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Intelligence and creativity: an investigation of threshold theory and its implications

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Abstract

Researchers have long been debating the relationship between intelligence and creativity. One of the most popular theories concerned about the relationship between intelligence and creativity is threshold theory which predicts a positive correlation between intelligence and creativity scores up to an IQ level of 120 and no correlation above this threshold. However, there is no clear reason why the threshold should be fixed at an IQ of 120. The main purpose of this study was to confirm the threshold theory within the samples of 222 senior high school student. Segmented regression analysis was performed to decide the optimal breakpoint of the threshold. For the criterion of potential creativity, a breakpoint was detected at an IQ of 106 points. When the threshold of IQ = 106 was tested, correlations between intelligence and creative abilities below the threshold are positive and significant (r=0,24; p<0,05), whereas above the threshold they are not significant (r=0,15; p>0,05). These results confirmed the threshold theory. Once the intelligence threshold is met, other factors become more predictive for creativity.

Keywords : threshold theory; intelligence; creativity; segmented regression; breakpoint detections

1. Introduction

Creativity is associated with craftsmanship and the ability to create new ideas to produce something (Ramy, Beydokhty, & Jamshidy, 2014). Creativity is an important psychological trait for human resource development, economic growth, and competitiveness of a nation (Park, Kim, & Lee, 2015). In the educational setting, creativity is important because it can serve daily life skills (McLellan & Nicholl, 2013) and affects the academic performance in schools (Nami, Marsooli, & Ashouri, 2014). Unfortunately, the evidence shows that creativity has not developed well in Indonesia. The Global Creativity Index (GCI) by Martin Prosperity Institute in 2015 shows that of the 139 countries studied, it was known that Indonesia was ranked 115th.

One of the internal factors that affect creativity is intelligence (Benedek, Franz, Heene, & Neubauer, 2012; Setyabudi, 2011). Some models of intelligence treat creativity as a lower order factor of intelligence. One important condition of creativity is divergent thinking, the ability to generate diverse and numerous ideas (Runco, 1991). These models assume a substantial correlation between creativity and intelligence. However, the relationship between creativity and intelligence is still unclear. Kim (2005) conducted a meta-analysis study of 21 studies that had been published from 1961 to 2004 with a total sample of 45,880 and indicated that the relationship between IQ scores and creativity is small and positive. The average correlation coefficient was small (r = 0,174; p <0,05). But, this coefficient was varied at different levels of cognitive ability. Guilford (1967) was the first researcher that discovered this condition and has become popular as “threshold theory”.

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Threshold theory notions that high intellectual ability is a necessary condition for high creativity, but high intellectual ability only is not a sufficient condition for high creativity. More specifically, it is assumed that there is a threshold in intelligence which is usually set to an IQ of 120. The threshold theory predicts that there is a correlation between creativity and intelligence in low to average IQ samples group, whereas there should be no correlation between creativity and intelligence in groups of higher IQ.

According to Karwowski & Gralewski, (2013), to investigate the threshold theory, there are three different categories of accepting threshold theory. The liberal criterion would be a significant correlation below the threshold and an insignificant correlation above it. The conservative criterion should be a significant positive correlation below the threshold, an insignificant correlation above the threshold, and a significant difference between both of them. The more conservative criterion should be a significant correlation below the threshold that is significantly higher than the correlation above the threshold.

Threshold theory is generally agreed by many researchers. In support of this theory, many researchers investigated this theory in various kinds of samples. Fuchs-Beauchamp, Karnes, & Johnson (1993) investigated preschooler children and found a significant correlation between intelligence and creative potential, but no significant correlations for gifted children. Other researchers found similar results that there was a significant correlation between intelligence and creative potential in samples with IQ below 120, but found lower correlation coefficient for them whose IQ was above 120 (Cho, Nijenhuis, van Vianen, KIM, & Lee, 2010).

However, the threshold effect has not always been supported by empirical research. Preckel, Holling, & Wiese (2006) investigated the threshold theory in a sample of gifted and non-gifted children. They found correlations between intelligence and creativity at all levels of cognitive ability. Kim (2005) also performed a meta-analysis study and estimated the correlations below and above an IQ of 120. The mean correlation for samples below IQ of 120 was r = 0,20 and for samples above IQ of 120 was r = 0,23. Therefore he rejected the threshold theory. Thus, from the studies investigated the threshold theory, the results are still inconsistent.

There are so many consideration related to this inconsistent result. It can be explained from the perspective of the samples and the cut-off point the threshold itself. Torrance (1972) showed that correlations between creativity and intelligence are consistently lower in boys than in girls. Kim (2005), mentioned in his meta-analysis study that the correlation was higher for older students than for younger ones. Moreover, Karwowski & Gralewski (2013) give their opinion that "it is not known why the threshold is established at 120 points rather than a few IQ points more or less" (p. 25). This opinion was supported by the study from Jauk, Benedek, Dunst, & Neubauer (2013) that the cut-off point of the threshold was not fixed at 120, but it was depended on the types of creativity measured. In fact, none of the sources are usually quoted explicitly assert that the threshold should be fixed at IQ of 120.

Another issue related to the investigation of the threshold theory was about statistical analysis used in the study. To investigate the existence of the threshold theory, the correlations between creativity and intelligence among higher and lower IQ groups are usually compared. However, the threshold theory may be a statistical artifact caused by differences in scores distribution below and above the threshold. Intelligence variance in the IQ < 120 group is greater than in the IQ ≥ 120 group. Low variance made a low correlation, which artifactually leads to confirmation of the threshold theory. One possible solution to answer this issue is correcting the correlation coefficients below and above the threshold for range restriction (Thorndike,1949) and then comparing them.

Overall, the main purpose of this study is to confirm the threshold theory within the samples of senior high school student. The following research questions: Can the threshold theory be confirmed within a sample of the senior high school students in Yogyakarta? What is the possible threshold point in the intelligence–creativity relationship?

2. Methodology

2.1. Participants

The participants were native Indonesian students who were attending Senior High School in the province of Yogyakarta, Indonesia from grade 10 to grade 11. The total of the participants were 222 students that came from a public school and two private schools. Specifically, 59.9% of the participants were female (N = 133) and 40.1% were male (N=89). The age of the participants ranged between 14 to 20 years old (Mean=16.47; SD=0.69). State authorities had approved this study and students consented to their participation.

2.2. Instruments

2.2.1. Verbal Creativity Test

Verbal Creativity Test (TKV) was the adaptation version the Torrance Tests of Creative Thinking (TTCT) that was developed by Munandar (Institute for Measurement Instrument and Psychological Education Development, 2011) to measure the potential verbal creativity. It consisted of six sub-tests, namely the beginning of a word, composing a word, forming a three-word phrase, the same traits, the various uses, and the consequences.

Verbal Creativity Test (TKV) had satisfaction validity and reliability. Interrater reliability ranged from 0,94 to 0,99, Test-retest reliability between 0,65 to 0,86 and Split-half reliability of 0,95. Validity verified using several tests. Concurrent validity showed a fairly high correlation with school achievement. Similarly, factor analysis shows that this construct could be distinguished by measures of intelligence (Institute for Measurement Instrument and Psychological Education Development, 2011).

2.2.2. Culture Fair Intelligence Test (CFIT)

Culture Fair Intelligence Test (CFIT) was a test measuring the fluid intelligence that is hereditary (congenital). CFIT was developed by Raymond B Cattell, A Karen Cattel, and other research staff from the Institute of Personality Testing (IPAT). We used only form A of CFIT scale 3 that was consisted of 4 sub-tests: series, classification, matrices, and conditions.

CFIT has satisfaction psychometrics properties. Sloan found that correlation between CFIT and Stanford Binet was 0,85, while Tilton found that correlation between CFIT and Wechsler Bellevue of 0,84. Knapp found reliability using Split-half coefficient was found to be 0,90 and 0,92 (in Cattel & Cattel, 1957). The verification of the validity and reliability in Indonesian samples was also proven. The average internal consistency was quite high at 0,78 to 0,88. Validity tested by factor analysis found that each factor was supported by variables with the minimum loading factor of 0,70 (Setyabudi, 1996).

2.3. Procedure

After we got a permission from the school to collect the data, we made an agreement with the teacher to schedule the time of collecting the data in the classroom during class hour. The participants were given brief information about the objective of the research and then the participants who were willing to participate in the research complete the test of TKV and CFIT. The duration of the test took approximately 2 hours for completing both of the two tests.

2.4. Data analysis

Data analysis was conducted in two steps. First, we performed a segmented linear regression analysis with The SegReg program(http://www.waterlog.info/segreg.htm). The segmentation is done by introducing a breakpoint. The selection of the best breakpoint and function type is based on maximizing the statistical coefficient of

explanation and performing tests of significance. Intelligence served as the independent variable, and the measures of creative potential served as the dependent variable. Segmented linear regression was conducted to decide the threshold point of intelligence that affect creativity.

Second, after we gained the threshold point, Pearson's r above and below the thresholds were analyzed. Threshold point was obtained from the breakpoint from the segmented linear regression analysis. Additionally, we used a correction for restriction range for both of the analysis (Thorndike, 1949) to compare the correlation coefficient. The analysis of the second step was conducted using SPSS 22.

3. Results

3.1. Descriptive Statistics

Descriptive statistics of Intelligence and Creativity among the participants are reported in table 1. Analysis of independent t-test showed that there was no difference of intelligence between male and female samples (t=0,55; p>0,05), and also there was no difference of creativity between male and female samples (t=1,3; p>0,05). Correlation between intelligence and creativity within all of the sample was significant (r=0,306; p<0,01).

Table 1. Descriptive statistics of Intelligence and Creativity

Statistic		Intelligence	Creativity
Male	Mean	105,87	94,8
	SD	12,46	12,2
Female	Mean	105	97,01
	SD	11,87	12,54
Total	Mean	105,35	96,12
	SD	12,09	12,42

3.2. Segmented Linear Regression Analyses

Segmented linear regression analysis was performed with The SegReg program to decide the optimal breakpoint of the threshold. For the criterion of potential creativity, a breakpoint was detected at an IQ of 106 points. It means that for students who have IQ below 106 points, intelligence strongly can predict creative abilities, but it did not happened for them who have IQ above 106 points. The breakpoint model is shown in Figure 1.

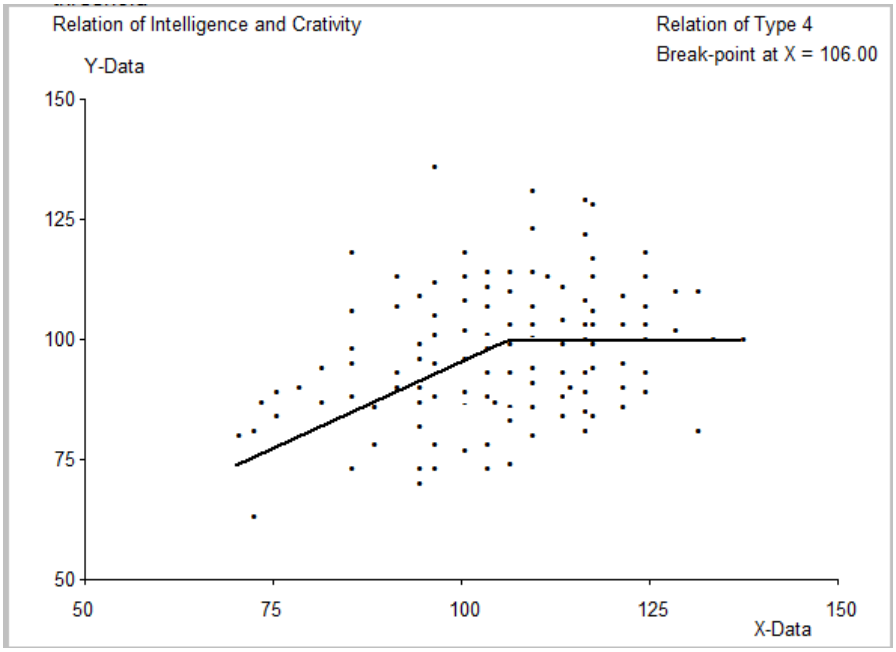

Figure 1. Breakpoint models of intelligence for the creativity

3.3. Comparisons of Correlation Coefficients Below and Above Thresholds

In the next step, the correlation coefficients on IQ and CQ scores below and above the threshold (106 IQ points) were calculated. A correction for restriction range was also applied to analyze intelligence thresholds. Comparison of correlation coefficients of the threshold is reported in table 2.

Table 2. Comparisons of Pearson r's below and above tested thresholds

Tested threshold	N	Mean	SD	r	r'
IQ ≥ 106	123	113,79	7,01	0,15	0.25
IQ <106	99	94,86	8,24	0,24*	0.34

* p < .05.
r' r corrected for restriction range

When the threshold of IQ = 106 is tested, correlations between intelligence and creative abilities below the threshold are positive and significant (r=0,24; p<0,05), whereas above the threshold they are not significant (r=0,15; p>0,05). These results confirm the threshold theory when the proposed liberal criterion is applied. Comparison of r's above and below the threshold shows that they do not differ significantly (z = -0,68; p>0.05). Correction for range restriction increases correlation coefficients also performed. After we made a correction for range restriction, the correlation coefficients were increased, and the result was still consistent with the threshold theory that the correlation coefficient above the threshold was lower than the correlation coefficient below the threshold.

A linear regression analysis was conducted on intelligence to creativity within two group of sample: below and above the threshold. For group of samples who had IQ points below 106, intelligence is significantly predict creativity (F=6,14; p<0,05) with the regression equation Y=57,3 + 0,37X and R2=0,060. For group of samples who had IQ points above 106, intelligence is not significantly predict creativity (F=2,84; p> 0,05) with the regression equation Y=70,4 + 0,25X and R2=0,023. The scatterplot and regression slope of booth analysis can be seen in figure 2.

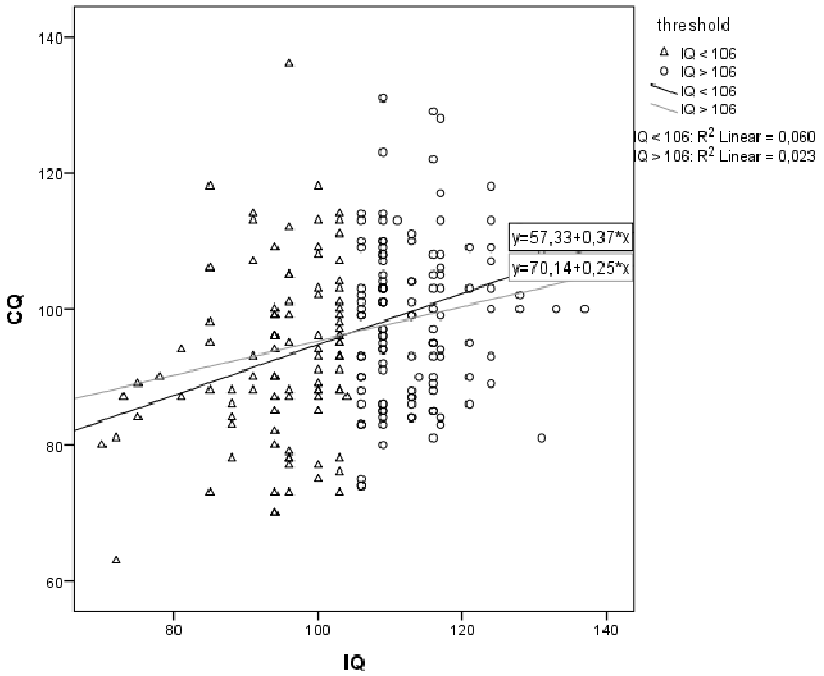

Figure 2. Scatterplot of linear regression analysis

4. Discussions

The present study investigated the relationship between intelligence and creativity. This study supports many other studies on the intelligence-creativity relationship (Benedek et al., 2012; Kim, 2005; Setyabudi, 2011). The correlation coefficient between intelligence and creativity in this study is stronger than the average correlation coefficient from meta-analysis study by Kim (2005). Kim (2005) found that the average correlation coefficient between intelligence and creative thinking of 21 studies that had been published from 1961 to 2004 was 0,174, while the correlation coefficient in this study is 0,306.

This study also finds that threshold theory is confirmed within the samples of senior high school student in Yogyakarta. People do not need to be genius to be a creative person. But to be creative people requires a level of intelligence. When a person has reached a certain level of IQ, enhanced intelligence does not play a role in improving the ability to think creatively. Jauk et al. (2013) mentioned that very high level of IQ only needed to predict ideational originality rather than fluency. Thus, once people have reached the threshold, they don't need intelligence anymore to increase fluency.

Past studies that investigated the threshold theory, which states that correlations between intelligence and creativity are stronger for lower ability levels, are inconsistent. Mostly, researchers used the cut-off point of IQ 120, while others used another cut-off point. But, it is still unclear why the threshold is established at 120 points. Thus, in this study, we performed segmented linear regression analysis to decide the breakpoint of the threshold. From the result of our study, the optimal breakpoint of IQ is 106. It is lower than commonly cut-off point 120. This finding is similar with the finding from Jauk et al. (2013) that for top 2 originality score, a significant breakpoint was detected at an IQ of 104 points.

How can the discrepancy between the IQ threshold of 106 and 120 IQ points be explained? The most straightforward interpretation would tell that it needs higher intelligence to produce creativity. Mostly said that an individual's creativity would be best predicted by intelligence for them who has IQ points below 120, but above that, there are many factors that affect the creativity. But from the result of this research, it

is found that individual's intelligence can be the best predictor for creativity only up to 106 IQ points. It means that creativity for them who have IQ point above 106 is determined by other factors. It also means that intelligence is important for creativity, but only for some level, for this case is 106 IQ point, the rest is determined by other factors.

Recently researchers indicate that the importance of intelligence for creativity should not be exaggerated (Kim, 2005). Since it is known that the effect of intelligence on creativity is only needed for some certain levels, it is better if researchers start to investigate other variables that can increase the creativity. According to past researchs, there are many variables can influence creativity, such as mood (To, Fisher, Ashkanasy, & Rowe, 2012), openness personality (Jauk et al., 2013), emotional intelligence (Landau & Weissler, 1998), democratic parenting style (Moghadam, Poshtareh, Ahmadi, & Goodarzi, 2016), and creative climate (McLellan & Nicholl, 2013).

Parenting style and creative climate are two variables that can be manipulated in the family and school setting. Creative climate has 9 dimensions of challenge, freedom, trust/openness, idea time, playfulness/humor, conflict, idea support, debate, and risk-taking (McLellan & Nicholl, 2013). Democratic parenting style also influences on the creativity (Moghadam et al., 2016). Teacher can manipulate the situation in the class to have positive creative climate and more democratic to increase creativity of the students. Researcher can also conduct a research to investigate the effectiveness of these two variables to increase creativity.

The main limitation of this research is related to the type of intelligence measured. This research only focuses on fluid intelligence. Recent research points out that crystallized intelligence was found to show higher correlations with specific measures of creative potential than other components of intelligence (Cho et al., 2010). While fluid intelligence involves ability to reason and deal with complex information, crystallized intelligence involves learning, knowledge, and skills that are acquired over a lifetime. In future research, it is better to confirm the effect of crystallized intelligence on creativity.

5. Conclusion

This research is in line with early assumptions about threshold theory which said that intelligence is necessary for creativity, but the kind of relationship depends on the level of intelligence. The threshold point we found in this research is 106 IQ points. Once the intelligence threshold is met, other factors become more predictive for creativity. Related to this finding, the future research should focus on investigating the effectiveness of the other factors (e.g. parenting style and creative climate) on creativity. This research only focuses on potential creativity and fluid intelligence. Further researchs are suggested to involve different samples and different measures of creativity and intelligence.

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