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REVIEW ARTICLE

Neuropsychological disorders in juvenile delinquents

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Abstract

Juvenile delinquents are young people who break the law. They are usually males of low socio-economic status and low education, and are more exposed to brain damage risk factors, especially drug use, and have a higher prevalence of attention deficit hyperactivity disorder. These characteristics suggest a delay in the development of the prefrontal cortex of the brain, which is related to neuropsychological functions such as language, memory, attention, and executive functions. To assess the evidence of a delay in the development of prefrontal functions, a search was conducted for studies that evaluated neuropsychological functions in inmate juvenile delinquents, comparing them to a control group, and only 14 articles were found with these characteristics. The review showed that, despite methodological issues on task selection and on the composition of control groups, there is evidence that juvenile delinquents have disorders on neuropsychological functions such as language comprehension, visuospatial working memory, selective and sustained attention, and components of executive functions such as cognitive inhibition, cognitive flexibility, and planning. These findings agree with the hypothesis that there is a developmental delay in the prefrontal functions of juvenile delinquents. Understanding the deficits juvenile delinquents have on neuropsychological functions is crucial to design prevention and treatment programs for juvenile delinquency.

Key words: *Juvenile delinquency. Adolescence. Neuropsychology. Executive functions. Education.*

Trastornos neuropsicológicos en delincuentes juveniles

Resumen

Los delincuentes juveniles son jóvenes que violan la ley. Por lo general, son hombres de bajo nivel socioeconómico que tienen poca educación, están más expuestos a factores de riesgo de daño cerebral, especialmente el uso de drogas y tienen una mayor prevalencia de TDAH. Estas características sugieren un retraso en el desarrollo de la corteza prefrontal del cerebro, que está relacionada con funciones neuropsicológicas como el lenguaje, la memoria, la atención y las funciones ejecutivas. Para evaluar la evidencia de un retraso en el desarrollo de las funciones prefrontales, se realizó una búsqueda de estudios que evaluaran las funciones neuropsicológicas en delincuentes juveniles internos, comparándolos con un grupo de control y solo se encontraron 14 artículos con estas características. La revisión mostró que, a pesar de los problemas metodológicos en la selección de tareas y en la composición de los grupos de control, existe evidencia de que los

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delincuentes juveniles tienen trastornos en las funciones neuropsicológicas, como la comprensión del lenguaje, la memoria de trabajo visoespacial, la atención selectiva y sostenida y los componentes de las funciones ejecutivas como la inhibición cognitiva, la flexibilidad cognitiva y planificación. Estos hallazgos concuerdan con la hipótesis de que existe un retraso en el desarrollo de las funciones prefrontales de los delincuentes juveniles. Comprender los déficits que tienen los delincuentes juveniles en las funciones neuropsicológicas es crucial para diseñar programas de prevención y tratamiento para la delincuencia juvenil.

Palabras clave: *Delincuencia juvenil. Adolescencia. Neuropsicología. Funciones ejecutivas. Educación.*

Introduction

Juvenile delinquents are young persons that break the laws of a state or nation before being of legal age in that region, usually at 18 years of age[1]. Only adults can be found guilty of an illegal act since younger persons lack the capacity to fully understand the negative consequences of their actions. Most juvenile delinquents commit only misdemeanors, such as fights, vandalism, and unarmed theft; nevertheless, some of these adolescents get involved in serious crimes such as homicide, sexual assault, organized delinquency, and kidnaping[2]. Juvenile delinquency, compared to adult delinquency, causes a great part of the global number of lesions, premature deaths, and disabilities[3]. Juvenile delinquency also reduces productivity, the value of property, and the quality of life of the general population[4].

Economic theories of delinquency propose that people respond to the costs and benefits of criminal activity[5]. Geographical theories focus on the distribution and environment where crimes happen and propose interventions on urban space[6]. Social theories explain delinquent behavior through the social and cultural conditions surrounding the juvenile delinquent and analyze variables such as peer influence, family relationships, race, ethnicity, poverty, neighborhood, and criminal subculture[7].

Gender and socioeconomic status are two social factors that appear in every country where delinquency has been studied. The great majority of juvenile delinquents are males; for example, in Mexico the homicide rate is 10 times higher in males compared to females[2]. Low socio-economic status is the norm in the juvenile delinquent population[8], and it relates to other brain damage risk factors, such as less access to health and education services, greater exposure to illegal drugs, and a greater prevalence of family violence[9,10].

On the other hand, biological and psychological theories analyze the characteristics of the person that commits the crime, instead of its relations to the environment. Early biological explanations of delinquency ended up supporting deterministic ideas, particularly Lombroso's concept of a "natural born criminal." Deterministic explanations take a single trait that is common among delinquents and portray it as the main cause or predictor of future delinquency. Trying to explain delinquency through a single cause is dangerous because it can bring social exclusion, mass incarceration, or even genocide to a social class, a race or an ethnic group living in disadvantageous conditions. Contemporary biological and psychological theories are mostly not deterministic, but it is common to notice attempts in politics and the media to isolate a risk factor and portray it as the major cause or explanation for delinquency[11].

A contemporary non-deterministic biological explanation stems from the premise that, if behavior depends on the brain, delinquent behavior must somehow be related to peculiarities of brain functioning or development. There is neurological and neuropsychological evidence enough to state the hypothesis that a delay in the development of the prefrontal cortex increases the risk of adolescents of getting involved in delinquency[12]. Some of the evidence in juvenile and adult delinquents that supports this hypothesis is presented below.

Delinquents have a higher level of dopamine than controls; this neurotransmitter appears in the frontal cortex and is related to the display of aggression and cognition[13]. Adolescents with higher aggression have lower levels of orbitofrontal serotonin, a neurotransmitter related to pain detection and aggression inhibition[14]. This evidence suggests there are abnormalities in the prefrontal cortex neurotransmitters of adult delinquents.

The incidence of electroencephalographic abnormalities in adult delinquents is between 25 % and 50 %[15], which suggests a reduction of the input that the reticular activating system has on the cortex and the rest of the brain; nevertheless, more studies are needed to confirm these findings.

Raine et al.[16,17] showed, through positron emission tomography, that a group of adult delinquents had lower metabolic activity in the prefrontal cortex and other subcortical areas, compared to non-delinquents; a literature

review on functional neuroimaging in delinquents confirms these findings[18]. Adolescents living in reformatories with high indices of violence and aggression showed greater activity in the fusiform gyrus, recorded through functional magnetic resonance when presented with violent images[17]. Nevertheless, another study using magnetic resonance did not find differences in prefrontal activation during an economic task, which suggests juvenile delinquents activate similar neural networks than controls during decision making, despite having worse results[19]. Alterations in the gray and white matter morphology of the brain have been reported in delinquents with aggressive or violent behavior[20].

Most of these studies were done after the crimes were committed; therefore, it is difficult to determine that these findings were not due to the incarceration process. Nevertheless, these results suggest that juvenile delinquents have differences in the structure and functioning of the brain that could result in a delay of prefrontal development.

Some factors associated with a delay in prefrontal development that are common in the juvenile delinquent population are early malnourishment[21], drug use[22], and traumatic brain injuries[23]. Lewis et al.[23] reported that juvenile delinquents are in a higher risk of having suffered parental negligence, which affects brain development and lowers cognitive capacity. Furthermore, juvenile delinquents have more emergency room visits for severe head or face trauma than other adolescents, which can alter brain development[24].

Juvenile delinquents also have problems to learn at a similar pace as other adolescents, especially while learning to read, write, and calculate[25] and have a greater prevalence of academic failure[11]; these school problems are usually interpreted as a delay in the development of cerebral circuits. Juvenile delinquents that have learning problems have been found to have a higher index of recidivism, compared to other delinquents with better academic performance[26]. Even though not all adolescents with school problems commit felonies[27], school abandonment has been related to a greater probability of getting involved in criminal activities[28].

In terms of psychiatric disorders, conduct disorder (CD) and oppositional defiant disorder are expected in juvenile delinquents, since some of the criteria for their diagnosis includes arrests and trouble with the police. On the other hand, depression and anxiety have a high prevalence in juvenile delinquents[29], these disorders have been related to an alteration of prefrontal activity and its influence in the limbic system[30], suggesting a prefrontal alteration.

Juvenile delinquents usually have problems with drug use, for example, 8% of school attending adolescents in the United States report abuse or dependence on alcohol or drugs, but this prevalence increases to 23% in arrested adolescents[31]. Most juvenile delinquents report having started using drugs the year before their first felony, but others report having committed crimes to sustain their habit[32]. Drug use can alter neurotransmitter metabolism and the number of synaptic receptors in the brain[33] and it has been related to low performance in neuropsychological tests that evaluate reticular, parietal, and frontal lobe functions[34], specifically on memory,[35] and executive functions tasks[36].

Besides having a negative impact on brain development, drug use has been related to a diagnosis of attention deficit hyperactivity disorder (ADHD)[37] because these patients have greater indices of use and abuse of substances than other adolescents[38]. This relationship is not yet clear since it has not been possible to determine if drugs are part of the causes of ADHD or if ADHD patients use drugs as a form of self-medication[39].

Adolescents with more childhood ADHD symptoms tend to commit more misdemeanors at a younger age than those without the disorder[40]. ADHD has been related to a delay in the development of prefrontal areas; therefore, the high prevalence of this disorder among juvenile delinquents[41] suggests that these youngsters have a delay in prefrontal development. This delay would manifest as immaturity in neuropsychological functions such as attention, memory, and executive functions[42].

These characteristics suggest that juvenile delinquents are an at-risk group for having a delay in the development of the prefrontal cortex. It is possible that this delay manifests as neuropsychological disorders, increasing the chances for school dropout, which combined with poverty, family issues, and other mental health problems leave adolescents with few options, and vulnerable to get involved in criminal groups. Nevertheless, although there are many analyses of these functions in juvenile delinquents, they need to be sorted and discussed to evaluate the neuropsychological evidence of a developmental delay of the prefrontal cortex. Therefore, the objective of this revision is to analyze the evidence of neuropsychological disorders in juvenile delinquents.

Methods

The present study is an integrative review that collects, analyzes, and synthesizes evidence from diverse

sources while clearly stating the search criteria. A search for journal articles was performed using combinations of the terms "juvenile delinquency," "delinquent adolescent," "juvenile offenders" or "young delinquents" with "neuropsychology," "attention" and "executive functions" on three search engines: *Google Scholar*, *Medline,* and *Redalyc*.

For an article to be included in the revision it had to be published between January 1980 and April 2018, in English or Spanish, have an experimental group formed by adolescents residing at a center for committing a crime, have a control group of non-delinquent adolescents, and the use of a neuropsychological task. All articles were from peer-reviewed journals, except two theses that covered the other requirements and were included due to their relevance. A longitudinal analysis authored by Moffit and her team was also included because of its great influence in the field; nevertheless, it was not included in the results table. Articles were excluded for: not having a sound neuropsychological assessment and for forming an experimental group through self-reports of delinquent behavior, or with adolescents that were not legally responsible for a crime. With these criteria, 25 articles were taken into account, and in a closer analysis ten were discarded, to finally include 14 articles in this review (Table 1).

Analysis and discussion

The articles were grouped by the neuropsychological functions that are evaluated. The method and results of each article are discussed in the text; the particular tasks and indices that were used and the scores that each group obtained are detailed in table 1.

Language

Juvenile delinquents have difficulties on complex aspects of language, such as verbal fluency[43], production of complex sentences, and verbal comprehension, in comparison to adolescents without legal problems and of similar age, race, and socio-economic status to the juvenile delinquent group[43-46]. These differences were determined using subtests of the Wechsler intelligence scales and the Clinical Evaluation of Language Fundamentals. Comprehension and verbal fluency are related to the functioning of the prefrontal cortex; these results suggest a delay in the development of these areas, and therefore on other prefrontal functions.

Memory

Even though memory is a basic cognitive process, it has been analyzed scarcely. A study reported juvenile delinquents had lower scores on a verbal learning task, which heavily recruits memory, meaning they had a lower capacity to improve their recall of a word list during subsequent exposures, compared to other student adolescents[47]. A longitudinal study showed a weak correlation (under 0.20) between number of arrests and the score of this same task during adolescence years[48].

Working memory is the capacity to recall relevant information for the task at hand and has three components: the visuospatial storage, the phonological storage, and the central executive component. In the spatial working memory task, juvenile delinquents had a low level of performance compared to control adolescents[49,50]. Other studies that measured visuospatial working memory through the Benton visual retention test report more errors in juveniles, compared to controls paired by socioeconomic status (SES), sex, and ethnicity[43,51].

These results indicate that juvenile delinquents have a deficit on the visuospatial component of working memory, which is the capacity to store the position of objects in space; nevertheless, more studies are needed to analyze the remaining components. These results could also be due to an alteration in the central executive component of working memory, in charge of prioritizing the storage of task-relevant information in the visuospatial or phonological storages and, when affected, it greatly disturbs the functioning of the other two components. This component is more directly related to prefrontal functioning, and therefore a delay in prefrontal development could reduce performance on working memory tasks, such as it is observed in juvenile delinquents.

Attention

The majority of the reviewed studies focus on evaluating a single component of attention and employ tasks with indices that are not sensible enough. Olvera et al.[44] did not find differences in selective attention when comparing a juvenile delinquent group to a group of adolescents of the same community, age, sex, ethnicity, and similar SES. This study employed a cancellation task with a very low demand that was probably not sensitive to group differences. On the other hand, Chae et al.[52] reported that juvenile

Table 1. Neuropsychological studies of juvenile delinquents

First author	Experimental and control groups	Paired by	Function	Tasks and tests	Indices	Group score comparison (E: Experimental, C: Control)
Abdou (2011)	25 juvenile delinquents 15 adolescent students	Age, sex, SES	Cognitive flexibility	WCST	Perseverative responses	Males: E: 33 C: 9.2 Female: E: 22.6 C: 9.6
Appellof (1985)	23 juvenile delinquents 29 adolescent students	Age, ethnicity, sex, SES	Cognitive flexibility Executive functions Planning Verbal fluency Verbal comprehension Visuospatial memory	WCST Porteus maze TVF Token Test BVRT	Perseverative responses Number of categories Qualitative score Correct responses Correct responses Correct responses	E: 20.39, C: 16.72 E: 4.96, C: 4.76 E: 27.35, C: 22.07 E: 14.87, C: 17.45 E: 36.65, C: 37.62 E: 8.87, C: 9.10
Blanton (2007)	18 juvenile delinquents 14 adolescent students	Age, race, SES	Language Executive functions Language	KBIT subtests CELF-3	Vocabulary score Matrices score Receptive score Expressive score	E: 86.3, C: 93.2 E: 99.0, C: 101.9 E: 88.6, C: 99.1 E: 90.7, C: 99.6
Borrani (2011)	12 juvenile delinquents 26 normal education adolescents 12 low-education adolescents	Age, sex, education	Sustained attention	Continuous performance task	Percentage of correct responses DS of correct responses R of correct responses Longest sequence	JD: 77.11 NE: 94.96 LE: 80.22 JD: 2.37 NE: 0.90 LE: 2.46 JD: -0.10 NE: -0.20 LE: 0.09 JD: 7.58 NE: 2.77 LE: 9.75
Borrani (2015)	27 juvenile delinquents 27 low-education adolescents 27 normal education adolescents	Age, sex, education	Cognitive inhibition Cognitive flexibility	Modified Stroop task	Word reading Color naming Switching errors	JD: 23.93 LE: 24.48 NE: 23.56 JD: 53.22 LE: 57.56 NE: 45.74 JD: 68.39 LE: 74.54 NE: 62.19
Carrol (2006)	43 juvenile delinquents 43 adolescent students	Age, sex	Cognitive inhibition	Stroop task	Word reading Color naming Interference	E: 34.38, C: 43.17 E: 34.93, C: 42.21 E: 51.38, C: 55.29
Caufman (2005)	78 Juvenile delinquents 78 Adolescent students	Age, ethnicity, SES	Planning Spatial working memory	Tower of London Spatial Working Memory	Problems completed Strategy score (overall performance)	E: 8.51, C: 8.46 E: 36.20, C: 34.56
Chae (2001)	17 juvenile delinquents 47 adolescent students	Age, sex, SES	Attention	Test of variables of attention	Omissions Commission RT variability Decrement in performance	E: 1.56 , C: 1.37 E: 4.14, C: 2.55 E: 89.60, C: 89.27 E: 4.29, C: 5.12

(Continues)

Table 1. Neuropsychological studies of juvenile delinquents *(Continued)*

First author	Experimental and control groups	Paired by	Function	Tasks and tests	Indices	Group score comparison (E: Experimental, C: Control)
Lueger (1990)	21 juvenile delinquents (with a diagnosis of CD) 20 adolescents from a community center	Age, sex Planning	Cognitive flexibility Executive attention Sustained attention Verbal memory Planning	WCST SMMT AVLT Trail making test	Perseverative responses Number of categories Number of errors Learning Time (seconds)	E: 44.50, C: 20.62 E: 3.14, C: 4.58 E: 17.77, C: 9.45 E: 2.69, C: 3.38 E: 39.27, C: 30.71
Olvera* (2005)	16 juvenile delinquents 26 adolescents from the community	Age, sex, ethnicity, SES	Cognitive inhibition Cognitive flexibility Planning	Stroop WCST Tower of London	Word reading Perseverative responses Number of moves	E: 97.2, C: 107.8 E: 90.2, C: 111.9 E: 104.6, C: 90.2
Poon* (2014)	29 juvenile delinquents with ADHD 29 adolescent students	Age, sex, SES	Cognitive inhibition Visuospatial memory Planning	Stroop BVRT Tower of London	Interference Total errors Number of moves	E: 0.16, C: 0.30 E: 0.70, C: 0.06 E: 0.14, C: 0.01
Romi (2007)	111 juvenile delinquents 31 adolescent students	Age, sex, education	Language	WISC	Vocabulary score	E: 8.52 C: 10.27
Wolf (1984)	56 juvenile delinquents 48 adolescent students	Age, sex, SES	Language Cognitive inhibition Selective attention Planning	TBNT Token test Stroop Trail making test Porteus maze	Correct responses Correct responses Word reading (time) Color naming (time) Interference index Perceptual errors Qualitative score Correct responses	E: 28.4 C: 32.7 E: 15.8, C: 17.3 E: 55.0, C: 46.4 E: 75.5, C: 67.1 E: 140.7, C: 129.1 E: 9.9, C: 5.6 E: 18.8, C: 9.0 E: 72.1, C: 72.7

WCST: Wisconsin Card Sorting Test; CELF-3: clinical evaluations of language fundamentals; SMMT: sequential matching memory test; AVLT: auditory verbal learning test; BVRT: Benton visual retention test; TBNT: the Boston naming test; SD: standard deviation; SES: socioeconomic status; KBIT: Kaufman brief intelligence test.
*These studies report only their transformed data and the method of transformation is not entirely clear.

delinquents had a higher percentage of commission errors, compared to a group of adolescents of normal education and similar SES, which could be taken as index of selective attention; although significant, these differences between groups were small. On this same study, the decrement of performance was analyzed and found to be steeper in juvenile delinquents compared to controls, indicating a deficit on sustained attention in juvenile delinquents.

Another study[53] analyzed this process with a neuropsychological task that evaluates sustained attention, which is the capacity to respond at the same level during a prolonged period. Sustained attention is related to prefrontal cortex functioning[54]. This study found that juvenile delinquents had difficulties on this component of attention, compared with normal-education adolescents; it also found a deficit on sustained attention on an education-paired group, compared to a more

educated group. These results indicate that juvenile delinquents have a developmental delay in prefrontal functions and its connections to the reticular system.

Regarding attention, this study was the only one found to consider the education of the participants, and the only one that tried to control this factor by incorporating a control group with the same age and education as the juvenile delinquent group. Through this protocol, differences in attention surfaced between groups of different education, since low-education adolescents (delinquents and non-delinquents) had the same low attention capacity, which suggests that these deficits are related to low education, and therefore not directly related to legal status. Even though attention problems and school dropout appear in juvenile delinquents, they are not a direct cause of delinquency.

Executive functions

The components of executive functions are initiative, planning, prevision, cognitive inhibition, cognitive flexibility, self-monitoring, verification, and correction[55]. These functions are denominated as "executive" due to their role in regulating other brain functions that have a much more limited and specific operative roles[56].

Executive functions are related to the prefrontal cortex, and lesions in the dorsolateral area of this cortex usually produce disorders in cognitive inhibition, the capacity to stop prevalent responses. This manifests as impulsive behavior[57], responding to irrelevant stimuli, producing answers out of time, out of context, or that interfere with actions directed to a goal, for example, making inappropriate and offensive commentaries[58].

On the other hand, a great part of prefrontal lesion patients shows deficits in cognitive flexibility, the capacity to change behavior based on environmental cues, which impairs the formulation of a different strategy to solve a new problem[59]. This perseverative behavior makes patients persist on the same response strategy, even though they can acknowledge it is not working[57].

Patients with prefrontal lesions also have deficits on planning, meaning they have difficulties setting goals, selecting the action strategies pertinent to achieve them, and executing the behavior sequence that is required to reach those goals[56]. This deficit affects daily life, making prefrontal patients break more rules, omit necessary behaviors, and perform actions unrelated to the proposed goal, especially when confronting new and unstructured problems[56,59]. Prefrontal patients commit more mistakes and require more time to solve tasks that evaluate planning, such as the Tower of London and the Porteus Maze[60].

Juvenile delinquents have low scores on the performance of neuropsychological tasks related to executive functions[43,61]. Olvera et al.[44] found that a group of inmate juvenile delinquents had worse performance on a Stroop-type task, compared to middle-class adolescents of the same age, sex, and race, which indicates juvenile delinquents have lower cognitive inhibition. Other studies that employed other Stroop-like tasks also reported significative differences in the indices of inhibition[51,62].

Another study found that juvenile delinquents have deficits on inhibition using a modified Stroop task[64], compared to adolescents of normal education; nevertheless, these difficulties were also observed in a group of low education non-delinquents. Therefore, juvenile delinquents have a deficit on cognitive inhibition, and this deficit is shared between delinquents and non-delinquents of low-education; this implies that this deficit is probably related to their school problems, which is a risk factor for involvement in criminal activities. This study is the only one on executive functions that takes education into account and attempts to control its effect through a group paired by education.

On cognitive flexibility, Lueger and Gill[47] found that a group of juvenile delinquents (diagnosed with CD) had more perseverative responses on the Wisconsin Card Sorting Test (WCST), compared to a group of adolescents paired by verbal IQ and race, but that had no symptoms of CD and no criminal history. Nevertheless, this result could be influenced by the fact that the control group had a mean age 1 year older than the inmate group. Appellof[43] reported that juvenile delinquents had more perseverative responses on the WCST than a group of adolescents of the same age, race, sex, and socioeconomic status. Olvera et al.[44] compared two groups, similar to the Appellof pairing, reporting a greater quantity of perseverative responses on behalf of juvenile delinquents. Abdou et al.[65] found in a study with male and female juvenile delinquents that both groups had a greater number of perseverative responses on the WCST, compared to the control groups. Nevertheless, even though the groups were paired by age, the control group had more education years than the delinquent group. Finally, Zou et al.[50] did not find differences between the perseverative responses of the delinquent group and the control group, and the groups had a difference in education of three school years.

On the other hand, juvenile delinquents with a diagnosis of bipolar disorder or CD needed ten more movements to solve the Tower of London, a task related to planning and prevision[44], compared to a control group paired by age, sex, ethnicity, and SES. Using this same task, Appellof[43] found a lower quantity of correctly solved problems in juvenile delinquents in comparison with a control group. Zou et al.[50] reported differences between juvenile delinquents and controls in a similar task but on another index, the total number of problems solved. Cauffman et al.,[49] on the other hand, did not find differences in the quantity of solved problems in the Tower of London compared to a control group, similarly to Poon and Ho[51], both using the same index. Lueger and Gill[47] took the time to finish the trail making test as index for planning and found longer times in the delinquent group compared to adolescent students.

Since executive functions have a modulating role on the rest of neuropsychological functions, it is possible that the low-performance that juvenile delinquents show on intelligence, language, memory, and attention tasks are explained by their difficulties in executive functions. Nevertheless, the relationship between executive functions disorders and delinquent behavior is not necessarily causal[66].

Even though there is evidence that juvenile delinquents have a deficit on cognitive inhibition, cognitive flexibility, and planning, there are contradictory results, which could be due to differences in the conceptualization of executive functions, to poor selection of tasks indices to assess its components and finally, to the lack of adequate control groups[67]. A common methodological problem in these studies is the lack of control of the participant's education. This is particularly serious since juvenile delinquents have a lower education level and the great majority of neuropsychological tasks are affected by education, making it unclear if these executive functions deficits are related to the legal status of adolescents or their lower education[67]. Some authors state that the crimes of juvenile delinquents may be due to their difficulties in executive functions, which make them react inadequately to the environment[68]. Nevertheless, at least one of the reviewed studies demonstrated that juvenile delinquents have the same problems in executive functions than other adolescents of the same age and education but that had committed no crimes, thus proving that the delinquent behavior of these adolescents cannot be fully explained by their deficits on executive functions. Similarly, not all patients with disorders on executive functions have aggressive or violent behavior[67].

It is important to notice that a disorder on executive functions affects almost invariably on academic performance[68] and that low academic performance is the main reason for school dropout. Silberberg and Silberberg[69] state that low education and school dropout are the factors that most increase the risk for an adolescent to get involved in criminal activities. Nevertheless, it is evident that not all adolescents with school problems or all patients with prefrontal deficits or ADHD become juvenile delinquents, therefore making it dangerous to state a causal relationship between these factors and criminal behavior. Nevertheless, early interventions in these neuropsychological deficits can improve protective factors and deter adolescents from criminal activities.

Conclusions

The literature reviewed shows that juvenile delinquents have neuropsychological disorders on language, working memory, selective, and sustained attention, besides disorders on components of executive functions such as planning, cognitive inhibition, and flexibility. These findings support the hypothesis that juvenile delinquents have a delay in the development of the prefrontal cortex. It is important to analyze how the combination of these neuropsychological disorders and other social factors raise the risk of getting involved in criminal activities, to prevent school dropout and juvenile delinquency.

Conflicts of interest

The authors here declare that there are no conflicts of interest in this article review.

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