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The Relationship between the Diagnosis of Human Immunodeficiency Virus (HIV) and Executive Functions in School Age Children

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Abstract

The human immunodeficiency virus (HIV) affects not only adults, but also children, many of whom are infected in the perinatal period and suffer the consequences throughout their development. One of the areas of cognition frequently adversely affected by the presence of HIV is intellectual functioning. However, although conceptually akin to intelligence, executive functions encompass a wider range of abilities and skills. The purpose of this study was to determine if executive functions, as such, are impaired in children who are HIV infected. A sample of 60 children between the ages of 6 and 12 years participated in this study. The performance of 30 HIV infected children in an instrument designed for the assessment of executive functions in school age children (ENFEN) was compared with the performance of a group of 30 healthy controls, matched for age, gender, and socio-economic status. The results revealed impairments in HIV infected children across all executive functions assessed.

Keywords

Executive Functions, HIV, Human Immunodeficiency Virus, Children

1. Introduction

There can be no doubt that the human immunodeficiency virus (HIV) and the acquired immunodeficiency syndrome (AIDS) represent a major concern for health care in the 21st Century (del Palacio, Alvarez, & Muñoz Fernández, 2012). Both the diagnoses of HIV positive and AIDS are associated with cognitive impairments of

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various types in children. Among these intellectual functioning, both verbal and non-verbal, as well as attentional and fine motor processes have been specifically identified (Hoare et al., 2012). Among the deficits identified, for instance, in early adolescence in children infected in the perinatal period are impairments in executive functions. A number of functions have been implicated, including processing speed, response inhibition, working memory, cognitive flexibility, planning, and attention (Laughton et al., 2013).

The purpose of this study is to explore the relationship between the diagnosis of being infected with the human immunodeficiency virus (HIV) and the presence of impairments in executive functions in school age children. To this effect, the performance of 30 children infected with HIV was compared with the performance of 30 control, non-infected children in a comprehensive measure of executive functions, the ENFEN (Neuropsychological Evaluation of Executive Functions in Children; Portellano Perez, Martinez Arias, & Zumarraga Astorqui, 2009).

2. Literature Review

Nozyce et al. (2006) explored the cognitive profile of HIV infected children. These authors found that the mean value of the full scale, verbal, and performance IQ scores were significantly below the normative sample means. Thomaidis et al. (2010) found that HIV infected children with neuroimaging abnormalities, contrary to those that did not present these findings, had significantly lower full scale, verbal, and performance mean IQ scores.

The severity of the HIV infection has also been associated with the level of cognitive and adaptive impairment in infected children and adolescents. In this regard, Smith et al. (2012) found that the level of affectation predicted performance in overall IQ, as well as in perceptual reasoning and processing speed, although not in verbal comprehension and working memory. In a study which included various samples of HIV infected, HIV exposed, and HIV non-infected nine-year-olds, Puthanakit et al. (2013) found that the mean full scale, verbal, and performance IQ scores of all infected children, as well as the processing speed index, were significantly below those of non-infected children.

In an early review of the literature regarding the neuropsychological evaluation of HIV or AIDS infected children, Clemente-Millana and Portellano (2000) comment on the use of various batteries and strategies for the identification of cognitive impairment in these children. In their review of the pertinent literature, these authors found that the neurocognitive impairments presented by HIV or AIDS infected children went beyond those functions usually assessed by intelligence tests. In a second review of the literature, once again these authors found that children infected with HIV or AIDS had a wide range of impairments of higher cerebral functions (Millana-Cuevas, Portellano, & Martínez Arias, 2007).

According to Diamond (2013), executive functions refer to a series of “top down” processes necessary for the regulation of behavior. Behaviors associated with executive functions are resisting giving in to temptation, thinking through what to do next, and stop doing something and change the course of action adaptively, This author goes on to enumerate the three “core functions” that can be included in the concept of executive functions. These are inhibitory control, working memory, and set shifting or flexibility. These, in turn, are the basis for reasoning, problem solving, and planning.

The question, as to which extent intelligence and executive functions are the same, was addressed by García-Molina et al. (2010). These authors review an ample number of studies and concluded that, while the concepts of intelligence and executive functions share a number of components in common, executive function is a broader concept, that, indeed, includes processes not tapped by intelligence tests.

The literature reviewed initially in this article points to the presence of consistently below average scores in the various measures included in intelligence tests, such as full scale, verbal, and performance IQ scores, as well in measures of processing speed. However, the question remains if children that are HIV or AIDS infected have impairments in executive functions. That is precisely the objective of the present study, to determine the extent and nature of impairments of executive function in children who are HIV infected.

To this effect, Nagarajan et al. (2012) found significant differences between HIV infected and non-infected early adolescents in attention/processing speed as a domain, and not in the psychomotor and executive/problem solving domains, which can be considered part of executive functions. In contrast to this finding, Lowick et al. (2012) reported significantly lower scores in tasks involving performance and practical-reasoning skills in HIV infected children. These, of course, can also be conceived as part of executive functions. Given the equivocal findings of studies such as these, it became necessary to conduct a study in order to establish the nature and ex-

tent of impairment in executive functions in AIDS infected children.

Woods et al. (2009) framed the impairments in executive functions exhibited by HIV positive patients within the broader context of HIV-associated neurocognitive disorder (HAND) and described these as impairments in abstraction and novel problem solving, deficient prepotent response inhibition, as well as set shifting and cognitive and social planning. They also described impairment in semantic event sequencing as a consequence of being HIV positive, as part of impairments in executive functions.

For the purposes of the present study, executive functions are defined as follows: "the ability of human beings to formulate goals, plan objectives, and execute behaviors in an efficient manner" (Portellano Perez, Martinez Arias, & Zumarraga Astorqui, 2009: p. 19).

Once again, the aim of this study is to establish the presence of impairment of executive functions in a sample of HIV infected children between the ages of 6 and 12 years.

3. Methodology

3.1. Ethical Considerations

This study was initially approved by the Institutional Review Board of the Doctoral Program in Psychology with a Major in Applied Cognitive Neuroscience of Maimonides University, Buenos Aires, Argentina. Informed consent for participation in this study was obtained from the parents of all study participants.

3.2. Participants

The total sample of participants in this study were 60 children between the ages of 6 and 12 years from the cities of Barranquilla and Cali, in Colombia, South America. The HIV infected group included 15 girls and 15 boys. Of these, eight were recruited in the city of Barranquilla and 22 in the city of Cali. The control group was made up of 15 boys and 15 girls individually recruited in the city of Barranquilla, with no history of infection or systemic disease, who were matched in terms of age, gender, and socio-economic status with the HIV infected group.

3.3. Instruments and Procedures

All study participants were administered the ENFEN (Neuropsychological Evaluation of Executive Functions in Children; Portellano Perez, Martinez Arias, & Zumarraga Astorqui, 2009). This is an instrument designed specifically for the assessment of executive functions in school age children. This instrument includes five different sub-tests, which can be used independently or as a battery. Following is a description of the sub-tests included in the ENFEN. Verbal Fluency is made up of two different tasks, The first part, Phonological Fluency, assesses the child's ability to generate words that begin with the letter M in a 60 second interval.

The second part, Semantic Fluency, requires the child to generate as many names of animals as possible in a 60 second interval. The functions assessed by Verbal Fluency in the ENFEN are: expressive language, breath of vocabulary, verbal memory, crystallized intelligence, working memory, general knowledge, and explicit memory.

The second sub-test included in the ENFEN is Trails. The first part, Grey Trails, requires the child to unite numbers from 20 to 1 in a sheet of paper with a pencil. The second part, Color Trails, requires the child to unite numbers in order, alternating, however, between two colors, pink and yellow.

The functions assessed by Trails in the ENFEN are: programming ability, decision making, prospective memory, strategy utilization for problem solving, working memory, selective attention, sustained attention, inhibition, visual-motor coordination, spatial perception, logical reasoning, perceptual speed, procedural memory, anticipatory ability, dual programming, graphomotor integration, and mental flexibility.

The third sub-test included in the ENFEN, Rings, is a task similar to the Tower of London or the Tower of Hanoi, frequently used to assess executive functions. The abilities assessed by Rings in the ENFEN are: capacity to program behavior, plan and sequence, form abstractions, breakdown a problem into partial goals, as well as to sustain cognitive effort. In addition to these, the following functions are included in the Rings sub-test of the ENFEN: spatial orientation, spatial memory, prospective memory, working memory, mental flexibility, visual-motor coordination, and visual constructional praxis.

The fourth sub-test included in the ENFEN is called Interference. This is a Stroop type task in which the child

is asked to name the color of the ink in which words, that in turn are also names of colors, are written. The following functions are assessed by Interference sub-test of the ENFEN: selective and sustained attention, inhibition, resistance to interference, mental ability, and ability to make classifications.

The ENFEN was administered to all participants in this study in Spanish, as this was their dominant language.

3.4. Data Analysis

A comparison of the mean value of the scores obtained by the HIV infected sample and the healthy control sample in the different components of the ENFEN was conducted by means of an analysis of variance (ANOVA) statistical procedure.

4. Results

Table 1 shows the results obtained by both groups in the Phonological Fluency (Verbal Fluency) of the ENFEN. The difference between the means of the HIV infected group and the control group was highly significant, in favor of the latter. To this effect, HIV infected children showed a decreased ability to access words by phonological cues, a task considered to reflect the integrity of executive functions.

The results shown in **Table 2** reflect the performance of both groups in the Phonological Fluency (Verbal Fluency) task of the ENFEN. Once again, the values obtained by the HIV infected children were significantly below those of the healthy controls. These findings indicate that HIV infected children have a decreased ability in accessing words by their meaning, another task used to assess executive functions.

Table 3 shows the results obtained by both groups in the Grey Trails (Trails) subtest of the ENFEN. In this task, HIV infected children also performed significantly below the healthy control group. These results point to a decreased ability in visual search and visual spatial skills, also often associated with executive functions.

The results obtained by both groups of participants in this study in the Color Trails (Trails) subtest of the

Table 1. Means and standard deviations by groups for Phonological Fluency (ANOVA).

Group	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	2.33	1.39	−4.96	0
Control	30	4.6	2.08		
Total	60	3.47	2.092		

HIV+ = HIV infected.

Table 2. Means and standard deviations by groups for Semantic Fluency (ANOVA).

Group	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	3.4	1.81	−2.37	0.0213
Control	30	4.47	1.68		
Total	60	3.93	1.81		

HIV+ = HIV infected.

Table 3. Means and standard deviations by groups for Grey Trails (ANOVA).

Group	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	2.23	1.85	−7.21	0
Control	30	5.87	2.05		
Total	60	4.05	2.66		

HIV+ = HIV infected.

ENFEN are found in **Table 4**. The ability to formulate strategies, as well as cognitive flexibility, and sequencing skills often associated with executive functions were, once again, found to be significantly below the level attained by healthy controls in HIV infected children.

The problem solving and visual constructional praxis abilities of HIV infected children, as assessed by the Rings sub-test of the ENFEN were found to be significantly below those of the healthy control group. These results can be clearly seen in **Table 5**.

Table 6 shows the results obtained by both groups of participants in this study in the Interference sub-test of the ENFEN. Once again, the scores obtained by HIV infected children were significantly below those obtained by healthy controls.

5. Discussion

Executive functions are a set of skills or abilities that allow human beings to be able to formulate intentions and strategies, attain conceptual thinking, solve problems, and monitor the success of behavior. The human immunodeficiency virus has been shown to adversely affect brain functioning in various degrees. This is particularly so in regards to executive functions mediated by the frontal lobes (Delgado-Mejia & Etchepareborda, 2013).

The findings of the present study demonstrated that HIV positive school age children present significantly lower scores in a number of tasks that make up the construct of executive functions. Among these are phonological and semantic fluency, attentional processes, problem solving, ability for set shifting, ability to plan and execute efficiently, as well as the ability to inhibit a prepotent response.

Not only are adults infected with the HIV, but children are as well. Many children are infected in the perinatal period and suffer the consequences throughout their lives. This study addressed the impact of HIV infection on the cognitive functioning of school age children showing how executive functions are impaired in children infected with the human immunodeficiency virus across a wide range of abilities.

6. Conclusions and Recommendations

On the basis of the results obtained in this study, there can be no doubt that there is a significant and pervasive

Table 4. Means and standard deviations by groups for Color Trails (ANOVA).

Group	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	1.83	1.34	−5.9	0
Control	30	4.53	2.11		
Total	60	3.18	2.22		

HIV+ = HIV infected.

Table 5. Means and standard deviations by groups for Rings (ANOVA).

Goup	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	2.16	1.78	−5.9	0
Contro	30	5.3	2.26		
Total	60	3.73	2.56		

HIV+ = HIV infected.

Table 6. Means and standard deviations by groups for Interference (ANOVA).

Group	N	M	*SD*	F Ratio	*Value of p*
HIV+	30	2.06	1.08	−4.22	0.0001
Control	30	3.77	1.92		
Total	60	2.92	1.77		

HIV+ = HIV infected.

affectation of executive functions in HIV infected children. This was demonstrated across all of the sub-tests and tasks included in the ENFEN, an instrument specifically designed to assess executive functions in school age children.

Although the literature has placed a great deal of emphasis on the intelligence scores obtained by HIV infected children, as mentioned above, it should be remembered that executive functions, although perhaps conceptually related to intelligence, involve a wider range of abilities. The assessment of executive functions in HIV infected children should be included in any psychological or neuropsychological assessments conducted with them. Perhaps, by specifying the nature and extent of impairments of executive functions in HIV infected children, their educational opportunities and consequent educational outcomes can be improved.

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