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EXECUTIVE FUNCTIONS AND DECISION MAKING REGARDING DRUG ADDICTS IN ABSTINENCE

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SUMMARY

Background: Research has demonstrated impairments in executive functions in drug addict communities, many studies show significant alterations in various executive function components in individuals with polydrug habits. On the other hand, drug addicts not only show a decreased executive function ability but a decreased decision making ability as well. This study's goal was to compare a drug addict community's executive performance and decision making to those of a control group. And then make a correlation between the executive performance and decision making performance in the drug addict group alone.

Material/ Methods: A total of 96 individuals took part in this research, out of which the experimental group consisted of 65 individuals of both sexes and with, at least three years of problematic usage of substances. For the purpose of evaluating the executive functioning, and, more precisely the decision making ability, a few neuropsychological tests were used that are considered to be pertinent to that purpose, namely and respectively the BADS and IGT.

Results: The obtained results showed that the drug addicts have decreased results in both tests when compared to the control group. Finally, the BADS profile score and the decision making performance in the IGT, in the drug addict group alone, when correlated, has showed a positive correlation.

Conclusions: A worse cognitive profile seems to be synonymous with a worse decision making ability, which could lead to a greater difficulty in making important decisions, like choosing not to go back to drug consumption. This could point out the hypothesis that drug addicts with a lower cognitive profile are more likely to return to drug consumption. Therefore, the need for future investigations addressing this matter arises.

Keywords: neuropsychology, executive process, polydrug habits, BADS

BACKGROUND

Nowadays, drug addiction is considered to be a psychosocial disturbance, whose phenomenology is denominated by the degree of addiction, characterized by the search for and compulsive use of drugs (Melega, Raleigh, Stout, Huang & Phelps, 1997, amongst others). This clinical condition, also constituting a cerebral state, results from the passage of controlled drug consumption to an uncontrolled one (Marques Teixeira, 2001).

This drug consumption, whether it is acute or chronic, changes the cerebral functions resulting in behavioural alterations, which are maintained even though the subject has stopped using the substance for long periods of time (Nestler, 1996).

Specialized literature shows the involvement of multiple neuropsychological processes (e.g. memory, perception and attentional process) (Rogers & Robbins, 2001; Verdejo-Garcia, López-Torrecillas, Orozco, & Pérez-Garcia, 2004) and especially the executive functions in drug addicts (Bidzan 2014; Bechara, 2005; Fillmore, 2003; Lubman, Yucel, & Pantelis, 2004; Verdejo-García et al., 2004).

Executive functions are an integrated set of skills related to production, supervision, and behavioural control, which work towards specific objectives (Stuss & Knight, 2002; Roberts, Robbins, & Weiskrantz, 1998), and which also are implied in the regulation of emotional states that are considered to be adaptable to the successful execution of those same objectives (Bechara, Damásio, & Damásio, 2000; Davidson, 2002; Stuss & Alexander, 2000).

Many studies confirm the existence of alterations in various executive function components in individuals with polyuse substance habits , including, cocaine (Bolla, Eldreth, London, Kiehl, Mouratidis, Contoreggi, et al. 2003; Kubler, Murphy & Garavan, 2005), heroin (Lee and Pau, 2002; Fishbein, Krupitsky, Flannery, Langevin, Bobashev, Verbitskaya, et al. 2007; Brand, Roth-Bauer, Driessen & Markowitsch, 2008) or alcohol (Ratti, Bo, Giardini & Soragna, 2002; Bjork, Hommer, Grant & Danube, 2004).

In this matter, a wide body of investigations has identified a strong bond between executive deficits and structural or functional alterations of the central nervous system (CNS), being the executive processes strongly dependent on the pre-frontal cortex (Volkow, & Goldstein, 2002; Eisenberg, & Berman, 2010), mainly in the dorsolateral area (Mega & Cummings, 1994; Garavan, Ross, Li & Stein, 2000), also including the orbitofrontal cortex and the anterior cingulate gyrus (Volkow, Fowler, & Wang, 2003), and equally dependent on the corticostriate pathways (Elliot, 2003).

The orbitofrontal cortex has still reciprocal connections with the cerebral areas responsible for rewarding effects, as well as compulsive behaviours and decision making (Rolls, 2000; Volkow & Fowler, 2000).

Besides the orbitofrontal cortex, the dorsal part of the lateral pre-frontal cortex also seems to be implicated in the dysfunctional behaviours of subjects addicted to drugs, namely cocaine. (Bolla et al., 2003). The dorsal part of the lateral pre-

frontal cortex performs an important role in the maintenance of attention towards more demanding behaviours like task planning, behavioural feedback (MacDonald, Cohen, Stenger & Carter, 2000), memory and learning (Zubicaray, McMahon, Wilson & Muthiah, 2001).

The specialized subject literature presents drug addicted individuals as having behavioural deficits similar to those observed in patients with neurological damage in the pre-frontal cortex (Verdejo-García et al., 2006), namely deficits in the emotional regulation, changes in decision making, problems with impulsiveness and deficits in the inhibitory control (Bechara, Dolan, Denburg, Hindes, Anderson & Nathan, 2001).

The neuropsychological tests results, from among various investigations, seem to meet these findings, showing a performance deficit in drug addicts in tasks that involve judgment and decision making when compared to the control groups (Strickland, Mena, Villanueva-Meyer, Miller, Cummings, Mehringer et al. 1993; Ardila, Rosselli, & Strumwasser, 1991; Bolla et al.,1999.,2000).

Decision making is a dynamic process which favors the choosing, in situations of uncertainty, of a more suitable alternative between various outcomes, valuing its influence on future actions (Clark, Cools, & Robbins, 2004; Clark, Manes, Antoun, Sahakian, & Robbins, 2003).

These behavioural alterations also include the clinical symptoms of apathy, disinhibition and executive dysfunction (disorganized behaviour, planning difficulties and problem-solving), equally present in both drug use and abstinence periods.

These alterations also negatively affect the family members of the individual concerned, as well as their "*social network*" (Bechara et al., 2001; Moriyama et al., 2002), causing a variety of negative effects in their daily activities, like in their ability to work, their home responsibilities or in the establishment of appropriate social relationships (Rolls, 2004).

Thus, the impact of the executive dysfunction not only manifests itself in a purely cognitive plane (the alteration of which can be identified by the classic neuropsychological tests), but also in the emotional-affective-cognitive plane expressing itself in the individual's day-to-day tasks. (Lezak, Howieson, & Loring, 2004)

For the above-mentioned reasons, the neurophysiological study of the executive dysfunction and its rehabilitation processes face inherent difficulties, one of them being the valid and precise evaluation of the executive functions. Characterizing and measuring executive alterations are one of the most dramatic challenges to modern neuropsychology. (Tirapu-Ustárroz, Munoz-Cespédes, & Pelegrín-Valero, 2002).

Besides that, the neuropsychological evaluation devices that have been used are of an excessively artificial and structured nature, with only a few of them having been really developed to evaluate the executive functions, not truly reflecting the demands of real life actions in which the dysfunctions are more felt (Barbosa & Monteiro, 2008), with little consideration of its ecological value.

Through Burgess and Wilson's cooperation with Alderman, the Behavioural Assessment of the Dysexecutive Syndrome (BADS) is born which includes tasks that emulate quotidian activities to evaluate the executive functions (Wilson, Alderman, Burges, Esmlie & Evans, 1996) and combines a solid theoretical formation with a greater ecological validity.

Therefore, BADS appears to be the answer to the necessity for more sensitive neuropsychological instruments, valid to this purpose, trying, at the same time, to overcome the weaknesses associated with conventional tests (Silva, Monteiro, & Lopes, 2012). Despite its recent development, various investigators (Burgess, Alderman, Evans, Emslie & Wilson, 1998) see this battery as showing a promising potential to provide the answer to those needs.

As we mentioned earlier, the subject literature says that drug addicts present executive deficits, namely in inhibition, practical problem-solving, action planning and decision making. Therefore, besides characterizing and describing the executive functioning in drug addicts, we also pretend to evaluate their decisional profile as well as the relationship between the two.

For this purpose, the Iowa Gambling Task (IGT) was used, in order to assess the decision making (Bechara et al., 1994).

Therefore, and based on the previous bibliography, this study aims to compare the executive performance of drug addicts with the habits of polydrug consumption of substances against a control group.

It also aims to offer a new perspective as it tries to understand the relationship between the cognitive profiles of drug addicts when related with their decision making abilities.

Participants

A total of 96 individuals took part in this research, out of which the experimental group consisted of 65 individuals of both sexes and with, at least three years of problematic usage of substances, ages ranging from 21 and 59 years old (M=39.74 , DP=9.12).

The data collection was obtained in support clinics in the north area of the country (Portugal). For the selection of the participants some criteria of inclusion and exclusion was applied, having been included subjects aged 18 or over, with a history of problematic polydrug consumption, with an educational level equal or above the fourth grade, being abstinent for at least a month and having been institutionalized. The participants were excluded if they showed any history of neurological or psychological impairment.

On the other hand, the control group consisted of 31 individuals from both sexes, aged between 20 and 55 years old (M=35.52, DP=10.21). This group was recruited in residential areas in the north of the country to ensure the best possible sample adjustments. All the participants were well informed of the nature and objectives of the study, and the participation in all of the neuropsychological tests was voluntary.

MATERIALS AND METHODS

To evaluate the executive functioning, and more precisely the decision making, a few neuropsychological tests were used that are considered to be pertinent to that purpose, namely and respectively the BADS and IGT.

BADS is structured within six sub-tests, with tasks that simulate real life activities, conceived to diagnose the existence of deficits in the general executive functioning or within specific components of the executive functions. It is especially sensitive to the competences involved in problem-solving, planning and intentional organization over long term periods (Barbosa, Peixoto, & Silveira, 2011).

To each task we obtain a profiled score (with a maximum of 4 and a minimum of 0). The *Rule Shift Cards* test evaluates the ability to change a certain type of established answer pattern using familiar materials. The *Action Program* evaluates the ability to solve practical problems. *Key Search* is a test designed to evaluate actions strategies. The *Temporal Judgment* includes four questions that evaluate the ability to predict or estimate how much time, on average, it takes to accomplish various tasks, events or day-to-day activities. The *Zoo Map* test evaluates the action planning. Lastly, the *Six Elements Test* (modified) is a planning test, a temporal organization of tasks and self-evaluation of success (Wilson et al., 1996).

The IGT was created to evaluate real life decision making in a laboratory environment. The preponderance of evidence supports the use of the IGT in the detection of deficits in decision making on clinical populations (Melissa, T., Buelow & Julie A., Suhr., 2009). It constitutes a *gambling* task that emulates the decision making in an ecological way, using factors like uncertainty, reward and penalty. The subjects are given four decks of cards and a "loan" of 2000€ and the only request made in the test is to accumulate the biggest possible amount of money.

The IGT version used in this study was the digital version of Mueller (2010), through its software (The Psychology Experiment Building Language (PEBL) Version 0.13 by Shane T. Mueller). In this version four virtual decks are presented in the computer monitor, and the subjects are told that every time they pick a card, they will win some money (reward), although, some of the cards will take away some money (penalty), the test ends when the subject has chosen a total of 100 cards. The four decks differ in the amount of money they offer to the subject and in their disposition of the "penalty" cards, allowing us to see that there are "good" decks and "bad" decks. The test is programmed in such a way that every time the subject chooses a card from the deck A or B they will win the sum of 100€, and each time they choose a card from the decks C or D they will win a total of 50€. Although in each and every one of the decks the subjects will face some unpredictable money loss (penalty). The amount of the penalties is programmed to be higher in the decks that provide more money (A and B) and lower in the decks that provide less money (C and D). In decks A and B, per 10 cards selected from each deck, the subject finds a loss of 1,250€, while in decks C and D per 10 cards chosen the subject makes a total loss of 250€. So, in the long term, the A and B decks proved to be more disadvantageous because they

lead to more losses. On the contrary, decks C and D show themselves to be more advantageous, being there a loss of €250 per 10 cards, thus resulting in a gain of €250 per 10 cards chosen.

The penalty/reward structure in this version is identical to that of Bechara et al., (1997); with each deck comprising 40 cards, the advantage in the digital version is that, unlike the classic test, if the 40 cards of a determined deck are chosen that self same deck is presented again from its beginning. Besides this, the digital version presents itself as a more accessible input for the user.

Procedures

The data collection was conducted in Drug Addicts Support Clinics in the north of the country, following a positive response from the respective clinical directors to the consent given by their patients for the data collection itself. The tools used in this study were administrated linearly in each of the sessions with an estimated duration of one hour per session.

Adhering to the inclusion and exclusion criteria, there was an initial and earlier study of the clinical processes for each of the drug addicts institutionalized in the various clinics, which were then chosen accordingly to both of the criteria. Afterwards we proceeded to the completion of the data collection sessions, all of which were held in large rooms, in a quiet environment, in which only the researcher and the participant were present. At the beginning of each session the main objective of the study was explained to the participants and what was the goal of it. Following informed consent, the session would proceed with a brief questionnaire to obtain the demographical data of the subjects, and then came the BADS and IGT tests.

Analysis and Data Processing

The statistical analysis was performed with the aid of the SPSS – Statistical Package for the Social Sciences, version 20.0 computer program for statistical analysis. Descriptive analysis procedures were carried out, namely central tendency and dispersion measures (median and standard deviation) through the Student t Test for independent samples, to enable the establishment of the relation between both of the groups and their performances in BADS and IGT, wherein differences with $p < .05$ were considered as significant. To analyse the performance of both groups in each of the five different IGT block of cards (five different conditions) a multivariate analysis was made. We also performed a correlation analysis to verify the relationship between the performance on the IGT and BADS Profile Scores in the experimental group participants.

RESULTS

The results obtained by both of the groups in BADS, concerning the total score obtained, show that the drug addicts group obtained clearly lower results (M=12.95, DP=4.31) when compared to the control group (M=20.55, DP=1.78),

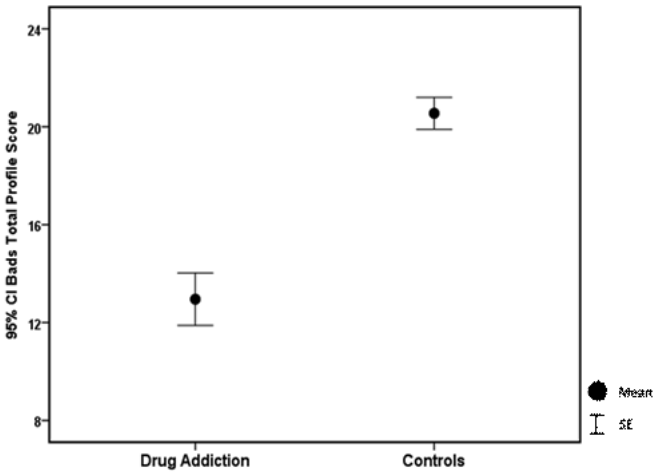

Fig. 1. Averages and standard error of the total score obtained by both drug addiction and control groups in BADS completion.

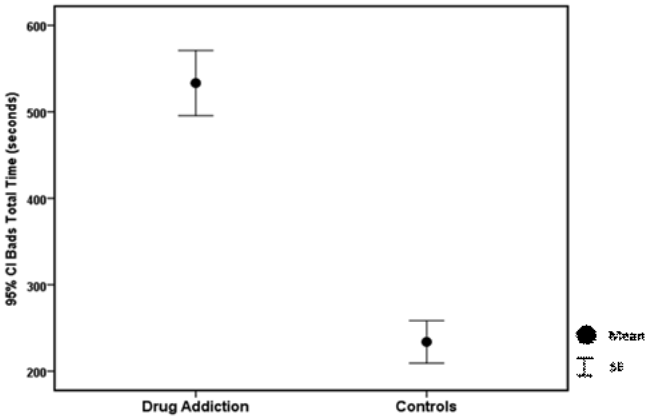

Fig. 2. Averages and standard error of the total time spent (in seconds) by both drug addiction and control groups in the completion of the BADS subscales.

resulting in a significant difference (t=-9.398, p <.001, 95% IC [-9.199, -5.990] (see Fig.1). Also, the analysis of the total time spent for the full implementation of the battery revealed a statistically significant difference (t = 10.465, p <.001, 95% IC [242.614, 356.229], in which the drug addicts group shows a greater amount of time needed to conclude the battery (M=533.29, DP=152.16), when compared to the control group (M=233.87, DP=66.925) (see Fig. 2).

Concerning the scores obtained in each subtest of BADS, we can see that the drug addicts obtained less success when compared to the control group in

the majority of the subtests, with the exception of the *Action Program* test (see Table 1). The differences in the performance observed turned out to be statistically significant, with a significance degree of $p<.05$. As for the time taken to perform each task, for those subtests in which time was taken into account (subtests 1, 2, 3 and 5), as well as the time spent for the execution of the entire test, the drug addicts group generated once again lower results. In accordance with the data obtained in Table 1, the drug addicts group present significant differences when compared with the control group in almost every subtest, except for the subtest *Key Search*, concerning the time expended. It appears that drug addicts required significantly longer periods of time for the execution of the tests, as well as for the implementation of the entire battery (see Table 2).

Regarding the performance on IGT, the group of addicts had worse results in the amount of money raised at the end of the test (M = 1771.54, SD = 760 292) when compared with the control group (M = 2381.67, SD = 773 843), in a highly significant way (t = -3616, p <.001, 95% CI [-945 235, 275 022].

When comparing the performance of both groups in different blocks of the IGT, significant differences in groups and blocks was found, in which the group of drug addicts again displayed significantly inferior results when compared to the control group F [4,465] = 2.893, p <.022

When Correlated, the profile score of BADS in the drug addicts group alone and their performance in the IGT (final money),it is possible for us to verify that

Table 1. Averages, Standard Deviations, t Values, p Values and Confidence Intervals of the results of the Drug Addiction and Control Groups in each of the BADS subtest

BADS Subscales	Drug Addiction Group		Control Group				95% CI	
	M	*SD*	*M*	*SD*	*t*	*p*	*LL*	*UL*
Rule Shift	2.15	1.349	3.81	.402	-7.662	<.001	-2.145	-1.160
Action Program	3.42	.788	3.55	.506	-4.858	.393	-.441	.175
Key Finding	1.60	1.196	2.71	1.131	-5.573	<.001	-1.619	-.600
Temporal Judgment	1.25	.952	2.81	.833	-7.301	<.001	-1.957	-1.163
Zoo Map	1.97	1.159	3.74	.445	-14.720	<.001	-2.201	-1.344
Modified Six Elements	2.57	1.089	3.97	.180	-15.524	<.001	-1.791	-1.007

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

there exists a positive correlation between both: drug addicts with the best results in BADS are also the ones that display the best results in IGT.

Table 2. Averages, Standard Deviations, t Values, p Values and Confidence Intervals of time spent (in seconds) by the Drug Addiction and Control Groups in completing each of the BADS subtest

Timed BADS subscales (seconds)	Drug Addiction Group		Control Group				95% CI	
	M	*SD*	*M*	*SD*	*t*	*p*	*LL*	*UL*
Rule Shift	60.89	19.185	48.03	10.607	3.481	.001	5.524	20.196
Action Program	120.00	.000	66.68	8.972	48.199	<.001	51.126	55.519
Key Finding	45.65	37.082	32.29	18.932	1.888	.062	-.691	27.403
Zoo Map	307.40	137.176	86.87	47.207	8.688	<.001	170.131	270.927
Total Time	533.29	152.106	233.87	66.925	10.465	<.001	242.614	356.229

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit

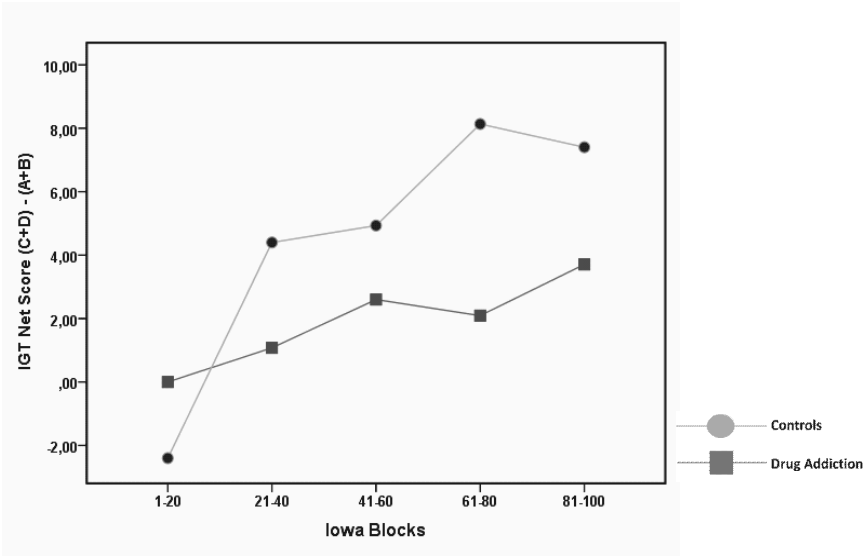

Fig. 3. Learning curves and performance of both drug addiction and control groups in each of the IGT blocks

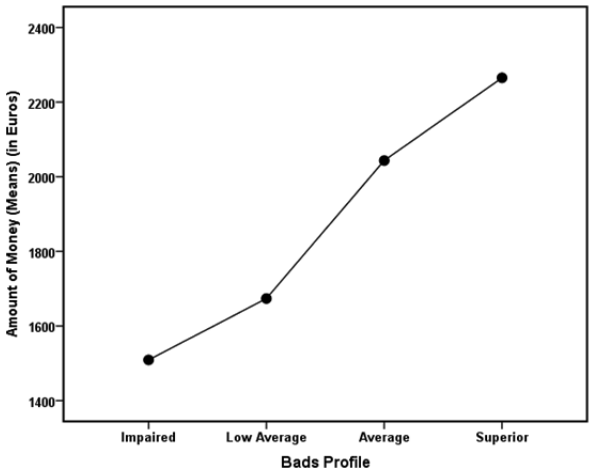

Fig. 4. A correlation between the averages of the IGT final amount of money with the BADS profile score obtained by the drug addiction group alone.

DISCUSSION

Regarding the data obtained through BADS, we can see a lack of performance in the experimental group in various components of the executive functioning when compared to the control group. In the *Rule Shift Cards* test, we can see difficulties within the experimental group to change the standard response previously established (mental flexibility). In the *Action Program* test, drug addicts revealed more difficulties in handling different materials in order to solve practical problems, although the performance of drug addicts was lower than the control group, this does not show a statistically significant difference. In turn, the *Key Finding* test, which aims to evaluate the ability to plan a strategy in order to solve a specific problem, once again, are observed as big issues for drug addicts in planning effective actions and in the ability to monitor their own performance.

The *Temporal Judgment* test requires an individual to do a review of temporal estimation, assessing the ability to predict or estimate the time that is spent, on average, on daily activities. Again, drug addicts had greater difficulties concerning the ability of temporal exploration. Difficulties for the subjects of the experimental group performing the *Zoo Map* test are also visible; this test primarily assesses their planning action capacity. Finally, in the *Modified Six Elements* test, drug addicts had, once again, great difficulties in planning, the temporal organization of tasks and the self-monitoring of performance.

With regards to the total time spent by participants executing these same tests, it appears on average that the drug addicts group took longer to fulfil them than did the control group, and, once again, also obtained worse results.

Regarding the data of the IGT, we can observe through IGT blocks that both groups show a positive learning pattern, although, once again, the drug addicts

group display worse results in decision making when compared to those of the control group; with the exception of the first IGT test block of cards , drug addicts have a diminished ability for decision making, with their final results being lower than those of the control group.

The data obtained in this investigation will, therefore, meet the expectations and assumptions initially raised. Similar data can be encountered in the specialized literature, which corroborates it (Bechara, 2005; Fillmore, 2003; Lubman et al. 2004; Verdejo-García et al., 2004). Although there is already a comprehensive study of executive functions in drug addicts, which resorted to the BADS battery of neuropsychological assessment, and also to the study of decision making through IGT in this same target population (Bechara et al, 2001;. Grant, Contoreggi, & London, 2000), the present study is unique in that it correlates these two dimensions.

Therefore, to better understand the cognitive profile of drug users and its relationship with the decision-making capacity, a correlation between these two dimensions was performed. We could verify the existence of a clear positive correlation between the cognitive profile of drug addicts and the final results of IGT: drug addicted subjects with a lower cognitive profile have worse outcomes in IGT, which leads to the conclusion that most of them have deficits in decision making; while drug addicted subjects with a higher cognitive profile show better results in IGT, representing less difficulty in decision making.

CONCLUSION

A worse cognitive profile seems to be synonymous of a worse decision making ability, and also a worse capacity to reverse a previous learned pattern, specifically their previous decision making pattern, which could lead to a greater difficulty in making important decisions in their lives, ones that differ from those previously taken, like choosing not to go back to drug consumption. This could point to the hypothesis that drug addicts with a lower cognitive profile are more likely to return to drug consumption, although, the methodology of this study does not allow us to confirm this hypothesis. Therefore, the need for future investigations arises.

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