Revista Iberoamericana de Neuropsicología, Vol. 6, No. 2: 183-195, julio-diciembre, 2023.

Decision-making on an explicit risk-taking task in children and adolescents with high intellectual abilities: a neuropsychological perspective

Josué Pérez-Tejera[1]; Mariana Cairós González[2]; Emilio Verche[3]*y África Borges[1]

ABSTRACT

Objective: *Two processing pathways have been described in explicit risk decision-making tasks: an emotional and a cognitive feedback pathway. The objective of the study was to examine decision-making on an explicit risk-taking task in children and adolescents with high intellectual abilities compared with a control group typical development and to determine whether their execution is similar or different.*

Methods: *This study explores differences in quality of decision making between gifted (n = 28) and average intellectual ability (n = 37) students of two different age groups (children vs. adolescents). Groups were compared using the scores obtained in the Cambridge Gambling Task (CGT).*

Results: *Results show that gifted students displayed better decision making as evidenced by higher cognitive self-control to postpone immediate rewards and quality of decision when compared to the control group. Deliberation time in gifted was faster in the adolescent group and slower in the child group.*

Conclusion: *This finding suggests developmental influences that need to be considered to explain the effects of the G factor in decision making skills. Procedures help to reflect upon the contribution of controlled cognitive tasks in elucidating abilities related to general intelligence. Neuropsychological basis of decision-making is briefly discussed.*

Keywords:

Quality in decision–making, gifted students, explicit risk–taking, high intellectual abilities.

Correspondence:

Calle Rector Royo Vilanova s/n. Department of Psychobiology and Methodology in Behavioural Sciences. Faculty of Education. Universidad Complutense de Madrid. 28040 – Madrid. Spain. Phone number: +34.91 394 6233 Email: everche@ucm.es

[1]Department of Clinical Psychology, Psychobiology and Methodology, School of Psychology, Universidad de La Laguna, Tenerife, Spain; jperez.psicologia@outlook.es; aborges@ull.edu.es.
[2] Faculty of Health Sciences, Valencian International University. mecairos@universidadviu.com
[3]Department of Psychobiology and Methodology in Behavioral Sciences, Universidad Complutense de Madrid, Madrid, Spain; everche@ucm.es

INTRODUCTION

Human cognition and the processes that underlie it have been studied in psychology since the second half of the twentieth century, in response to behavioral perspectives and as an approach to the so-called "black box" problem[1-3]. However, cognitive neuroscience and the progress of neuroimaging techniques have overcome these difficulties allowing studying brain functioning from a broad perspective.

Multiple cognitive processes have been studied throughout history. Among them is executive functioning, which involves the ability to plan, select and maintain behaviors, as well as to deal with multiple sources of information simultaneously. It also allows inhibiting inappropriate responses, resisting distractions and interference[4,5]. It is known that intelligence and executive functions represent different functions. However, ~~that~~, in some tasks, behaviors or situations, they share cognitive components, overlap, and contribute to react appropriately to mainly novel situations, changing or subject to adaptation[6]. Neuroanatomical and neurofunctional studies have shown that the anatomical structure that regulate these functions is the frontal lobe, specifically the prefrontal cortex and the connections that this area has with other cortical areas and subcortical structures[7] .

After analyzing previous theories on executive functioning, Verdejo-García and Bechara[8] classified the different proposals into four groups of models: (a) hierarchical modulation models, which postulates that the main function of the executive system is the resolution of novel situations through the activation of routine or default programs while applying and adjusting new cognition-action schemes[9]; (b) temporal integration models, which maintains that the work of the executive system is the manipulation of information to project it towards directed action[10]; (c) models that consider that the executive system is both a manager and a repository of information in relation to structured events complexes[11] ; and (d) last groups of models that address more specific aspects of frontal-executive functioning, taking an interest in more complex mechanisms, including the somatic marker theory[12], which comprehensively explains decision-making processes.

The decision-making process has aroused great interest among researchers from different fields, both in psychology and in other branches of knowledge, especially economics[13,14]. One of the main aspects of life for individuals is the decision-making process that involves various cognitive processes, such as the processing of task-specific stimuli, the recall of previous experiences, and the estimation of the possible consequences of different options. Likewise, the metacognitive processes of monitoring and control involved in recall make it possible to evaluate the accuracy of the information and decide whether a response should be. All these processes require the involvement of the working memory and, mainly, of the executive functions[15].

Decision-making is not a unidimensional construct but varies according to the accuracy and predictability of the possible consequences of the decision. Therefore, a distinction is made between ambiguous and explicit risky decision tasks[16]. In explicit risky decision-making tasks, task resolution requires evaluating which option is more favorable compared to what is expected. Examples of tasks of this type are included in the Cambridge Gambling Task (CGT), Game of Dice Task (GDT), or Cups Task (CT)[17,18]. Bechara et al.[19] consider decision-making as a process guided not only by cognitive information, but also by emotional cues that contribute to anticipating the consequences of the different possible scenarios derived from the choice options.

On the other hand, ambiguous risk decision-making tasks refer to those situations in which the probabilities and consequences of the decision are implicit. That is, the participant does not have explicit information about the possible consequences of the decision, and to solve the task, must discern among the alternatives that are preferable, based on the feedback received in previous decisions. This type of decision-making task is assessed with tests such as the Iowa Gambling Task (IGT)[20], in which the participant must learn which decks generate profits and which incur losses. The neural processes underlying these two types of decision-making tasks are different. Decisions in contexts of ambiguity appear to rely less on cognitive control mechanisms and more on learning and working memory skills, whereas explicit risk decisions rely more on neural systems related to general executive functioning[21].

Several models have been proposed to explain this type of decision-making. From a neuropsychological perspective, the most widespread model postulates that there is a dual processing system in the explicit risk decision-making task. It combines the processing theory of Bechara and Damasio[20], based on the somatic marker hypothesis, and the principles of the model proposed by Brand et al.[22]. It supports the involvement of two differentiated control systems: one of automatic, emotional, spontaneous, and rapid control; and another of reflexive, contained, deliberate and slow control[23]. At the same time, studies have shown that executive functions hold an important role in risk-taking behavior[24].

Research examining response styles shows that participants with poor executive functioning need to make greater use of feedback, whereas those with good executive functioning apply more independent feedback strategies[25]. This finding is related to the double process theories of decision-making because people with abnormalities in the so-called cold executive functions (cognitive flexibility, inhibition, etc.) are predisposed to the use of exploratory strategies to follow their intuition and adapt their behavior according to the feedback, rather than relying on their executive abilities to find a rational solution to the problem[26]. Bad decision-making has been correlated with worse executive functioning, specifically in categorization, cognitive flexibility, and concept formation[27]. In addition, people with a higher IQ are faster decision makers and adjust better to the risk assumed by adapting their response to probabilistic changes to win[28], so people who can integrate both the rational aspects of the options and the feedback of their previous decisions perform superior to those who only use one of the two modes of interaction[22].

An increasing number of neuropsychological studies are providing results on the configuration and functioning of people with high abilities[29], characterizing high abilities students with a higher operating neural efficiency. Some of these cognitive areas were correlated with better performance in executive function tasks in gifted children[30]. For example, greater set-shifting skills were related to mathematical talent[31], memory processing[32] and problem solving[33], as well as to tasks of varying degrees of difficulty[34] and mental image manipulation tasks[35]. The brains of people with high ability show specialized activation patterns and a robust interconnection between brain areas, accompanied by greater effectiveness, providing a basis for cognitive and executive functioning at a high level. These processes, especially those related to complex problems solving and executive tasks performance, involve a decision-making process. However, despite the accumulation of knowledge on high intellectual abilities, comparative studies on possible differential role in giftedness or talent profiles, which would allow a better understanding, are especially scarce[36].

The relationship between intelligence and executive function has raised controversies, that is not yet been resolved. Intelligence and executive function overlap in some respects, but not in others, and the establishment of relationships is limited by the different instruments used to measure both constructs[37]. However, there are studies that clearly establish: the relationship between intelligence and executive function, both in the set of variables that compose it[38,39] and in specific factors, such as working memory[40].

The literature on decision-making in the high-ability population is not very abundant and tend to focus on specific use of decision-making, i.e., vocational choice[41-45], ~~but~~ whereas studies focusing on the decision-making process are less common, although some interesting results have been reported. Differences found with adults of different intellectual abilities show that people with higher intellectual ability were faster in making decisions and better at risk adjustment[28]. They revealed greater strategic ability[46] and lower aversion to risk[47], although some researchers disagree[48]. In the cold (cognitive) or hot (emotional) processing debate, using the IGT[19], better scores were shown for those who presented higher cognitive, but not emotional intelligence.

Yun et al.[49] found that the adolescent group of high abilities, compared to the normative sample, won more games, were more cooperative, and assumed more risks. Using the IGT test[19], with a sample of children, it was found that those with higher intelligence were superior strategy and speed of decision-making; their performance was also better considering future consequences[50].

The study of cognitive processes related to executive functioning such as reasoning, problem solving, and, more specifically, decision-making, among others, is key within the field of high intellectual abilities to capture and understand the differences between the general population and people with high abilities when solving different types of cognitive tasks.

For this reason and given the lack of evidence related decision-making in gifted children and age-related differences, the objective of the present research is to study the decision-making process with an explicit risk-taking task in children and adolescents with high abilities, comparing their performance with a normative group of participants.

METHODS

Participants

Sixty-six people participated in this investigation. The participants were 29 gifted and 37 non-gifted children and adolescents (table 1). The sample was recruited through intentional sampling. For the determination of high ability, the assessment carried out by the Regional Education Administration of the Canary Islands (Spain) was considered. This diagnosis consisted of having an IQ equal to or greater than 130.

The group of those with high abilities, who were diagnosed as such by the Education Administration, was composed of students participating in the Comprehensive Program for High Ablities (PIPAC)[51].

The community sample consisted of two age groups, one of adolescents[52] and the other of children[53], who had been previously assessed in decision-making and intelligence and whose scores were between an IQ of 85 and 120.

Table 1. Participants: distribution by gender and average age of each group.

	Children Sample		Adolescents	
Gender	Male	Female	Male	Female
High abilities	14	3	7	5
Age mean	9.35	10.33	16.71	13.8
Community sample	12	9	6	10
Age mean	10.64	10.74	14.36	14.55

Instruments

The Cambridge Gambling Test[54] (CGT) was used to assess decision-making. This computerized test assesses decision-making under an explicit risk condition, in which the consequences of the decision are explicit or calculable, and there is no need for learning by completing a full task. It lasts approximately 30 minutes.

In each trial, the participant is shown at the top of the screen a row of ten boxes colored in red or blue. The proportion of the boxes of each color varies according to different ratios: 9:1, 8:2, 7:3, or 6:4, where the first number refers to the color option chosen. At the beginning of the task the participants must decide where a small yellow piece may be hidden, then they have to bet the points according to the decision made. The objective of the game is to accumulate as many points as possible. There are two types of bets, ascending and descending modes. In each of these modes, 40 bets are divided into four blocks of 10 each. The choice of the number of points is made once the color has been chosen, by stopping an automatic counter that appears on the top right of the screen. The counter's values were always related to a percentage of the score (5%, 25%, 50%, 75%, and 95%). The points are displayed in ascending or descending order according to the participant's evaluation stage (half of the participants started in ascending mode and half in descending mode). Once the bet is decided and chosen, the computer reveals the location of the small yellow piece and gives visual ("You win" or "You lose") and auditory (nice vs. unpleasant sound) feedback. If the participant succeeds the amount won is added to his total score, in case of failure he loses the points bet. Immediately after finishing the trial the next bet is presented.

Five parameters are reported: decision quality, deliberation time, risk taking, risk adjustment, and delay aversion. The program returns the answers in proportions, except for the deliberation time, which is measured in milliseconds, and risk adjustment, which is calculated by this formula: [2 (% bets 9: 1) + (% bets 8: 2) - (% bets 7: 3) -2 (% bets 6: 4)] /% average bets.

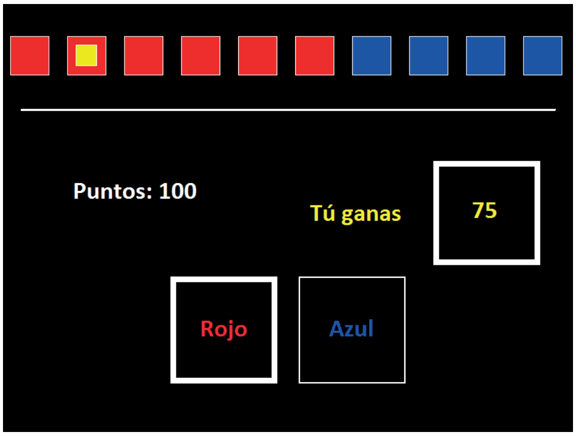

Figure 1. Cambridge Gambling Task test (CGT).

The intelligence in the control group was measured with the "g" factor test[55] which has three scales: scale 1, for people aged four to eight years; scale 2, for people aged eight to fourteen years and adults with a medium cultural level, and scale 3 for people aged fifteen years or more and adults with a high cultural level. All three scales were used in this study in the community sample.

Procedure

This was a prospective ex post facto factorial design. The study groups were established as follows: the high abilities group included participants with an IQ above 130, while participants with an IQ between 85 and 120 formed the sample community. The dependent variables were the responses to the Cambridge Gambling Task.

First, informed parental consent was requested from all groups. In all cases, the test was administered to the participants individually in a quiet place, without interruptions or disturbing variables. The assessments were performed by three trained neuropsychologists. After fulfilling ~~the~~ informed consent, the intelligence test was administered in the community sample group and then the CGT. In the gifted group, since the intelligence test was already performed for the diagnosis, the CGT was administered after informed consent was fulfilled.

The research was approved by the Ethics Committee of the University of La Laguna (code CEIBA2017-0229).

Data analysis

To ensure the generalizability of the sample under study, the optimization procedure of the Theory of Generalizability[56] was calculated through the EduG 6.0 program.

To test the differences between the groups (gifted vs. community sample) and age (children vs. adolescents), an ANOVA 2x2 was performed with the CGT outcome variables as dependent variables. The size effect was calculated with eta^2 partial. The ANOVA was calculated using the SPSS program, version 21.

RESULTS

The optimization of the number of participants, through the Generalizability Theory (GT), is shown in Table 2. For the study of optimization through the GT, two of the tasks —quality in decision-making and risk in decision-making— have been selected as they allow for a simple categorization of the answers because, being expressed in proportions, the results of the participants can be categorized guided by the system of interpretation of the correlation coefficients: 0-0.33 (low level of execution=1), 0.34-0.66 (average level of execution=2), and 0.67-1 (high level of execution=3). Moreover, because all the tasks have the same number of participants in all the groups, it was not necessary to carry out an optimization study for each test.

The observation plan carried out for the quality of the decision in the participants consist of three facets: group (G), with two levels (community sample and high abilities); level in the decision quality task (D), with three levels (low, medium, and high); and participants (P, with 38 levels). The estimation plan chosen was the one of random effects, cross-crossed design, GxDxP, where the facet of differentiation is the group and the level in the task and the facet to generalize the participants, following the GD/P measurement plan.

The observation plan for risk taking in children has three facets: group (G), with two levels (control and high abilities); level in the risk-taking task in the decision (R), with three levels (low, medium, and high); and participants (with 38 levels). The estimation plan was of random effects, cross-crossed design, GxRxP, where the differentiation facet is the group and the level in the task and the facet to be generalized is the participants, following the measurement plan GR/P.

The observation plan for risk-taking in adolescents has three facets: group (G), with two levels (control and high abilities); level in the decision of risk-taking task (R), with three levels (low, medium, and high); and participants (with 28 levels). The estimation plan chosen was random effects, cross-crossed design, GxRxP, where the facet of differentiation is the group and the level in the task and the facet to generalize the participants, following measurement plan GR/P.

The standard criterion for considering a coefficient of generalizability as adequate is a value of 0.80, the standard commonly accepted in descriptive studies[57]. As the G coefficients obtained according to the standards exceed the value of 0.80, and given that the increase of five participants does not imply a substantial gain in terms of generalizability, the sample size can be considered adequate.

Once the suitability of the sample size was established, the effects due to the group (high-ability group vs. community sample) and age (children vs. adolescent) were also determined. The average scores obtained and their standard deviations, in parentheses, for each subgroup are shown in Table 3.

Table 4 shows the results of the one-way ANOVA (group x age). There was a significant interaction effect in deliberation time. In addition, there was a main effect of group (gifted vs. non-gifted) in quality of decision and aversion to delay and main effect of age in deliberation time, which is greater in children.

DISCUSSION

This research contrasted the difference in decision-making between a group of students with

Table 2. Optimization plan for the number of participants

Task	Generalizability		Optimization study with 5 additional participants	
	Relative G Coefficient	Absolute G Coefficient	Relative G Coefficient	Absolute G Coefficient
Children				
Quality in decision making	0.95	0.95	0.95	0.95
Risk in decision making	0.86	0.86	0.87	0.87
Adolescents				
Quality in decision making	0.93	0.93	0.94	0.94
Risk in decision making	0.86	0.86	0.87	0.87

Table 3. Mean and standard deviation of each sample

Outcome	High ability		Community sample	
	Children	Adolescents	Children	Adolescents
Quality in decision making (proportion)	0.93 (0.06)	0.95 (0.05)	0.91 (0.09)	0.87 (0.11)
Deliberation time (ms)	3893.07 (964.16)	2212.37 (718.36)	2887.53 (791.97)	2475.56 (779.37)
Risk in decision making (proportion)	0.55 (0.17)	0.48 (0.15)	0.54 (0.13)	0.49 (0.13)
Risk adjustment	0.86 (0.67)	1.48 (1.26)	0.92 (1.26)	1.35 (0.96)
Aversion to delay (proportion)	0.26 (0.19)	0.24 (0.14)	0.51 (0.14)	0.41 (0.19)

Table 4. ANOVA results Group (gifted vs. community sample) x Age (children vs. adolescents) and effect size.

	Variables	F	p	Eta^2 partial
Quality in decision making	Group	4.37	0.041	0.066
	Age	0.33	0.564	0.005
	Interaction	2.31	0.134	0.036
Deliberation time	Group	3.21	0.078	0.049
	Age	25.50	0.001	0.291
	Interaction	9.37	0.003	0.131
Risk in decision making	Group	0.02	0.965	0.000
	Age	2.73	0.103	0.042
	Interaction	0.14	0.771	0.002
Risk adjustment	Group	0.13	0.910	0.000
	Age	3.80	0.056	0.058
	Interaction	0.124	0.726	0.002
Aversion to delay	Group	22.92	0.001	0.270
	Age	2.30	0.134	0.036
	Interaction	1.10	0.298	0.017

high intellectual abilities and a community sample, studying the age effect with children and adolescents. In general, it is found that participants with higher IQ have less aversion to delay, take better decisions and are faster taking decisions.

First, the results indicate that children and adolescents with high intellectual abilities show a greater capacity to postpone immediate rewards, so they can wait to bet/earn more points. The results seem to indicate a greater efficacy in the decision-making ability in children and adolescents with high intellectual abilities compared to the control group because they are less reluctant to wait in the short term in favor of a reward that they will obtain in the long term. This result indicates the use of the reflective system as a way of answering decisions based on cognitive self-control. These findings are consistent with those of studies that relate intelligence and self-control, on the one hand, and delay of reward on the other. Thus, there is clear evidence of the relationship between intelligence and self-control[58]. In addition, reward delay has been related to higher intelligence[59-61].

Based on previous studies[50], it was expected that the group of individuals with high abilities would present higher quality in the decision made. This was confirmed in our results with a medium size effect (table 4). Gifted participants decided to bet on the most likely outcome in a higher proportion of trials than the community sample group. This quality in decision-making is directly related with executive functions[27] and those with good executive functions apply decision-making strategies that are more independent of the given feedback compared with people with worse executive functioning[23].

Regarding deliberation time, the interaction effect found means that gifted adolescents took less time to decide than any other participants whereas gifted children needed more time than the others, with a medium effect size. This result is consistent with that obtained by Duan and Shi[34], who observed that boys and girls with high abilities had significantly longer response latencies on more difficult tasks compared to a control group. This finding seems to conflict with the idea that children with high abilities respond faster than the normative population in all tasks during childhood. Some studies have shown that executive functions predict the ability to develop learning and school performance[61]. According to Bryce et al.[62] metacognitive skills and executive functions are related to academic performance and are a better predictor of academic success than the level of general intelligence alone[63]. Therefore, considering the studies, the remarkable importance of executive functions in the school environment could be highlighted.

One limitation of this study lies in the size of the groups. Although the found with the TG indicates that the results are generalizable, the lack of significant results in the deliberation time between high-ability students and the control group could be an effect of the power of the test, which requires a greater size to reveal significant effects. On the other hand, considering the findings of Duan and Shi[34], it would be convenient to graduate the difficulty of the choices to be made to test whether there is a longer deliberation time in the group with the greatest intellectual ability when decisions are made more complicated. Another limitation in this study is the test used to measure intelligence in the control group, since the sample with high abilities is defined by the official diagnosis given by the educational authorities of the Canary Islands Regional Government. The test used reflect the fluid intelligence of the individual and was selected by Culture Fair Test, although it has the disadvantage of not being one of the most used for diagnosis in high abilities. Therefore, it would be convenient to replicate the study in a larger sample, measuring all the participants with the same test.

Executive functions play a very relevant role in educational processes[64], as well as decision-making. Therefore, it is essential to carry out more research to analyse the decision processes of high-ability students. In this sense, it would be advisable to establish educational programs that would allow more adequate decision-making. Life is full of decisions, and, as it is clear from the literature, the first thing that students must make is vocational choice. However, there are more basic cognitive processes underlying that vocational choice that should be addressed and this research helps to understand them. Well-founded decisions help to choose the most suitable approaches.

The findings here are relevant because the study of decision-making in gifted population has focused on vocational choice and not in the cognitive strategies used in that choice. These strategies seem to be more related with intelligence in gifted population than to emotional processes[50] so more research is required to determine the differences due to intelligence in different variables related with decision-making and executive functions[65]. As it was described by Deakin et al.[28], people with a higher IQ make better and faster decisions and have a better risk adjustment, but an effect of age on deliberation time was found. So far, this study is the first in considering the age effect in decision-making and showing how gifted adolescents are significantly faster than non-gifted participants and gifted children are the slowest.

As is well known, students with high intellectual abilities are not the highest achievers, according to popular conception[66]. A greater speed in learning, fundamentally and paradoxically, can lead to a decline in performance, which is why those with high intellectual abilities are considered a group of students with specific educational needs[67]. It is a priority to carry out studies that clarify their cognitive differences in a rigorous and clear manner. Therefore, more studies on the differences in these and other cognitive processes are required to determine the differential characteristics of this students and to be able to provide the appropriate educational response to their needs.

Conflicts of Interest:
The authors declare no conflict of interest.

Funding:
This research received no external funding

Acknowledgments:
We thank Dr. Itziar Quintero for collecting data in community sample group.

REFERENCES

1. Bruner JS, etc. Study of thinking. Nashville, TN: John Wiley & Sons; 1956.
2. Miller GA. Plans and the structure of behavior. Adams Bannister Cox; 1986.
3. Newell A, Shaw JC, Simon HA. Elements of a theory of human problem solving. Psychol Rev [Internet]. 1958;65(3):151–66. Available from: http://dx.doi.org/10.1037/h0048495
4. Ehlhardt LA, Sohlberg MM, Kennedy M, Coelho C, Ylvisaker M, Turkstra L, et al. Evidence-based practice guidelines for instructing individuals with neurogenic memory impairments: what have we learned in the past 20 years? Neuropsychol Rehabil [Internet]. 2008;18(3):300–42. Available from: http://dx.doi.org/10.1080/09602010701733190
5. Rzezak P, Lima EM, Pereira F, Gargaro AC, Coimbra E, de Vincentiis S, et al. Decision-making in patients with temporal lobe epilepsy: Delay gratification ability is not impaired in patients with hippocampal sclerosis. Epilepsy Behav [Internet]. 2016;60:158–64. Available from: http://dx.doi.org/10.1016/j.yebeh.2016.04.042
6. Ardila A, Pineda D, Rosselli M. Correlation between intelligence test scores and executive function measures. Arch Clin Neuropsychol [Internet]. 2000;15(1):31–6. Available from: http://dx.doi.org/10.1093/arclin/15.1.31
7. Diamond A. Executive functions. Annu Rev Psychol [Internet]. 2013;64(1):135–68. Available from: http://dx.doi.org/10.1146/annurev-psych-113011-143750
8. Verdejo-García A, Bechara A. Neuropsicología de las funciones ejecutivas. Psicothema. 2010;227–35.

9. Miller EK, Cohen JD. An integrative theory of prefrontal cortex function. Annu Rev Neurosci [Internet]. 2001;24(1):167–202. Available from: http://dx.doi.org/10.1146/annurev.neuro.24.1.167
10. Fuster JM. Upper processing stages of the perception-action cycle. Trends Cogn Sci [Internet]. 2004;8(4):143–5. Available from: http://dx.doi.org/10.1016/j.tics.2004.02.004
11. D'Esposito M. From cognitive to neural models of working memory. Philos Trans R Soc Lond B Biol Sci [Internet]. 2007;362(1481):761–72. Available from: http://dx.doi.org/10.1098/rstb.2007.2086
12. Bechara A, Damasio H, Damasio AR. Emotion, decision making and the orbitofrontal cortex. Cereb Cortex [Internet]. 2000;10(3):295–307. Available from: http://dx.doi.org/10.1093/cercor/10.3.295
13. Von Neumann J, Morgenstern O. Theory of games and economic behaviour. Nashville, TN: John Wiley & Sons; 1953.
14. Kahneman D, Tversky A. Prospect theory: An analysis of decision under risk. Econometrica [Internet]. 1979;47(2):263. Available from: http://dx.doi.org/10.2307/1914185
15. Tranel D, Damasio AR. Neuropsychology and behavioral neurology. In: Cacioppo JT, Tassinary LG, Berntson G, editors. Handbook of Psychophysiology. 2nd ed. Cambridge, England: Cambridge University Press; 2007. p. 119–41.
16. Brand M, Fujiwara E, Borsutzky S, Kalbe E, Kessler J, Markowitsch HJ. Decision-making deficits of korsakoff patients in a new gambling task with explicit rules: associations with executive functions. Neuropsychology [Internet]. 2005;19(3):267–77. Available from: http://dx.doi.org/10.1037/0894-4105.19.3.267
17. Friedman M, Savage LJ. The utility analysis of choices involving risk. J Polit Econ [Internet]. 1948;56(4):279–304. Available from: http://dx.doi.org/10.1086/256692
18. Keeney RL, Raiffa H. Decisions with multiple objectives: Preferences and value trade-offs. Cambridge, England: Cambridge University Press; 1993.
19. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. Cognition [Internet]. 1994;50(1–3):7–15. Available from: http://dx.doi.org/10.1016/0010-0277(94)90018-3
20. Bechara A, Damasio AR. The somatic marker hypothesis: A neural theory of economic decision. Games Econ Behav [Internet]. 2005;52(2):336–72. Available from: http://dx.doi.org/10.1016/j.geb.2004.06.010
21. Brand M, Recknor EC, Grabenhorst F, Bechara A. Decisions under ambiguity and decisions under risk: correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. J Clin Exp Neuropsychol [Internet]. 2007;29(1):86–99. Available from: http://dx.doi.org/10.1080/13803390500507196
22. Brand M, Labudda K, Markowitsch HJ. Neuropsychological correlates of decision-making in ambiguous and risky situations. Neural Netw [Internet]. 2006;19(8):1266–76. Available from: http://dx.doi.org/10.1016/j.neunet.2006.03.001
23. Schiebener J, Brand M. Decision making under objective risk conditions-a review of cognitive and emotional correlates, strategies, feedback processing, and external influences. Neuropsychol Rev [Internet]. 2015;25(2):171–98. Available from: http://dx.doi.org/10.1007/s11065-015-9285-x
24. Capone F, Capone G, Di Pino G, Florio L, Oricchio G, Di Lazzaro V. Linking cognitive abilities with the propensity for risk-taking: the balloon analogue risk task. Neurol Sci [Internet]. 2016;37(12):2003–7. Available from: http://dx.doi.org/10.1007/s10072-016-2721-8
25. Brand M, Laier C, Pawlikowski M, Markowitsch HJ. Decision making with and without feedback: the role of intelligence, strategies, executive functions, and cognitive styles. J Clin Exp Neuropsychol [Internet]. 2009;31(8):984–98. Available from: http://dx.doi.org/10.1080/13803390902776860
26. Schiebener J, Brand M. Self-reported strategies in decisions under risk: role of feedback, reasoning abilities, executive functions, short-term-memory, and working memory. Cogn Process [Internet]. 2015;16(4):401–16. Available from: http://dx.doi.org/10.1007/s10339-015-0665-1

27. Schiebener J, Zamarian L, Delazer M, Brand M. Executive functions, categorization of probabilities, and learning from feedback: what does really matter for decision making under explicit risk conditions? J Clin Exp Neuropsychol [Internet]. 2011;33(9):1025–39. Available from: http://dx.doi.org/10.1080/13803395.2011.595702
28. Deakin J, Aitken M, Robbins T, Sahakian BJ. Risk taking during decision-making in normal volunteers changes with age. J Int Neuropsychol Soc [Internet]. 2004;10(4):590–8. Available from: http://dx.doi.org/10.1017/S1355617704104104
29. Sastre Riba S. Niños con altas capacidades y su funcionamiento cognitivo diferencial. Rev Neurol [Internet]. 2008;46(S01):S11. Available from: http://dx.doi.org/10.33588/rn.46s01.2008008
30. Al-Hmouz H, Abu-Hamour B. Do Executive Functions Differentiate Gifted Children, Children at Risk of LDs, and Average Children? International Journal of Special Education. 2017;32:88–114.
31. Abreu-Mendoza RA, Chamorro Y, Garcia-Barrera MA, Matute E. The contributions of executive functions to mathematical learning difficulties and mathematical talent during adolescence. PLoS One [Internet]. 2018;13(12):e0209267. Available from: http://dx.doi.org/10.1371/journal.pone.0209267
32. Gaultney JF, Bjorklund DF, Goldstein D. To be young, gifted, and strategic: Advantages for memory performance. J Exp Child Psychol [Internet]. 1996;61(1):43–66. Available from: http://dx.doi.org/10.1006/jecp.1996.0002
33. Rogers KB. Do the gifted think and learn differently? A review of recent research and its implications for instruction. j educ gift [Internet]. 1986;10(1):17–39. Available from: http://dx.doi.org/10.1177/016235328601000103
34. Duan X, Shi J. Intelligence does not correlate with inhibitory ability at every age. Procedia Soc Behav Sci [Internet]. 2011;12:3–8. Available from: http://dx.doi.org/10.1016/j.sbspro.2011.02.003
35. Gill HS, O'Boyle MW, Hathaway J. Cortical distribution of EEG activity for component processes during mental rotation. Cortex [Internet]. 1998;34(5):707–18. Available from: http://dx.doi.org/10.1016/s0010-9452(08)70774-3
36. Sastre Riba S, Viana Sáenz L. Funciones ejecutivas y alta capacidad intelectual. Rev Neurol [Internet]. 2016;62(S01):65. Available from: http://dx.doi.org/10.33588/rn.62s01.2016025
37. García Molina A, Tirapu Ustárroz J, Luna Lario P, Ibáñez Alfonso J, Duque San Juan P. ¿Son lo mismo inteligencia y funciones ejecutivas? Rev Neurol [Internet]. 2010;50(12):738. Available from: http://dx.doi.org/10.33588/rn.5012.2009713
38. Arffa S. The relationship of intelligence to executive function and non-executive function measures in a sample of average, above average, and gifted youth. Arch Clin Neuropsychol [Internet]. 2007;22(8):969–78. Available from: http://dx.doi.org/10.1016/j.acn.2007.08.001
39. Friedman NP, Miyake A, Corley RP, Young SE, DeFries JC, Hewitt JK. Not all executive functions are related to intelligence. Psychol Sci [Internet]. 2006;17(2):172–9. Available from: http://dx.doi.org/10.1111/j.1467-9280.2006.01681.x
40. Rodríguez-Naveiras E, Verche E, Hernández-Lastiri P, Montero R, Borges Á. Differences in working memory between gifted or talented students and community samples: A meta-analysis. Psicothema [Internet]. 2019;31(3):255–62. Available from: http://dx.doi.org/10.7334/psicothema2019.18
41. Jung JY. Modeling the occupational/career decision-making processes of intellectually gifted adolescents: A competing models strategy. j educ gift [Internet]. 2014;37(2):128–52. Available from: http://dx.doi.org/10.1177/0162353214529045
42. Jung JY, Young M. The occupational/career decision-making processes of intellectually gifted adolescents from economically disadvantaged backgrounds: A mixed methods perspective. Gift Child Q [Internet]. 2019;63(1):36–57. Available from: http://dx.doi.org/10.1177/0016986218804575
43. Kim B, Yonsei University, Seo YS, Cho M. Character strengths and career development of academically gifted adolescents. J Asia Pac Couns [Internet]. 2012;2(2):209–28. Available from: http://dx.doi.org/10.18401/2012.2.2.6

44. Muratori MC, Smith CK. Guiding the talent and career development of the gifted individual. J Couns Dev [Internet]. 2015;93(2):173–82. Available from: http://dx.doi.org/10.1002/j.1556-6676.2015.00193.x
45. Wilson HE, Adelson JL. College choices of academically talented secondary students. J Adv Acad [Internet]. 2012;23(1):32–52. Available from: http://dx.doi.org/10.1177/1932202x11430269
46. Benito-Ostolaza JM, Hernández P, Sanchis-Llopis JA. Do individuals with higher cognitive ability play more strategically? J Behav Exp Econ [Internet]. 2016;64:5–11. Available from: http://dx.doi.org/10.1016/j.socec.2016.01.005
47. Park NY. Domain-specific risk preference and cognitive ability. Econ Lett [Internet]. 2016;141:1–4. Available from: http://dx.doi.org/10.1016/j.econlet.2016.01.008
48. Taylor MP. Are high-ability individuals really more tolerant of risk? A test of the relationship between risk aversion and cognitive ability. J Behav Exp Econ [Internet]. 2016;63:136–47. Available from: http://dx.doi.org/10.1016/j.socec.2016.06.001
49. Yun K, Chung D, Jang B, Kim JH, Jeong J. Mathematically gifted adolescents have deficiencies in social valuation and mentalization. PLoS One [Internet]. 2011;6(4):e18224. Available from: http://dx.doi.org/10.1371/journal.pone.0018224
50. Li D, Liu T, Zhang X, Wang M, Wang D, Shi J. Fluid intelligence, emotional intelligence, and the Iowa Gambling Task in children. Intelligence [Internet]. 2017;62:167–74. Available from: http://dx.doi.org/10.1016/j.intell.2017.04.004
51. Rodríguez-Naveiras E, Díaz M, Rodríguez M, Borges Á, Valadez MD. Programa Integral Para Altas Capacidades: "Descubriéndonos". Una Guía Práctica de Aplicación. Mexico: El Manual Moderno; 2015.
52. Quintero I. Caracterización neuropsicológica de la memoria en niños/as pretérmimo: papel de las funciones ejecutivas. [La Laguna, Spain]: Universidad de La Laguna; 2017.
53. Verche E. Estudio neuropsicológico y de meta-análisis de la Epilepsia del Lóbulo Frontal. [La Laguna, Spain]: Universidad de La Laguna; 2016.
54. Cognition C. CANTABeclipse Test Administration Guide. Cambridge, England: Cambridge Cognition; 2011.
55. Cattell RB, Cattell AKS. Test de Factor "g." Madrid, Spain: TEA Ediciones; 1973.
56. Cronbach LJ, etc. Dependability of behavioural measurement: Theory of generalizability for scores and profiles. Nashville, TN: John Wiley & Sons; 1972.
57. Volpe RJ, Briesch AM, Gadow KD. The efficiency of behavior rating scales to assess inattentive-overactive and oppositional-defiant behaviors: applying generalizability theory to streamline assessment. J Sch Psychol [Internet]. 2011;49(1):131–55. Available from: http://dx.doi.org/10.1016/j.jsp.2010.09.005
58. Meldrum RC, Petkovsek MA, Boutwell BB, Young JTN. Reassessing the relationship between general intelligence and self-control in childhood. Intelligence [Internet]. 2017;60:1–9. Available from: http://dx.doi.org/10.1016/j.intell.2016.10.005
59. Duckworth AL, Tsukayama E, Kirby TA. Is it really self-control? Examining the predictive power of the delay of gratification task. Pers Soc Psychol Bull [Internet]. 2013;39(7):843–55. Available from: http://dx.doi.org/10.1177/0146167213482589
60. Funder DC, Block J. The role of ego-control, ego-resiliency, and IQ in delay of gratification in adolescence. J Pers Soc Psychol [Internet]. 1989;57(6):1041–50. Available from: http://dx.doi.org/10.1037/0022-3514.57.6.1041
61. Jacobson LA, Williford AP, Pianta RC. The role of executive function in children's competent adjustment to middle school. Child Neuropsychol [Internet]. 2011;17(3):255–80. Available from: http://dx.doi.org/10.1080/09297049.2010.535654
62. Bryce D, Whitebread D, Szűcs D. The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7 year-old children. Metacogn Learn [Internet]. 2015;10(2):181–98. Available from: http://dx.doi.org/10.1007/s11409-014-9120-4

63. Arán Filippetti V, Richaud MC. A structural equation modeling of executive functions, IQ and mathematical skills in primary students: Differential effects on number production, mental calculus and arithmetical problems. Child Neuropsychol [Internet]. 2016;1–25. Available from: http://dx.doi.org/10.1080/09297049.2016.1199665
64. St Clair-Thompson HL, Gathercole SE. Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. Q J Exp Psychol (Hove) [Internet]. 2006;59(4):745–59. Available from: http://dx.doi.org/10.1080/17470210500162854
65. Shamosh NA, Gray JR. Delay discounting and intelligence: A meta-analysis. Intelligence [Internet]. 2008;36(4):289–305. Available from: http://dx.doi.org/10.1016/j.intell.2007.09.004
66. Pérez-Tejera J, Borges Á, Rodríguez-Naveiras E. Conocimientos y Mitos sobre Altas Capacidades. Talincrea: Revista de Talento, Inteligencia y Creatividad. 2017;4:40–51.
67. Comes G, Díaz E, Luque A, Moliner O. La evaluación psicopedagógica del alumnado con altas capacidades intelectuales. Revista de Educación Inclusiva. 2008;1:103–17.