high performance group was also found to differ significantly from the medium performance group on the dimension, Competition.

Discussion

Apart from above-average intelligence, scientists include a wide range and a different type compared to any other group of individuals. The development of
these people into successful scientists will partly depend on their level of AM. This study attempted to investigate the AM of scientists, and to identify the factors that differentiate the high-performers from the low-performers. The high-performance group was found to differ significantly from the other two groups on four dimensions of AM as follows:

i) **Anticipatory Behaviour** - This indicates that the high performance group exhibits more anticipatory behaviour than the low-performance group;

ii) **Competitiveness** - The medium-performance group of scientists were found to differ significantly from both the low- and high-performance groups. Those who scored high on the dimension competitiveness prefer conditions or activities of competition;

iii) **Perseverance** – This result indicates that the high-performance group has higher perseverance than that of the other two groups; and

iv) **Test-taking Behaviour** – The scientists in the high performance group have scored higher indicating a preference for longer test-taking time. The high performance group has scored high on most of the positive dimensions of AM. It is also to be noted that the other six dimensions did not contribute significantly to the classification of the three groups of performance, probably due to that scientists, as a population, are highly motivated. Hence, there is a need to cross-check and verify this finding with a different set of population.

**Conclusions**

AM is not a unidimensional construct. Rather, it would appear to be a derivative of a set of other more specific traits of the person, which in concert blend to define a level of AM. The relevance or more precisely the validity of the 10 factors, which were identified, gains support in the research literature as being related to the components of AM. It is also important to note that the individual character of the factors was identified. As a group they relate not solely to the way in which the person perceives himself, but the dimensions were identified relating to how the person sees himself being affected by the behaviour of others. Based on these findings, one cannot simply choose to direct efforts at altering something called AM in a general sense, but rather consider more individual traits.

**Acknowledgement**

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**References**


Appendix 1

AM Factors and items with highest factor loading

Factors (% of variance - cumulative % of variance) Items (communality value)

Task orientation (16.2-16.2) 1. A difficult task is always a challenge for me (0.64).
4. I enjoy trying to solve problems some people would consider impossible (0.69).
35. I feel that I can succeed at almost anything I try (0.74).
37. In a job, I look for challenge more than security (0.79).
38. I often choose moderately difficult tasks rather than very difficult ones (0.69).

Perseverance (9.5- 25.7) 7. I do not mind putting in extra hours and work if it helps me finish a task (0.63).
10. After pondering upon a problem, I prefer to shift to an easier one (0.69).
11. There are times when I really doubt the saying, "Never give up" (0.58).
17. When I take up a problem I do not rest until I succeed (0.81).
19. If I cannot solve a problem, I would rather try an easier one than keep working on the same task (0.80).
24. I dislike leaving any task incomplete (0.54).

(Contd.)
Appendix 1 (contd.)

AM Factors and items with highest factor loading

**Anticipatory behaviour** (8.6-34.4)

9. I often pack my suitcase days before I am ready to leave (0.63).
20. I frequently find myself doing something now in preparation for future (0.82).
23. It is important to me to have long range goals clearly in mind (0.76).
25. I am not as much bothered about the present as I am about the future (0.82).
26. I always keep track of time (0.66).

**Competitiveness** (6.5-40.9)

2. I enjoy competing against the clock (0.79).
15. I am more productive when working alone than in a group (0.67).
40. I enjoy being in groups with people as able as I am (0.74).

**Test taking behaviour** (5.7-46.6)

12. I am frequently the first person done with a test (0.65).
27. I often take up a difficult problem after failing at an easier one (0.59).
31. I like to work on a difficult task and fail rather than work on a task in which I can succeed almost effortlessly (0.74).
36. It is very important to me to finish a task once it is started (0.76).

**Reaction to success or failure** (5.5-52.1)

5. Successful completion is the primary goal of any endeavour (0.62).
32. I almost do my best in order to avoid the embarrassment of failure (0.64).
34. Success encourages me to attempt even more difficult problems (0.64).
39. I realize the limits of my own ability and knowledge (0.60).

**Future orientation** (4.7-56.8)

3. I often end up speaking /thinking about the future (0.80).
18. I generally work for a future goal (0.58).
33. I am often compelled to know the exact time (0.68).

**Independence** (4.6-61.4)

8. I like to work alone rather than with group (0.63).
16. I often seek advice before I make a decision (0.72).
22. I never ask for help while I am working on a problem (0.66).

**Rigidity** (4.2-65.6)

14. I would rather change my opinion than disagree with the consensus of a group (0.66).
29. It is more important to have friendly co-workers than flexibility in the job (0.84).
30. I like to work for a company that pays well rather than work for one that pays less but gives greater freedom (0.72).

**Involvement** (3.5-69.0)

6. I work hard at things even if they sometimes seem hopeless (0.71).
13. I often take time off when I complete one stage of a large project (0.53).
21. I enjoy completing many easy tasks rather than just a few difficult ones (0.65).
28. I work longer on problems I believe I can solve, than on those I consider close to impossible (0.73).