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Synthetic-Creative Intelligence and Psychometric Intelligence: Analysis of the Threshold Theory and Creative Process

Sentetik-Yaratıcı Zeka ve Psikometrik Zeka: Eşik Kuramı ve Yaratıcı Süreç Analizi

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Abstract

There has been an increasing body of research to uncover the relationship between creativity and intelligence. This relationship usually has been examined using traditional measures of intelligence and seldom using new approaches (i.e. Ferrando et al. 2005). In this work, creativity is measured by tools developed based on Sternberg's successful intelligence theory. Our aims were two-folded: to examine the relationship between intelligence and creativity and to investigate possible differences on the creative process depending on students' level of intelligence. A total of 385 students from primary and secondary schools took part in the study. Students completed 5 tasks from the Aurora Battery aimed to measure the synthetic-creative intelligence. They also completed the Cattell's general intelligence test. The results showed that there were statistically significant differences depending on students' level of intelligence on the five tasks of creativity, always favouring the more intelligent group. In relation to the creative process, the three groups (low, average and highly intelligent students) showed similar patterns: they performed better at the end and weaker at the beginning of mot of the tasks. Students with lower intelligence were more stable in their performance across tasks than students with average and higher I.Q were.

Keywords: creativity, intelligence, threshold theory

Öz

Yaratıcılık ve zekâ arasındaki ilişkiyi ortaya çıkarmaya çalışan birçok araştırma bulunmaktadır. Bu ilişki araştırılırken genellikle geleneksel zeka ölçümlerine, nadiren de yeni yaklaşımlara başvurulmaktadır (Ferranda et al. 2006). Bu çalışmada yaratıcılık, Sternberg'in başarılı zekâ teorisine dayalı araçlarla ölçülmüştür. Çalışmanın iki amacı vardır; birincisi yaratıcılık ve zekâ arasındaki ilişkiyi araştırmak, ikincisi ise zekâ düzeylerine göre yaratıcı süreçteki olası farklılıkları incelemektir. Çalışma 385 ilkokul ve ortaokul öğrencisi ile gerçekleştirilmiştir. Öğrencilere Aurora Bataryasındaki sentetik-yaratıcı zeka ile ilgili 5 görev ve Cattell'in genel zekâ testi uygulanmıştır. Sonuçlara göre yaratıcılık görevlerinin tamamında zeka düzeyi yüksek gurup lehine istatistiksel olarak anlamlı farklılıklar bulunmuştur. Zekâ ile yaratıcılık süreci arasındaki ilişki üç grup (zekâ düzeyi alt, orta ve üst) için de benzerlik göstermektedir: Öğrencilerin performanslar görevin başlangıcından sonuna doğru giderek artmıştır. Alt gruptaki öğrencilerin üst ve orta guruptaki öğrencilere göre daha kararlı performans sergiledikleri görülmüştür (alt guruptaki öğrenciler tüm görevlerde benzer performans sergiledikleri söylenebilir).

Anahtar Sözcükler: zekâ, yaratıcılık, eşik kuramı

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Synthetic-Creative Intelligence and Psychometric Intelligence: Analysis of Threshold Theory and Creative Process Depending on Students IQ

In the study, the relationship between intelligence and creativity was investigated. The relationship between these two constructs have been studied using correlations (e.g. Ferrando, Prieto, Ferrándiz, &Sánchez, 2005; Getzels & Jackson, 1962; Hocevar, 1980; Kim, 2005), predictions of one over the other (e.g. Batey, Furnham & Safiullina, 2010; Furnham & Bachtiar, 2008; Silvia, 2008; Silvia & Beaty, 2012) and in terms of individual differences between students of low versus high creativity or intelligence (e.g. Getzels & Jackson, 1962; Preckel, Holling & Wiese, 2006; Runco & Albert, 1986).

The results obtained in empirical studies have lead to speculate five different possibilities of how creativity and intelligence are related: from being different and unrelated constructs, to being the same constructs (see Batey & Furnham, 2006; Kim, Cramond & VanTassel-Baska, 2010; Sternberg & O´Hara, 1999). One of these relationships is the perspective that they are overlapping constructs. According to this perspective, the relationship between the both is weaker for higher IQ scores. This is called the 'threshold theory' (Guilford & Hoepfner, 1971; Torrance, 1962). This theory states that creative students have a minimum level of intelligence, whereas students with higher intelligence are not necessarily creative. Recent research has failed to confirm this theory (Ferrando, et al. 2005; Kim, 2005; Naderi & Abdullah, 2010; Preckel, et al., 2006; Runco & Albert, 1986). As stated by Nusbaum & Silvia (2011, p. 36-37), contemporary creativity research views intelligence and creativity as distinct traits that are only modestly related.

Most of the studies in testing the threshold theory were conducted before the 1990's, and recently a new interest in this subject has reemerged (Kim en 2005; Preckel, et al., 2006; Olatoye & Oyundoyin, 2007; Palaniappan, 2007; Naderi & Abdullah, 2010; Pereira de Barros, Primi, Koich, Almeida, & Oliveira, 2010; Nusbaum and Silvia, 2011; Ferrando, Bermejo, Sainz, Ferrándiz, Prieto, & Soto, 2012). A meta-analysis carried out by Kim (2005) has become a work of reference in this area. She studied the relationship between creativity and intelligence aiming at verifying the threshold hypothesis and to identify which variables may be moderating the relationship between the two constructs (such as the test used, gender, age of participants). The synthesis of the relationships found between creativity and intelligence were positive but low, the coefficient correlations were more heterogeneous for 120 IQ and below, which was examined as one of the possible moderators in the relationship. When IQ scores were divided into four different levels (CI<100 [r=.260]; 100<CI>120 [r=.140]; 120<CI>135 [r=.259] y CI>135 [r=-.215]), no statistically significant differences were found among the correlations in these four levels of IQ. The threshold theory could not be confirmed. Apparently, only the creativity test used and age were the only significant moderators that explained the variability in the correlations between creativity and intelligence

In a study published in 2006, Preckel, Holling and Wise did study the threshold theory using a sample of 1328 gifted and non-gifted students. They used the Berlin Test of Intelligence (BIS-HIB), which also measure creativity besides intelligence. They divided the sample in four different levels of IQ (93-120; 121-130; 131-145 & 146-165). For the whole sample they found statistically significant correlations between creativity and intelligence (above r=.3). After they splited the sample in four groups, they did not find statistically significant correlations between creativity and intelligence, except for the relationship between intelligence and verbal fluency (r=.25) and verbal flexibility (r=.27) in the group of students with IQs between 131 and 145.

Olatoye and Oyundoyin (2007) investigated the power of intelligence at predicting creativity. They tested 460 secondary school students from Ohio State using the Slosson's Intelligence Test (Slosson, 1981) and Ibadan Creative Assessment Scale (ICAS, Akinboye in 1977). After using different regression analysis, they found that IQ accounted for 8% of variance in creativity (R2 = 0.80). In addition, IQ also predicted each of the four components of creativity.

Palaniappan (2007) conducted a research with 497 students from Malasia to study the creativity and intelligence relationship with academic performance. He used the CFIT to measure intelligence and the TTCT to measure creativity. Students were grouped depending on their levels of IQ and creativity (G1: high IQ and high creativity, G2: high IQ and low creativity, G3: low IQ and high creativity and G4: low IQ and low creativity). They found statistically significant differences on academic performance between the groups of high IQ-high creativity and low IQ-low creativity. They did not find any statistically significant differences between high IQ-low creativity vs. low IQ-high creativity and high IQ-low creativity.

Naderi and Abdullah (2010) investigated whether intelligence could predict creativity. They tested 153 students from different universities in Malasia. They used the Cattell test of g factor and the Kathena-Torrance questionnaire of creativity. Results verified that the g factor can significantly predict the dimension 'sensibility to the environment' of the self-perceived creativity.

Pereira de Barros, et al. (2010) also studied the relationship between creativity (as metaphoric thinking) and intelligence. The sample was 163 university students. They completed the Metaphors Creation Test (MCT, Primi et al., 2006) and the Battery of Reasoning Test (Almeida & Primi, 1998). Their results showed low and moderate correlations between the BPR-5 tests and Metaphor Creation Test, specially the abstract reasoning test (the nearest to "g" factor). With verbal reasoning test, the correlation was higher, which authors explain as a cause of the vocabulary knowledge necessary to perform in both task. Therefore, authors concluded that the resolution of tasks calling for metaphorical reasoning should not to be confused with intelligence, as is evaluated through tests of analogical reasoning type, given that this is the most traditional format of the items in intelligence tests.

Recently, new approaches have try to shed some light on how both constructs are related. For example, Nusbaum and Silvia (2011) proposed to study the relationship between creativity and intelligence by using structural equation models. The results of their research point out that individual differences in fluid intelligence significantly predict creativity, and these results were partially explained by the effects of fluid intelligence in the executive change.

Other new approaches are based on the study of students' profiles. Ferrando, et al., (2012) took a step forward and look into students' cognitive profiles. It is hypothesised that, if creativity occurs as a result of relating distant concepts, a more balanced profile among cognitive abilities –a flat profile – could facilitate a loose relationship between concepts. Therefore, creative individuals would present a cognitive profile with less peaks and troughs. However, their study could not confirm the hypothesis.

Intelligence also could be related to the creative process. However, no studies have been conducted on this relationship. We hypothesize that students' intelligence also may have an effect on the process of creation that they follow. A similar procedure was carried out to study consistency during the creative process in the study conducted by Bermejo, Ferrándiz and Prieto (2005) using as dependent variable, students' level of creativity.

In the present study we aimed to analyze the relationship between creativity and intelligence in a sample of young students. Most of the research conducted has taken adults participants. Younger people may show a differentiation between skilss/abilities (Austin, Deary & Gibson, 1997). In addition, we wanted to analyze whether there was an effect of intelligence on the creative process. It is hypothesized that more intelligent students may experiment a "training" during the completion of the task, and then they would be more creative at the end of the task rather that at the beginning of it.

Method

Sample

A total of 385 students (174 boys and 211 girls) from primary and secondary schools in Spain. Their age ranged from 8 to 15 years. They attended the 3rd to 6th grade of primary school and the 1st and 2nd grade of secondary school (mean age= 10.51, SD = 1.75). A detailed distribution of the sample by grade and gender is shown in table 1.

Table 1. Distribution of the Sample by Grade and Gender

	Grade						Total
	Primary Education				Secondary Education		
	3dt	4th	5th	6th	1st	2nd	
Boys	35	28	34	39	18	20	174
Girls	34	35	44	42	30	26	211
Total	69	63	78	81	48	46	385

Instruments

Creativity was measured using the Aurora Battery (synthetic intelligence test). Aurora is a set of assessments. One of these assessments, Aurora-a (for augmented), hereafter, Aurora the battery's paper and pencil test and our main focus in this article-was developed to assess analytical, creative, and practical abilities in a group or classroom setting. It consists of 17 subtests: six analytical, five creative, and six practical. The instrument is characterized by variation in its types of item formats (multiple choice, short answer, and open-ended items, which are scored by trained raters). The subtests were designed to assess abilities across and between stimulus domains (six verbal-Words, five numerical-Numbers, and six figural-Images subtests) and item formats such that a balanced range of opportunities could be offered to demonstrate various abilities within and across domains (Chart, Grigorenko & Sternberg, 2008). The Aurora Battery is an instrument aimed at gifted and talented identification following the Sternberg's triarchic intelligence theory. Five task from the synthetic intelligence test were used:

Inanimate Conversations. Inanimate Conversations allows students to imagine what certain objects might say to each other if they could speak. The students are asked to imagine a dialogue between objects that do not talk, for example, between a fork and a knife.

Figurative language. Students are asked to identify the meaning of metaphors used in common language from a list of possible responses.

Multiple uses. Students are asked to give three alternative uses to common objects.

Book Covers. It allows students to generate a brief story plot to describe somewhat abstract pictures described as children's book covers. Students are asked to imagine the history behind a given book cover (abstract or ambiguous images).

Number Talk. It allows students to explain the reason for a social interaction briefly described and illustrated between two cartoon numbers. Students are presented cartoon numbers in different situations and are asked about what is happening and why with those numbers. For instance number 2 and number 4 may appear happy together.

Except for metaphors, which is a multiple-option task, the other four tasks were scored using a rubric developed by Sternberg and Grigorenko research team. Each task obtained a unique score for creativity. According to Soto (2012) who adapted these tasks to the Spanish population, the task showed a reliability of α=.75 for figurative language, .76 for unanimated conversations, .71 for numerical conversations, .78 for multiple uses and .73 for book covers.

Intelligence was measured using the Cattell and Cattell (2001) general intelligence test, known as "g factor test" which is aimed to measure the general capability by using non-verbal task, eliminating the influence of crystallized intelligence and culture. In this study, the scales 2 and 3 were used according to participants' age. The scales are composed of four subtests: series, classifications, conditions and matrices. The reported reliability index in the manual is .86 (Cattell & Cattell, 1997).

Results

Relationship Between Intelligence and Creativity

The preliminary analysis showed that IQ had statisticly significant correlations with the five tasks of creativity (figurative language r=.34, p<.001; unanimated conversations r=.28, p<.001; numerical conversations r=.15, p= ,004; multiple uses r=,363, p<.001; book covers r= ,269, p<.001). Then, the sample was splitted into three groups (low, average and highly intelligent students) following Almeida and Freire procedure (2003), taking cut points as IQ=85 and IQ= 115. In the low intelligence group, (IQ<85) 52 students were placed. The average IQ group (IQ between 85 and 115 score) consisted of 208 students, and the highly intelligent group (IQ>115) was composed of 127 students. Table 2 shows the descriptive statistics obtained by each group in the different creativity tasks.

Table 2. Scores Obtained by Students According to IQ Level

	Low IQ < 85 (n=52)		Average IQ 85-115 (n=208)		High IQ >115 (n=127)	
	Min-Max	M (SD)	Min-Max	M (SD)	Min-Max	M (SD)
Fig. Language	0-12	4.04 (2.60)	0- 12	6.50 (2.90)	1-11	7.31 (2.82)
Unanimated conv.	11.33-33.33	20.73 (4.14)	6.67-31.33	22.76 (3.55)	16.33-31	23.67 (2.97)
Numerical conv.	5.5-23	13.10 (3.23)	4.5-21	13.39 (3.14)	8-20.5	14.38 (2.98)
Multiple Uses	3-43	24.24 (10.10)	3-47.5	28.02 (10.75)	6-47.5	32.38 (9.80)
Book Covers	5-18	11.44 (2.84)	2-17.5	12.05 (2.41)	7.5-18	13.22 (2.15)

As table 2 shows, there exists a progressive rise on the creativity scores with IQ increments. The group with low IQ scores always scored lower than their peers, whereas high IQ group always scored higher. In addition, the variability on students scores is lower for the high IQ group than for the low IQ group. An ANOVA was conducted to test whether these differences were statistically significant. The results showed that there were statistically significant differences in all the tasks. These differences existed between the average IQ group and the high IQ group, and also between the low and high IQ group except for numerical conversations. Differences between low and average IQ groups were found only for the figurative language task.

Table 3. Results of the ANOVAs and Post-hoc Comparisons

	F	Post- hoc		
Figurative language	$F(2, 371) = 23.13$; $p<.001$	L ≠A	L≠H	A≠ H
Unanimated conversations	$F(2, 338) = 10.85$; $p<.001$	L ≠A	L≠ H	A≈ H
Numerical conversations	$F(2, 353) = 4.51$, $p= .012$	L ≈A	L ≈H	A≠ H
Multiples uses	$F(2, 305)= 10.13$; $p<.001$	L ≈A	L≠ H	A ≠H
Book covers	$F(2, 359) = 13.03$; $p<.001$	L≈ A	L≠H	A ≠H

L: Low IQ group, A: Average IQ group, H: High IQ group

As our sample is quite heterogeneous in terms of age and grade, it was necessary to control the influence of grade when examining the differences depending on students' IQ. Because it is expected that, for example, a 1st grader with and IQ of 120 will not perform similar to a

3rd grader with the same level. To control this, a MANOVA (3X6) was conducted, taking level of IQ as independent variables (low, average, high) and grade (3rd, 4th, 5th, 6th grades of Primary Education and 1st and 2nd grades of Secondary Education). The simple effects of grade were statistically significant [Wilks' Lambda= .57; $F(25, 900) = 5,901$; $p<.001$; $\eta2= .107$; power=1], as well as the simple effects of IQ level [Wilks' Lambda= .802; $F(10, 486) = 5.65$; $p<.001$; $\eta2=.105$; power= 1]; but, the combined effect of IQ and grade was not statistically significant [Wilks' Lambda = .763; $F(50, 1107.05) = 1.35$; $p=.053$; $\eta2=.053$; power= .99]. For the effects of these variables in each task, the simple effects of IQ level were significant for each of the five creativity tasks, except for unanimated conversations. Simple effects of grade were statistically significant for all the tasks except for multiple uses. The combined effect of IQ level and grade was statistically significant only for the figurative language and multiple uses (See Table 4).

Table 4. Simple and Combined Effects of IQ Level and Grade over the Five Creativity Tasks

	IQ Level	Grade	IQ level* Grade
Fig. Language	$F(2, 246) = 13.35$; $p<.001$; $\eta2=.098$	$F(5, 246) = 21.78$;$p<.001$; $\eta2=.307$	$F(10, 246) = 2.19$; $p=.019$; $\eta2=.082$
Unanimated conv.	$F(2, 246) = 2.78$; $p=.063$; $\eta2= .022$	$F(5, 246) = 8.66$; $p<.001$; $\eta2=.150$	$F(10, 246) = 1.9$; $p=.038$; $\eta2= .074$
Numerical conv.	$F(2, 246) = 3.89$; $p=.022$; $\eta2=.31$	$F(5, 246) = 7.41$; $p<.001$; $\eta2=.131$	$F(10, 246) = 1.35$; $p=2$; $\eta2=.052$
Multiple uses	$F(2, 246) = 10,09$; $p<.001$; $\eta2=.076$	$F(5, 246) = .77$; $p=.572$; $\eta2=.015$	$F(10, 246) =.60$; $p=.80$; $\eta2=.024$
Book's covers	$F(2, 246)=10.23$; $p<.001$; $\eta2=.077$	$F(5, 246) = 6.99$; $p<.001$; $\eta2=.124$	$F(10, 246) = 1.82$; $p=.057$; $\eta2=.069$

The graphic of means for figurative language and multiple uses are displayed in figure 1. In the figurative language task, the average IQ group always scored higer than their peers, except in the 2nd grade of secondary education, in which the lower IQ group scored the highest. In general, it seems that older students perform better in this task. In the Multiple Uses task, again average students are those who score the higher, in the six grades. Higher IQ students in the 3rd and 4th grade of primary education scored lower than the lower IQ group.

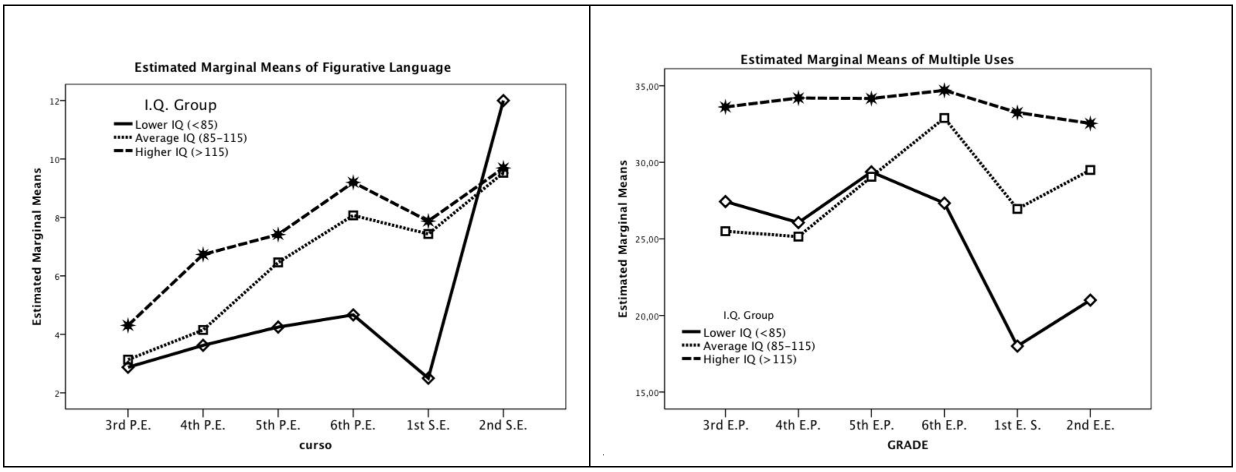

Figure 1. Graphics Displaying Creative Task Scores Depending on IQ Level and Grade

Differences on the Creative Process Depending on Students' Intelligence Level

In order to study the consistency of the creative process, each task was splitted into two halves. Students perform better in the 1st half, at the beginning and slightly worst in the second half (see Table 5). The paired t-tests showed that low IQ students were more stable in their creative process, whereas both average and high IQ students were inconsistent in their scores during the creativity process. For the task of multiple uses, the three groups performed significantly lower at the second half. In addition, both average and high IQ groups performed significantly lower in the second half of the inanimate conversations. The average and high IQ groups significantly improved their scores in the second half of numerical conversations and figurative language respectively.

Table 5. Descriptive statistics and T-test for Paired-samples for the Creativity Tasks

		Fig. Language	Inanimate conv.	Numerical conv.	Multiple uses	Book covers
Whole sample	M (SD) 1st half	3.15 (1.60)	11.06 (2.37)	5.96 (1.90)	12.01 (4.43)	5.02 (1.22)
	M (SD) 2nd half	3.21 (1.79)	10.26 (2.48)	6.25 (1.76)	10.69 (4.24)	4.88 (1.39)
	Correlation	*r*=.601; p<.001	*r*=.373; p<.001	*r*=.374; p<.001	*r*=.538; p<.001	*r*=.443; p<.001
	T- test	t(379)= -.135; *p*=.892	t(379)= 7.09; p<.001	t(379)= -2.478; *p*=.014	t(379)= 6.841; p<.001	t(379)= 2.494; *p*=.013
Lower IQ IQ < 85 (n=52)	M (SD) 1st half	2.13 (1.40)	9.69 (2.78)	5.61 (2.00)	9.22 (4.54)	4.76 (1.37)
	M (SD) 2nd half	1.80 (1.58)	9.37 (2.87)	5.70 (1.92)	8.36 (3.84)	4.67 (1.45)
	Correlation	*r*=.523; *p*= 0	*r*=.169; *p*=.262	*r*=.198; *p*=.203	*r*=.742; *p*= 0	*r*=.5; *p*= 0
	T- test	t(49)= 1.94;; *p*=.058	t(49)= 1.99; *p*=.053	t(49)=.32; *p*=.747	t(49)= 2.46; *p*=.018	t(49)=.42; *p*=.674
Average IQ 85-115 IQ (n=208)	M (SD) 1st half	3.22 (1.56)	11.14 (2.19)	5.80 (1.82)	12.00 (4.33)	4.85 (1.20)
	M (SD) 2nd half	3.19 (1.73)	10.31 (2.47)	6.15 (1.74)	10.51 (4.21)	4.72 (1.42)
	Correlation	*r*=.597; p<.001	*r*=.456; p<.001	*r*=.4; p<.001	*r*=.499; p<.001	*r*=.39; p<.001
	T- test	t(204)=.62; *p*=.539	t(204)= 5.30; p<.001	t(204)= -2.68; *p*=.008	t(204)= 5.28; p<.001	t(204)= 1.92; *p*=.057
Higher IQ IQ >115 (n=127)	M (SD)1st half	3.46 (1.59)	11.49 (2.28)	6.35 (1.94)	13.17 (4.04)	5.39 (1.11)
	M (SD) 2nd half	3.80 (1.65)	10.52 (2.28)	6.62 (1.68)	11.85 (4.04)	5.24 (1.24)
	Correlation	*r*=.53; *p*= 0	*r*=.268; *p*=.003	*r*=.366; *p*= 0	*r*=.428; *p*= 0	*r*=.437; *p*= 0
	T- test	t(124)= -2.12; *p*=.036	t(124)= 4.40; p<.001	t(124)= -1.22; *p*=.226	t(124)= 3.65; p<.001	t(124)= 1.64; *p*=.103

Conclusions

The results of this study do not confirm the threshold hypothesis. Also that according to the differentiation theory (Austin, Deary & Gibson, 1997), higher correlations between creativity and intelligence are expected. This hypothesis also was not supported. In addition, the higher IQ group significantly perform better than the other groups on creativity tasks. If the threshold hypothesis was to be confirmed, average and high IQ groups would not differ in their creative level. In terms of the effect of grade level on creativity, we found a simple effect of IQ level, but grade was also a significant variable accounting for differences in the creative performance.

The second aim of our study was to assess whether there were differences on the creative process depending on students' intelligence level. We wanted to present a new area of study, as the process of creation depending on students' IQ has not been studied before. In a previous study, Bermejo, Ferrandiz and Prieto (2005) studied the consistency of creative process depending on students' creativity level. They found that less creative students were more consistent in their process whereas more creative students tended to have significant differences between the beginning and end of the task.

We have hypothesised that IQ could influence the way in which the creative process is handled. In this sense, higher IQ may show more inconsistent process, as clever students could learn during the test and therefore can show more creativity at the end of the task. In our study, the results show that students with lower IQ show more stability in their creation process, whereas average and high IQ students show fluctuations in the production. These fluctuations seem to depend on the nature of the task itself. In the multiple uses and unanimated conversations tasks, for example, students show higher creativity at the beginning, whereas in figurative language and numerical conversations, there is a significant gaining of creativity in the second half of the task. Figurative language is a task that requires logical and convergent thinking to link the metaphors used. It is possible that students get used to the style and metaphors used in the task and they can perform better when they have some experience with it. The numerical conversation task does not necessarily require mathematical knowledge, but it can help productions of original and creative answers. Why it does not occur with multiple uses task and unanimated conversations? Contrary to the majority of creative task, these two tasks do not require fluency. These tasks are those in which the number of answers is not important, students are not required to give many answers but one answer that they consider as appropriate (in the case of unanimated conversations) or three answers at most that they consider as appropriate (in the case of multiple uses) for each item. It seems that these task are quite challenging for students, and therefore they perform better in the beginning and get tired towards the end.

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