HOW SOLVE VERBAL AND MATHEMATICAL INSIGHT PROBLEMS CHILDREN WITH HIGH GENERAL INTELLIGENCE LEVEL

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SUMMARY: We trying to study in depth selective and non-selective encoding processes (verbal and mathematical contain domains) in children with high general intelligence level. According to the selective encoding subtheory, high intelligence individuals select the important information quickly, whereas pupils of average intelligence find more difficult to use their insight properly. The results of our study demonstrate that there is an important relation between the scores obtained in mathematical and verbal tasks, what also happened in Davidson and Sternberg's research.

RESUMEN: Tratamos de estudiar cómo funcionan los procesos de la codificación selectiva en la solución de problemas de contenido verbal y matemático en los sujetos con un alto nivel intelectual. Se parte de la premisa según la cual los sujetos con alto nivel intelectual seleccionan la información relevante de manera rápida, mientras que los de inteligencia media lo hacen con mayor dificultad, necesitando incluso pistas o ayudas. Los resultados de nuestra investigación demuestran que existe una relación importante entre las puntuaciones obtenidas en tareas de contenido matemático y verbal, a favor de los sujetos con nivel intelectual general, los datos coinciden con los resultados obtenidos por Sternberg y Davidson.

RESUMO: Tratamos de estudiar cómo funcionan os procesos da codificación selectiva na solución de problemas de contido verbal e matemático nos suxetos cun alto nivel intelectual. Pártese da premisa segundo a cal os suxetos con alto nivel intelectual seleccionan a información relevante de maneira rápida, mentras que os de intelixencia media fanno con maior dificultade, necesitando incluso pistas ou axudas. Os resultados da nosa investigación demostran que existe unha relación importante entre as puntuacións obtidas en tareas de contido matemático e verbal, a favor dos suxetos con nivel intelectual xeral, os datos coinciden cos resultados obtidos por Sternberg e Dadivson.

1. ABSTRACT

The aim of our research is to study the insight process in students with a high level of general intelligence. The subjects, students (N=208) from 8 to 9 years old, had been identified as either superior to the average in their level of general intelligence on the bases of IQ test scores, teacher recomendations and academic work. In particular, we expected to prove the following hypotheses: a) children with high IQ level perform better than the normal ones in insight problems related to selective encoding, combination and comparison; b) children with high IQ level perform better than the normal ones in uncued problems; c) children with high IQ level perform better than the normal ones in mathematical and verbal insight problems. The results of our experiment were: 1) As predicted, children with high IQ level performed better than the normal ones in tasks related to mechanisms of insight; 2) The cueing information facilitated selective encoding to normal children (less than 120 IQ), but did not to children with high IQ level; 3) Children with high intellectual level scored higher in mathematical and verbal insight problems than the normal ones. However, we would like to say that children with high general intelligence got higher scores in verbal insight problems than in the mathematical ones. The results of our experiment are in general consistent with the information-processing theory of insight.

Most authors regard the cognitive aspects and components of intellectual functioning as important aspects of children with high general intelligence level or IQ

(Feldhusen, 1986; Renzulli, 1986; Detterman, 1993; Gardner, 1994; Sternberg, 1994).

Authors like Davidson and Sternberg (1986) consider that one of the most outstanding variables that define «brilliant» people is insight, that is, the ability to solve problems using new and unconventional methods.

Using Sternberg's Triarchic Theory of Intelligence, we have formulated three basic processes that underlie insight and that seem to be of help to differentiate individuals with high general intelligence level from the average ones (IQ). These process are: a) selective encoding, b) selective combination, and c) selective comparison.

Selective encoding consists in sifting out relevant from irrelevant information in order to solve new or unconventional problems and situations. Significant problems generally present a large amount of information, only some of which is relevant to problem solution. Pupils who make use of this process stand out because of their ability to study all the information they have about a particular topic and extract only the important pieces, what places them in a more privileged position than their peers.

Selective combination is activated when the individual has to find relations among apparently unconnected elements. Sternberg recalls the way Darwin formulated his theory about the selection of species. This process also takes place when students establish significant connections among the different types of information they are dealing with.

Finally, selective comparison consists in inducing a non-evident relation when comparing new and old information.

These three processes underlie the theoretical frame of Sternberg's theory of *insight* (1985; 1995). In any case, we must bear in mind that these processes give rise to insight only when the elements or cues of a particular situation or problem are encoded, combined or compared in a new, non-traditional way. From this point of view, they are controlled rather than automatic processes.

These three processes are different; that is the reason why people do not stand out in the three of them at the same time. This fact proves their independence. As Davidson points out (1986), there may be qualitative differences among children with high general intelligence level which are derived from combining the «ability to» and the «preference for» each type of insight. Thus, students who try to increase the amount of information received from their teacher in order to find new ideas might be seen as individuals who prefer selective encoding as a working method. On the other hand, a student who likes combining different types of information in order to elaborate a different hypothesis or theory might be regarded as a selective combiner. If a student is interested in expressing his ideas with unusual patterns or analogies, she/he might be regarded as a person inclined towards tasks that require a reflective use of selective comparison. People usually do better at one of the processes, what makes them feel more comfortable when dealing with tasks related to their best qualities.

The results obtained in the process used to valitate the insight construct support its existence (Sternberg & Davidson, 1982; Davidson, 1986). Insight is regarded as a unitary construct that is beyond the specificity of the particular task where it takes place. It shows a moderate relation with the traditional tasks used to assess analytical intelligence. Gifted students perform better than individuals of average intelligence regardless the type of task.

The methods used to validate the insight construct also include different procedures for internal validation that consist in manipulating the variables of the task that will enable us to check hypotheses about the theoretical-experimental validity of the tasks proposed for these constructs (Sternberg & Davidson, 1982; Sternberg & Davidson, 1983; Davidson, 1986). The main aim of these procedures is to isolate the three processes and to examine them by experimentally manipulating the type of task (Davidson, 1986).

Hereafter, the objectives proposed consist in a) studying the different performances of individuals with different intelligence level in insight tasks, b) validating in a converging-discriminating way the insight construct in order to state its specificity, c) achieving a deep understanding of the following insight processes: selective encoding and selective combination, and d) isolating the selective component of the encoding·process by experimentally manipulating the type of task.

These general aims give place to the following **specific working hypotheses**:

1) There is an important relation between the scores obtained in mathematical and verbal insight tasks, what means that it is a correct measurement of the same construct and that neither verbal nor mathematical tasks are more specific.

2) The relation is higher among insight tasks than between insight tasks and intellectual level when the latter is measured using a traditional test such as Cattell's «g» factor. However, there is a closer relation if we use the STAT (Sternberg) because it assesses intelligence in context and adds elements of knowledge acquisition that appear in unknown situations, that is, when most of the information is new.

3) When we take into account the different results of pupils with diverse intellectual levels in mathematical and verbal insight tasks, a) we expect different intellectual levels, b) we do not expect differences between mathematical and verbal insight, and c) we do not expect any interaction between the group and the type of task, what means that the insight construct is more general than the task and that it is always present in children with high general intelligence level, regardless the particular situation.

4) When we take into account the different results of pupils with diverse intellectual levels in selective encoding and selective combination tasks, a) we expect differences among those groups, b) we do not expect different results in selective encoding and selective combination tasks, and c) we do not expect any interaction between the group and the type of task.

5) When we isolate the selective encoding process from the non-selective encoding one using tasks with and without cueing, a) we expect different results in groups with different intellectual levels, b) we expect different results in both tasks (results are better if the task includes cues), and c) there may be an interation between intellectual level and cueing in such a way that the gap in the results obtained by students with high intelligence level and the normal ones is bigger when there are no cueing.

2. METHOD

Subjects

The sample is made up of 208 pupils from 8 to 9 years old who were taken from another sample of 1255 students. They have been classified in four subgroups according to their scores in two intelligence tests: Cattell's «g» factor test and Sternberg's Triarchic Ability Test (STAT).

The characteristics of the groups are: 1) Group I, the student's IQ score in both tests was > 120; 2) Group II, students who scored > 120 in Cattell's «g» factor test but 120 or less in the STAT; 3) Group III, students who scored > 120 in the STAT but 120 or less in Cattell's «g» factor test; 4) Group IV, students who scored < 120 in both tests. Individuals in group I were selected from the whole sample depending on their scores in both tests. Individuals in groups II, III and IV were selected at random from the students in each of the three groups. Table 1 shows the statistical data corresponding to the IQ of each subgroup and to the whole sample involved in part II.

TABLA 1. Mean, standard deviation and number of individuals from each subgroup of the sample where the IQ has been measured using the "g" factor test (GIQ) and Sternberg's test (STAT IQ).

DESCRIPTIVE STATISTICS OF THE SUBGROUPS ACCORDING TO THE IQ						
	G IQ			STAT IQ		
GROUP	MEAN	DEVIA.	N	MEAN	DEVIA.	N
+120 "G" and STAT	126.91	4.03	36	124.92	3.4	36
+120 G	127.42	6.44	74	109.44	10.1	74
+120 STAT	106.16	11.77	39	124.51	3.9	39
-120 BOTH	105.32	10.85	56	103.89	9.88	56
TOTAL	115.56	19.62	208	111.87	18.08	208

Instruments

The instruments used include two intelligence tests, Cattell's «g» factor and the STAT (Sternberg's Triarchic Ability Test), as well as other tasks to assess the insight processes developed by Sternberg & Davidson (1986).

R.J. Sternberg's *STAT* (1991) assesses intellectual ability. Initially it consists of ninety items divided into nine scales that measure metacomponential, practical and creative intelligence in verbal, numerical and figurative modalities. The psychometric rates are adequate. The score distribution is normal according to the Kolmogorov-Smirnov's test and we have established scales for each age group (8 and 9 years). The reliability of the internal consistency of each task, assessed with Cronbach's alpha rate, goes from .50 to .82; on the other hand, the whole internal consistency rate of the task is .93. The lineal correlation between Pearson's «r» and Cattell's «g» factor test in a group of 1255 individuals is .56.

The general intelligence test, that is, Cattell's «g» *factor*, is supposed to be «free of cultural influences». It is one of the most frequently used methods of intelligence assessment when working with groups of this age. Cattell's «g» factor test consists of forty-six items divided into four subgroups of tasks: Series, Classifications, Matrices and Conditions, what offers a global score and a general intelligence IQ score.

Insight tasks are a set of tests aimed at assessing the reasoning procedures (Davidson and Sternberg, 1986). Their most important characteristic is that their solution require the use of the main methods present in insight: selective encoding, selective combination and selective comparison. This work includes the following tasks: 1) *Insight problems with mathematical contents*, which consists of ten problems where pupils have to reason about everyday matters using their mathematical knowledge in an innovative way; there are five selective encoding problems and five selective combination ones. 2) *Insight problems with verbal contents*, which consists of ten tasks where the individual has to understand the meaning of a concept in a particular context. 3) *Selective encoding problems with and without cues*, where the individual faces six verbal problems, three with underlined words used as cues for selective encoding and three without concrete cues. The purpose of this last task is to isolate the selective encoding processes from the non-selective ones. Sternberg used the following example of insight (1985); we can find selective encoding and selective combination in it: «*There is a type of seaweed that doubles its size every twenty-four hours. At the beginning of the summer there is one stem in the lake. It takes sixty days before the lake is completely covered with seaweed. What day will the lake be only half covered?*»

Procedure

The general procedure followed in this research has been developed in two stages according to the general planning and aims. In the first stage, we apply and adapt the STAT intelligence and Cattell's «g» factor tests.

Since the STAT focuses on ability, we explain in the instructions that there is no *limit of time, although we advise our students not to waste it. They are also told that the* test will not affect their grade, although its main aim is to find out who uses better thinking strategies. Once it is over we classify the individuals in four categories according to their scores in both tests (subgroups 1, 2, 3 and 4).

In the second stage, we select some individuals from each intellectual subgroup according to the procedure explained in the section «*Subjects*». Then we carry out the insight tasks.

3. RESULTS

Correlational analysis

Consistent with the hypothesis formulated, we firstly analyse the data to correlate the results in insight tasks with the intellectual level (IQ) as well as verbal and mathematical insight tasks. Table 2 shows the correlation among insight tasks but also the correlation between insight tasks and intellectual level (IQ).

First of all, we observe that there is an average correlation between insight tasks and intelligence level (IQ) (either using the STAT or the «g» factor test), although this correlations is higher when the former is used. This means that insight tasks do not measure the same features as the intelligence tests used; they are different types of constructs. From this point of view we can say that insight tasks have their own specificity, different from intellectual ability, although this ability is, to a large extent, related to the reasoning process required by insight tasks, especially if that ability has been defined by the STAT, which seems to be more inclined towards insight than towards general and abstract intelligence as it is defined by the «g» factor test.

TABLA 2. Pearson's "r" correlations between insight tasks and intellectual level.

	(1)	(2)	ENCODING	GIQ	STAT IQ
(1)	1.00				
(2)	.61**	1.00			
ENCODING	.37**	.39**	1.00		
GIQ	.32**	.31**	.36**	1.00	
STAT IQ	.46**	.46**	.44*	.61**	1.00
N = 208; * - .01 ** - .001					

(1) MATHEMATICAL INSIGHT TASK

(2) VERBAL INSIGHT TASK

We conclude the insight common factor from the relation among tasks that include different contents such as verbal and numerical tasks but which show a high correlative degree; so, we believe that the three processes of insight are extensions of the knowledge-acquisition components to novel tasks and situations and that they are three separate yet related psychological processes (Sternberg & Davidson, 1983; 1995).

Differences in insight tasks among the groups

The method used to analyse these differences consists in comparing the intellectual level (IQ) with the kind of task (mathematical and verbal insight). It is an inter-intra individual method (the *inter* variable represents the intellectual level and the *intra* variable represents the type of task).

We carry out three analysis of this type. In the first one we cross the group variable with the type of insight task (with mathematical-verbal content). In the second one we cross the group variable with the type of problem that defines the task (selective encoding or selective combination); and in the third one we cross the group variable with the type of task with cueing or hints (selective enconding) and without cueing (non-selective encoding).

The results of the Variance Analysis 4x2 verbal content and the mathematical content ones show that there are significant differences among the group of individuals if we take into consideration both tasks as a whole ($F_{(3,201)}$= 6.21; p=.01). The effect produced by the type of task is significant too ($F_{(1,201)}$=28.12; p=.000). However, the interaction between the group variable and the type of problema (verbal or mathematical insight) is not significant ($F_{(3,201)}$=.50); p=.68). The means showed in table 3 can clarify these results.

As stated by Fisher's Least Significant Difference test (LSD), individuals in group 4, with intermediate abilities (IQ), got lower marks (mean = 4.75) than other groups, especially than group 3 (mean = 5.97) and group 1 (mean = 5.75). Regarding the differences among verbal insight tasks (mean = 5.81), the results are significantly better than the ones obtained in mathematical insight problems (mean = 4.94).

TABLA 3. Means of the four subgroups of individuals in each verbal insight and mathematical insight task.

VARIABLES	+120	+120g	+120 STAT	-120	TOTAL
MATHE. INSIGHT	5.222	4.730	5.513	4.304	4.94
VERBAL INSIGHT	6.278	5.297	6.436	5.214	5.81
GLOBAL MEAN	5.750	5.023	5.974	4.759	

According to the results of the Variance Analysis 4x2 carried out we find important differences in the groups in relation to both tasks seen as a whole ($F_{(3,201)} = 3.81$; $p = .01$). Similarly, the way both groups carry out both tasks (selective encoding and selective combination) is significantly different ($F_{(1,201)} = 56.95$; $p = .000$). However, there is no interaction between the group of individuals and the type of task ($F_{(3,201)} = .83$; $p = .47$) (see table 4).

TABLA 4. Means of the four groups of pupils in each selective encoding and selective combination task.

VARIABLES	+120	+120g	+120 STAT	-120	TOTAL
SEL. ENCOD.	3.056	2.784	3.051	2.429	2.83
SEL. COMBIN.	2.167	1.946	2.462	1.875	2.11
GLOBAL MEAN	2.61	2.36	2.75	2.15	

Groups 3 (mean = 2.75) and 1 (mean = 2.61) got the highest average score. On the other hand, group 4 got the lowest marks. Their performance in both tasks is significantly different because selective encoding (mean = 2.83) is easier than selective combination (mean = 2.11). Nevertheless, there is no interaction between the group and the type of task.

After analysing the scores obtained by the four subgroups in the selective and non-selective encoding tasks, we observe that the group variable is significant ($F_{(3,201)} = 4.16$; $p = .02$). On the other hand, the variable «cue» is not important enough for us to think that both tasks are different if we take into account the performance of the groups as a whole ($F_{(1,201)} = .69$; $p = .36$). However, there is an important interaction between the type of task (with and without cueing or hints) and the group variable ($F_{(3,201)} = 3.10$; $p = .02$). Table 5 explains better the principal effects of and the interaction among the variables.

Although there are no differences between both tasks (with and without hints) in the group, there are some among the four intellectual groups. Thus, groups 1, 2 and 3, whose individuals have a high intellectual level, carry out both tests similarly; on the other hand, the average intellectual group benefits from the hints in the solution of the problem. In this way, selective encoding is linked to high intellectual abilities (Davidson, 1995; Bermejo, 1995).

TABLA 5. Means of the four groups of pupils in each task with and without hints.

VARIABLES	+120	+120g	+120 STAT	–120	TOTAL
CUES	1.917	1.882	1.846	1.711	1.83
NO CUES	2.083	1.793	1.897	1.482	1.81
GLOBAL MEAN	2.00	1.83	1.871	1.596	

4. DISCUSSION

The results demonstrate that there is an important relation between the scores obtained in mathematical and verbal tasks, what also happened in Davidson and Sternberg's research (1986).

Common factors in insight tasks and processes are corroborated by the results referred to the differences among groups in relation to tasks with mathematical and verbal content. Although there are differences among mathematical and verbal tasks, the results make clear that there is no an important interaction between the group and the type of task, what means that every group behaves similarly in both tasks. The same applies to selective encoding and selective codification tasks. Those differences question whether both tasks assess the same insight construct. After having studied the data comprehensively, we come to the conclusion that both of them assess insight processes, although there are differences among the three subprocesses (selective encoding, combination and comparison), as stated in Sternberg´s Triarchic Theory.

When trying to study in depth selective and non-selective encoding processes, the results show, on the one hand, that the manipulation of the task seems to be correct if we want to isolate selective encoding methods specific to insight from non-selective encoding methods. On the other hand, the results show that individuals of average general intelligence (IQ) benefit from hints or cues more than high general ability ones (IQ), who do not need any kind of cueing or hints. This suggests that selective encoding is one of the elements that characterizes insight in thinking individuals (Sternberg, 1985; Davidson & Sternberg, 1986). According to the selective encoding subtheory, high intelligence individuals select the important information quickly, whereas pupils of average intelligence find more difficult to use their insight properly. The specific element of insight that takes place in information encoding is a selective process that makes possible to select the hints or cueing that help to solve the problem.

REFERENCES

Bermejo, M.R. (1995). *El insight en la solución de problemas: Cómo funciona en los superdotados*. Tesis Doctoral. Universidad de Murcia. No publicada.

Cattell, R.B. & Cattell, A.K.S. (1973). "G" factor test. *Scales 2 y 3* (Institute for Personality and Ability Testing). Madrid: TEA (Spanish adaptation).

Davidson, J.E. (1986). The role of insight in giftedness. In R.J. Sternberg & J.E. Davinson (Eds.), *Conceptions of giftedness (pp. 201-222)*. New York: Cambridge University Press.

Davidson, J. (1995). The suddennes of insight. In R. Sternberg & J. Davidson (Eds.). *The nature of insight*. (pp.: 125-155). Cambridge, MA: MTI Press.

Davidson, J.E. & Sternberg, R.J. (1982). Insights about insight. Paper presented to the *Annual Meeting of the Psychonomic Society*, Minneapolis, November, 1992.

Detterman, D. (1993). Giftedness and intelligence: one and the same?. In G.R. Bock & K. Ackrill (Eds.), *The origins and development of high ability (pp. 22-43)*. Chichester: John Willey & Sons.

Feldhusen, J.F. (1986). A conception of giftedness. In R.J. Sternberg & J.E. Davidson (Eds.), *Conceptions of Giftedness*. New York: Cambridge University Press.

Gardner, H. (1994). The giftedness matrix from a multiple intelligence perspective. In F.D. Horowitz and R. Friedman (Eds.), *Developmental approaches to identifying exceptional ability*. Washington, DC: American Psychological Association.

Renzulli, J.S. (1986). The three-rings conceptions of giftedness: a developmental model for creative productivity. In R., Sternberg & J.E. Davidson (Eds.). *Conceptions of giftedness* (pp.: 53-92). Cambridge, UK: Cambridge University Press.

Sternberg, R.J. (1985). *Beyond IQ. A triarchic theory of human intelligence*. Cambridge, MA: Cambridge University Press.

Sternberg, R.J. (1991). Theory-based testing of intellectual abilities rationale for the triarchic ability test. In H.A. Rowe (Ed.), *Intelligence: Reconceptualization and measurement*. Hillsdale, NJ: LEA.

Sternberg, R.J. (1994). A pentagonal implicit theory of giftedness. In F. Horowitz and R. Friedman (Eds.), *Developmental approaches to identifying exceptional ability*. Washington, DC: American Psychological Association.

Sternberg, R. y Davidson, J. (1995). *The nature of insight*.Cambridge, MA: MTI Press.

Sternberg, R.J. & Davidson, J. (1982). The mind of the puzzler. *Psychology Today*, 73, 1-16.

Sternberg, R.J. & Davidson, J. (1983). Insight in the gifted. *Educational Psychologist, 18*, 1, 51-57.