Threshold theory tested in an organizational setting: the relation between perceived innovativeness and intelligence in a large sample of leaders.

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Abstract

A large sample of leaders (*N*=4257) was used to test the link between leader innovativeness and intelligence. The Threshold theory of the link between creativity and intelligence assumes that below a certain IQ level (approximately IQ 120), there is some correlation between IQ and creative potential, but above this cutoff point, there is no correlation. Support for the Threshold theory of creativity was found, in that the correlation between IQ and innovativeness was positive and significant below a cutoff point of IQ120. Above the cutoff no significant relation was identified, and the two correlations differed significantly. The finding was stable across distinct parts of the sample, providing support for the theory, although the correlations in all subsamples were small. The findings lend support to the existence of threshold effects using perceptual measures of behavior in real-world organizational settings, and thus beyond creative potential measures applied in the psychological laboratory where it has previously been documented.

Keywords: threshold theory, individual innovativeness, intelligence, managers, leaders.

Introduction

Although multiple possible views on the relation between intelligence and creativity exists (Sternberg & O'Hara, 1999), most contemporary creativity research tend to view creativity and intelligence as distinct traits that are only modestly related (for reviews see e.g. Batey & Furnham, 2006; Kim, Cramond, & VanTassel-Baska, 2010). However, correlations between intelligence and creativity vary widely depending on what constructs are measured, how they are measured, and in what domain creativity is manifested. A metaanalysis (Kim, 2005) covering 447 correlation coefficients from 21 studies (N=45880) reported an average weighted *r* of .174. The correlation may, however, not be of the same magnitude throughout the IQ spectrum. The threshold theory of the link between creativity and intelligence assumes that below a certain IQ level (approximately IQ 120), there is some (weak to moderate) correlation between IQ and creative potential and achievement, but above this cutoff point, there is no correlation (Barron, 1961; Getzels & Jackson, 1958; Guilford, 1967; Guilford & Christensen, 1973; MacKinnon, 1962; Jensen, 1980; Walberg & Herbig,1991; Yamamoto, 1964). The threshold theory suggests that intelligence is necessary but not sufficient for creative potential and achievement, making a minimum of *g* capacity necessary to produce creative outcomes irrespective of other factors (Jensen, 1980). As such, while creativity should be limited by intelligence below the IQ 120 threshold, differences in intelligence should no longer be relevant to creativity in high ability groups.

Karwowski & Gralewski (2013) argued that the threshold hypothesis could be tested along liberal or conservative criteria. A liberal set would simply be an indication that there is a positive correlation between intelligence and creativity below the threshold, and an insignificant one above the threshold. A slightly less liberal version would be a significant positive relation below the threshold that is also significantly higher than the correlation above threshold. And the most

conservative version would be a significant positive correlation below threshold, and insignificant one above threshold, and a significant difference between the two.

In large samples, threshold theory may inadvertently receive empirical support for completely different reasons: From a cognitive ability approach creativity is sometimes seen as a broad ability factor (2R Broad Retrieval) in Carroll´s Three Stratum Theory of Cognitive Abilities, an ability that is independent but related to psychometric *g* (Carroll, 1993), thus assuming a substantial correlation between creativity and intelligence. Based on Spearman´s Law of Diminishing Returns one would expect the relationship between any broad ability factor and *g* to diminish with increased IQ level (Jensen, 1998), and hence give support for the Threshold theory as well. To counter this potential confound, it should be tested whether threshold effects are merely caused by a restriction of range.

Lubart (1994) claimed that the Threshold theory is generally agreed upon, but studies of the Threshold theory have shown mixed results (e.g., Runco & Albert, 1986). Early studies supporting the theory include Barron (1963, 1969) who found no significant correlation in a gifted sample, but a significant correlation in a sample of average intelligence. However, Preckel, Holling, and Wiese (2006) reported a study of 1328 German school students (age 12-16) that was not in support of Threshold theory. The metaanalysis of Kim (2005) did not find support for Threshold theory as a moderator, but it should be noted that only very few (14) studies reported correlation coefficients for IQ>120 samples, making it hard to draw firm conclusions.

It has been argued that the mixed past results may in part be due to variations in the creativity measures applied in past studies (Runco & Albert, 1986; Jauk, Benedek, Dunst & Neubauer, 2013). While some studies have used creativity measures of creative potential (assuming a normally distributed trait, measured for example through divergent thinking tests, or the Wallach & Kogan tests), others have focused on creative achievement (attempts at measuring real-life accomplishments in or across disciplines). Most studies finding support for the threshold theory

have utilized creative potential measures, while not much support seem to have been put forth when focusing on creative achievement.

Measuring creative potential, Fuch-Beuchamp, Karnes, and Johnson (1993) found support for threshold theory in a sample of pre-school children, and Cho, Nijenhuis, Van Vianen, Kim & Lee (2010) using measures of verbal and figural creative potential also found support in samples involving adolescents and adults. However, two recent studies of creative potential failed to find general support for threshold theory in school-children samples (Guignard, Kermarrec & Tordjman, in press; Mougues, Tan, Hein, Al-Harbi, Aljughaiman & Grigorenko, in press).

Turning to creative achievement, a recent set of studies following a group of intellectually gifted youth (measured on scholastic aptitude at age 13) longitudinally over 20 years revealed that even in the upper range of intellectual ability (top 1%), individual differences in intelligence predicted both occupational accomplishment (Wai, Lubinski & Benow, 2005) and achievements in the arts and sciences (Park, Lubinski & Benow, 2007; 2008) at middle age. The study by Jauk et al (2013) found evidence for threshold effects when using creative potential measures, but found no evidence of a threshold effect when utilizing the Inventory of Creative Activities and Achievements, leading to the conclusion that when it comes to real-life achievement IQ seems important for displaying creative behavior and productive creative achievements, even at the highest ability groups. The question thus remains whether evidence can be found for a threshold effect beyond the psychological laboratory utilizing measures of creative potential?

The present study attempted to examine the existence for a threshold effect involving organizational creativity, by relating perceptions of leader innovative behavior (individual innovativeness), with intelligence in an organizational setting. Following Axtell et al. (2000), innovation may be defined as a process involving the generation, adoption, implementation and incorporation of new ideas, practices or artifacts within the organization. In a business context,

innovation can be regarded as a broader concept than creativity (which mainly refers to idea generation), and can be said to comprise two different phases involving an awareness or suggestion phase, and an implementation phase (e.g., Amabile, 1988; Axtell et al, 2000). Past research on individual creativity or innovativeness in organizations has tended to use superordinate ratings of subordinate creativity (e.g., Tierney & Farmer, 2002; 2011; George & Zhou, 2001) or subordinate innovativeness (e.g., Axtell et al. 2000; 2006). In order to measure leader (rather than employee) innovativeness, subordinate aggregated ratings of their direct leader were used. In rating innovativeness, subordinates should have access to superordinate idea generation and especially idea implementation, as most often these ideas and implementations would involve and impact the subordinates directly.

The large leader sample utilized in the present study comes from one large international organization, tested for intelligence at recruitment and for innovativeness by their subordinates, thus offering ecological validity and suggesting practical relevance for the recruitment of leaders. The sample is among the largest ever reported upon in tests of the threshold hypothesis, and the utilization of a perceptual measure of innovative behavior by subordinates holds promise for the generalizability of the theory beyond the creative potential measure in the psychological lab, in so far as support may be evidenced. Based on threshold theory, and the fact that innovativeness subsumes managerial creativity skills, it was hypothesized that below IQ 120, a weak to moderate relationship between individual innovativeness and intelligence exists, while no significant relation would exist above this cutoff point, and with a significant difference in magnitude between the two correlations (thus testing the most conservative version of threshold theory).

Methods

Participants

The data were compiled from HR databases in a large international company with activities within multiple business segments, and in excess of 100.000 employees worldwide. The participants in this study were 4257 company leaders (1395 female, 2862 male), with a mean age of *M*=39.0 (*SD*= 8.4; range: 22-68 years). They had a mean seniority in the company of *M*=10.8 years (*SD*=7.7; range: 0-45 years). The sample represented 115 different nationalities, currently working in company branches in 117 different countries.

Measures

All data were provided to the researchers from the company for research purposes, provided the company could remain anonymous in any publication. Intelligence was measured using an in-house test for cognitive abilities developed for the company by a leading test developer. Innovativeness was measured using multiple subordinate ratings taken from a yearly employee satisfaction survey. Other demographic measures come from the company's HR Data systems. The data quality of data collected in real organizations is a potential confound, but due to the implementation of a new HR IT system the company has been through a major data cleanup prior to extracting the selected data. Although the data have been quality checked, the risk of error is present in real organizations since the business and every-day practical utility is valued over strict data collecting. Minor data inaccuracies that cannot be controlled may persist, but the large sample size should make this less of a concern.

2.3.1 Intelligence test.

All leaders were tested as a part of the recruitment procedure at the company using the in house intelligence test, developed by a leading global test developer. The test is a Wonderlic type 12 minute test with 50 items; 25 verbal, 17 numerical and 8 visual-spatial items. The tool is available in 68 different languages, and all employees take the test during recruitment following a

standardized test procedure administered by the company's HR professionals. Internal studies show a test-retest correlation of .76, and internal studies find correlations to the Raven Advanced Progressive Matrices test ranging from .40 to .59. Because the test is being deployed in the company's recruitment, the actual items cannot be shared, but include 2 sample items from the test introduction: A verbal item – "The hand is to the arm as the ear is to the ?" where the choice of answers are 1) eye, 2) nose, 3) head, 4) body, 5) finger (3 being the right answer), and a numerical item – "Identify the next number in the sequence 4, 8, 16, 32, ?" (64 being the right answer). Internal studies show p-values of the items ranging from .40 to .80 (the proportion of applicants that attempt to answer the item that get it right). The Threshold level of IQ120 was determined based on IQ scores from a separate sample of 1st time applicants at the company. Means and standard deviations were documented for the assessed ability dimensions. The ability groups were comparable with respect to age, and standard deviation.

Individual innovativeness.

Perception of leader innovativeness was scored using responses to the statement 'My leader is innovative and seeks out new ideas' from all subordinates directly reporting to the leader on a 5 point Likert scale from '1' (strongly disagree) to '5' (strongly agree), as part of a questionnaire on employee satisfaction. To reduce noise created from extreme cases where leaders were being rated by only a single or few subordinates and in order to increase reliability of the innovativeness rating, only leaders who were rated by at least 5 subordinates were included. In 2009, the leaders were on average rated by 8.1 subordinate employees, for a total of 21865 individual employees making innovativeness ratings of their direct leader, while in 2010, each leader was on average rated by 9.1 employees for a total of 26769 employees rating their leader's innovativeness. The leaders were rated in 2009 and/or 2010, with 1303 leaders rated only in 2009, 1567 leaders rated only in 2010, and 1387 rated in both years.

A small-scale construct validity pre-test of the innovativeness measure was conducted, by asking 30 subjects to rate their leader on the innovativeness measure used here and on Axtell et al.'s (2000; 2006) measure of individual innovativeness, which consists of two 6-item scales: *Suggestions* asks to which extend the respondent has proposed changes to various aspects of work, and *implementations* cover the same aspects of work, but instead asks to which extend suggestions have been implemented. Previous research has proven good internal consistency and factorial distinctiveness of these measures. Our innovativeness measure correlated highly with both suggestions $r(30)=.78$, $p<.001$, and implementations, $r(30)=.69$, $p<.001$, displaying satisfactory construct validity.

Reliability of the innovativeness ratings was tested in two ways: While the employee satisfaction questionnaire was anonymous, a subset of the subordinates volunteered their identity, making it possible to estimate test-retest reliability across the two sample years. The test-retest reliability for leader innovativeness, where the same group of at least 5 subordinates rated the same leader for two consecutive years (2009 and 2010 respectively), was $r(39)=.68$, $p<.001$. If the criterion was lowered to at least 4 subordinates rating the same leader for two consecutive years, a few more leaders for the test-retest estimate could be identified, while the correlation remained high $r(91)=.75$, $p<.001$. Overall, the subset of leaders who were rated in both 2009 and 2010 correlated $r(1416)=.49$, $p<.001$. Another way of estimating reliability was to identify leaders with multiple subordinates making ratings, and then randomly split the employees into two groups, making it possible to compare the average ratings of the two groups for the same leader. In effect this inter-judge measure constitutes a kind of interrater reliability for groups of raters, and with the criteria set to at least 9 subordinates in each group (the approximate average number of direct reports from subordinates in our leader sample), the correlation was $r(210)=.72$, $p<.001$, indicating a high level of agreement across subgroups.

The innovativeness measure used in the present study appears to be somewhat stable at the individual level across two distinct years and across samples of raters, and thus suitable for testing the link to IQ, and threshold theory. The measure of individual innovativeness used on the relation to IQ and occupational level was an average measure across the two years of rating (2009 and 2010).

Results

Test of Threshold Theory

For all participants, intelligence correlated with individual innovativeness $r(4257)=.09$, $p<.001$. Threshold theory was investigated by correlating innovativeness and intelligence with respect to the cut-off of IQ 120. Correlations for IQ<120 was $r(2863)=.10$, $p<.001$, as opposed to IQ>=120 which was $r(1394)=.01$, $p=.67$. The two correlations differed significantly from each other ($p=.008$). These three tests together provide support for the most conservative test of threshold theory (Karwowski and Gralewski, 2013).

To test reliability of these findings, the correlations for leaders having received ratings in 2009 and 2010 were run separately, excluding leaders who were rated both years. As such, correlations of two independent samples of leaders, rated in distinct years, could be compared. For leaders rated only in 2009, IQ<120: $r(855)=.15$, $p<.001$ vs. IQ>=120: $r(448)=-.06$, $p=.24$. These correlations differed significantly ($p<.001$). For leaders rated only in 2010, IQ<120: $r(1089)=.08$, $p=.014$ vs. IQ>=120: $r(478)=-.03$, $p=.49$. The correlations from 2010 were borderline significantly different ($p=.054$).

Given the possibility of restricted range in the bivariate correlations within subsamples, just reported, a step-wise regression was carried out.. In step 1 innovativeness was regressed onto IQ, and subsequently in step 2 innovativeness was regressed onto IQ and IQ-squared. The R^2 rose

slightly from step1 (R^2=.085) to step2 (R^2=.091), indicating evidence of non-linearity. The quadratic regression line was slightly concave, supporting the existence of a threshold effect.

Discussion

While past research has shown mixed results concerning the threshold effect of the link between creativity and intelligence, the present study utilizing a large sample of leaders from a real-world organization context did provide support for the theory. The correlation between leader innovativeness and intelligence was small but positive and significant below an IQ cut off point of IQ120, while there was no significant relation above this cut off point, and the two correlations were significantly different. The results were fairly reliable across two samples collected in two distinct years, and show support for the conservative version of Threshold theory. However, it should be noted that in all subsamples, the correlations between innovativeness and intelligence were small (in alignment with the small correlations reported in past studies and meta-analyses). The negligible correlations warrant caution as to the practical implication of this research; while the threshold theory was supported in the present real-life organizational context, the correlational magnitude should perhaps not suggest the use of intelligence thresholds in company recruitment, placement, or advancement for positions requiring individual innovativeness. The reason is that the small effect may only become statistically evident in very large samples, making it unwise to differentiate recruitment or advancement treatment above and below IQ thresholds at the individual level.

The present analysis was conducted in the context of a single international company working in multiple business segments. A central contribution of this study is the use of real life and ecologically valid measures used in organizations showing links between IQ and individual innovativeness. Given the case setting, it is thus not clear how the present findings will generalize to

other companies in other business segments. However, it should be noted that the company business segments mainly cover typical production, distribution and retailing domains. This is noteworthy because these domains are not considered typical creative industries in need of a high degree of innovation. Nonetheless, the theory that beyond a certain IQ threshold, variation in IQ does not predict creative performance was supported in a business context. Comparing these results to the past apparent lack of finding support for threshold theories for achievement measuring paradigms proves a bit of a paradox: why is threshold theory not supported among gifted individuals in the arts and sciences (Park et al., 2007; 2008), while it is with leaders in a business context? One possibility concern the potential domain specific character of creativity (Kaufman & Baer, 2005), where distinct creative domains may display varying threshold levels for the relation between IQ and creativity, or even that the threshold only hold true in certain domains (for example if IQ remains important for differentiating in the ability to produce scientific breakthroughs, while it may not help innovative behavior beyond threshold in a business context). Another possibility is that the explanation lies in part in the skills required to excel at the highest level of creativity: The business creativity context used in the present study could be characterized as 'day-to-day organizational creativity', where a certain IQ threshold may persist because beyond the threshold other factors dominate the ability to produce creative results, such as preference for creative work, and motivation for performing creative tasks. Contrast this with the high ability groups producing extraordinary and potentially domain changing creativity in the sciences (Park et al., 2008). At this level of potentially domain changing creativity, intelligence may be an important part of even the highest level of creative endeavor, given that creative activities would necessarily entail strong focus on domain knowledge acquisition and processing, identification of domain trends and logics, and problem solving of paradoxes and ambiguities (e.g., Csikszentmihalyi, 1990). All of these skills would seem intimately related to intelligence, whereby one would predict that creativity at the

highest levels would be correlated with intelligence. Further research is needed to clarify the issue of whether domain specificity, creative level or some other potential explanation may help resolve the apparent paradox.

The current study utilized a measure of individual innovativeness which encompass managerial creativity, but also extend beyond a normal creativity measure by including dimensions related to creative implementation in organizations. Future research is needed in order to clarify whether it is the idea generation or implications part of the measure (or both), that drive the threshold effect. This was not possible to disentangle in the present study because the volume of respondents made it unfeasible to utilize multiple dimension measures. Nonetheless, the findings constitute the first important evidence in support of threshold theory beyond creative potential measures, by applying perceptual measures of innovative behavior in a real-world organizational context.

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