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REVIEW

Etiology of pedophilia from a neurodevelopmental perspective: markers and brain alterations

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Abstract

Development: Distinct signs have been associated with a wide range of neurodevelopmental disorders and warning signs of neural developmental problems have also been observed in pedophiles. Continuing this line of research, several neuroimaging studies have found neural alterations in this disorder.

Conclusions: Pedophilia has been related to distinct indicators of neurodevelopmental alterations such as low intelligence quotient, left-handedness and smaller stature, among others. In addition, pedophiles show several neural alterations and a predominantly subcortical pattern of cerebral activation to sexual stimuli. The results of these studies suggest that the origin of pedophilia may partly lie in brain alterations due to problems during neural development, although these alterations do not absolve these persons of responsibility for their actions.

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PALABRAS CLAVE

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Neuroimagen

Etiología de la pedofilia desde el neurodesarrollo: marcadores y alteraciones cerebrales**Resumen**

Desarrollo: Diferentes señales se han asociado a una amplia serie de trastornos del neurodesarrollo, señales indicadoras de problemas en el desarrollo neural que se observan también en pedófilos. Actualmente, siguiendo esta línea de investigación, diferentes estudios de neuroimagen han hallado alteraciones neurales en este trastorno.

Conclusiones: La pedofilia se ha relacionado con diferentes indicadores de alteraciones del neurodesarrollo, como un bajo cociente intelectual, una mayor preferencia manual izquierda y menor talla física, entre otros. Además, los pedófilos muestran diferentes alteraciones neurales y presentan un patrón de activación cerebral predominantemente subcortical ante estímulos sexuales. Los resultados de estos estudios parecen mostrar que el origen de la pedofilia se puede encontrar, en parte, en alteraciones cerebrales debidas a problemas durante el neurodesarrollo, aunque estas alteraciones no libran a estas personas de ser responsables de sus actos.

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Introduction

News items concerning sexual abuse of minors are increasingly common and generate great social alarm. Pederasty (sexual abuse committed with children) and pedophilia (erotic or sexual attraction that an adult feels toward children or adolescents) are related terms. Although their meaning is different, clinically, only the term pedophilia is utilized.¹ The diagnostic criteria for pedophilia, according to the DSM-IV-TR, are shown in Table 1.

With respect to the choice of children as the object of sexual desire, the distinction has been made between pedophiles and hebephiles, depending on the age of the children. Thus, the term "pedophile" would refer to an adult who chooses as the object of his or her sexual desire children aged 12 years or under and that of "hebephile" would be utilized to designate adults who choose adolescents over the age of 12 years as their sexual object.² In relation to the array of sexual practices that these individuals can commit with the children, the activities range from exhibitionism or voyeurism to others such as caresses, rubbing their genitals against the child, masturbation in the presence of the child, oral sex and anal or vaginal penetration.³ Owing to the marked interest that this subject arouses in society, studies have been performed in an attempted approach to the condition, situation, factors, etc., that lead a person to become sexually attracted to children.

According to the results of the study of the causes of pedophilia, environmental factors can predispose individuals to convert themselves into pedophiles, since the findings often indicate that environmental stress is a factor that increases their impulses and the urge to attack children.¹ The principal etiological hypothesis, and one of the most obvious examples illustrating that environmental factors increase the risk of a person becoming a pedophile or child molester, is that the individual has been the object of sexual abuse when he or she was a child; this relationship is known as the "victim-abuser cycle" or the "molester molested phenomenon".^{4,5} The incidence of this

phenomenon varies widely depending on study selection criteria and the population studied but, according to different reports, the proportions of pedophiles who suffered abuse as children range between 28% and 93%, versus approximately 15% in control subjects, and the former show a preference for children similar in age to that of the pedophile when he or she suffered abuses.^{2,6}

The development of the central nervous system is a crucial process for the development of sexual behavior. This process is determined genetically and is modulated by neurochemical, dietary and environmental factors.⁷ A change in this process leads to the so-called neurodevelopmental disorders, which can be defined as brain damage that is expressed in the form of neuropsychiatric disorders, the origin of which would be related to the periods of intrauterine and postpartum sensory development.⁸ There are different signs or markers of anomalous development which are associated with a wide range of neurodevelopmental disorders; some of the principal ones are: a) a low intelligence quotient (IQ), since it has been observed that there is a significant intellectual deterioration in the neurological damage acquired during early childhood in individuals exposed to teratogenic substances and in genetic disorders with marked neurobiological effects (fragile X syndrome, Down's syndrome, etc.);^{9,10} b) a preference for left-handedness (or a considerable use of either hand for everyday tasks, especially writing), a feature that is significantly more common in populations with some type of neurological disorder and in individuals exposed to neurotoxins during prenatal stages or who have undergone stress during birth (extremely low birth weight, twin birth and premature birth);^{9,10} and c) height or size, which is affected by adverse conditions present during prenatal development (inadequate diet, exposure to pathogens) and postnatal development (suboptimal economic conditions),^{11,12} which lead to a decrease in the average proportional growth and an increase in the risk of several health problems during adulthood.¹³⁻¹⁸

One line of research, focusing on the comparison of the neuropsychiatric differences between pedophiles

Table 1 DSM-IV-TR criteria for the diagnosis of pedophilia

- A. Over a period of at least six months, recurrent and highly arousing sexual fantasies, sexual urges or behaviors that involve sexual activity with prepubertal children or children somewhat older (generally 13 years old or under)
- B. The fantasies, the sexual urges or the behaviors produce clinically significant unease or deterioration on the social or professional level or in other important areas of the activity of the individual
- C. The person is at least 16 years old and is at least five years older than the child or children referred to in criterion A.

Note: Individuals in the final stages of adolescence who have contact with 12 or 13-year-olds should not be included

Specify whether:

There is sexual attraction to males

There is sexual attraction to females

There is sexual attraction to both sexes

Specify whether:

The type is exclusive (attraction only to children)

The type is not exclusive

and different groups (the general population, the prison population and sex offenders of another type), points to the presence of adverse events during neurodevelopment as a possible etiological factor of pedophilia; thus, as a consequence of these neurodevelopmental changes, the abovementioned signs and different disturbances associated with this disorder can be observed. Taking into account the relevance of the subject of pedophilia and its etiology, the objective of the present report is to review: a) studies published on the aforementioned indicators of changes in neurodevelopment and pedophilia; and b) current studies on the neural, structural and functional changes found in pedophilia.

Markers of anomalous neurodevelopment in pedophilia: intelligence quotient, handedness and height

A literature search in MEDLINE with the combination of the key words "pedophilia", "IQ" and "handedness" identified 10 articles. The articles that referred to pedophilic patients were preselected for inclusion and those reports dealing with a single case, studies of normal individuals with pedophilic fantasies and those referring to neuroimaging techniques were excluded. In accordance with these criteria, five articles were selected. The combination of the key words "pedophilia" and "physical height" led to the identification of another three articles, which were included.

With respect to the IQ, Cantor et al¹⁹ encountered in one of their studies, carried out in a heterogeneous group of sex offenders, that a lower IQ is related to a larger number of child victims and more marked penile responses to sexual stimuli representing minors. Moreover, the lower the IQ, the lower the age of the child in which the pedophile is sexually interested. A later metaanalysis dealing with IQ in all types of sex offenders, with a total sample of 19 711 delinquents, 3187 of whom had committed sexual offenses against children, supported the aforementioned results.²⁰

The relationship between handedness and pedophilia has also been examined in different published studies; in the first of them, a higher proportion of left-handedness was observed in sex offenders who attacked children under 12 years of age, as compared with a control group.²¹ A more complete study to evaluate handedness in pedophilia and hebephilia shows a negative correlation of right-handedness with penile responses to stimuli in the form of prepubertal children, and a positive correlation with stimuli representing adults.²² A later work confirms these results after inclusion of covariates such as age and IQ.¹⁹ although the two reports differ in terms of the number of victims. In order to explore this difference, the later study combined the patient sample²² with that of the previous study.¹⁹ It was observed that the utilization of the left hand was twice as common in men who were sexually interested in prepubertal children than in those who exhibited a sexual preference for adult individuals.

In order to study whether the association observed among pedophilia, low IQ and handedness could be an artifact owing to the heterogeneity of the origin of the samples used, a current work forms homogeneous groups of pedophiles according to their legal status (whether they are being evaluated after having been referred by their lawyers, released on bail or paroled under surveillance). The relationships among pedophilia, a lower IQ, less education and an increase in the proportion of left-handedness in the different groups were shown to be the same as when the participants were all included in a heterogeneous group with different origins. This supports the existence of a relationship between pedophilia and genuine cognitive function and not as an artifact.²³

With respect to height, different studies have compared the statures of pedophilic and nonpedophilic men. The first studies show a lower height in pedophiles than in healthy subjects,^{24,25} although the differences are not statistically significant, possibly because of the insufficient power associated with the sample used in the two studies. The problem related to the sample size is solved by a recent study in which different groups are constituted according to the age of the victims (pedophiles, hebophiles and sexual offenders of adults), plus a control group of non-offenders. The pedophilic-hebophilic sexual offenders were found to be significantly shorter than the control subjects and the height of the sexual offenders who acted against adults ranged halfway between the preceding groups.²⁶ It can be observed that, upon increasing the sample size, the differences in stature become significant.

Aside from the signs described in previous studies, some reports find a relationship among pedophilia, lateness in the fraternal birth order^{27,28} and greater maternal age²⁹;

an increased proportion of pedophilia and lower levels of education and intelligence in individuals who have suffered injuries with loss of consciousness prior to the age of six years;³⁰ and the presence in this paraphilia of a high rate of comorbidity with impulse control disorders (for example, explosive personality disorder, kleptomania, pyromania, pathological gambling) of 30% to 55%.³¹ These data can be interpreted, along the line of previous studies, as possible indicators of neurodevelopmental changes in pedophilia,^{30,32} although they have received less empirical attention than the aforementioned indicators.

Neural alterations in pedophilia: recent findings

Previous neuropsychological studies have divided the predominant neuroanatomical theories concerning pedophilia into three large categories. On one hand, the frontal-executive dysfunction theories associate pedophilia with a dysfunction of the prefrontal cortex and with behavioral disinhibition.^{33,34} On the other, the temporolimbic theories implicate both regions in the behavioral disinhibition³⁵ and deep structures of the temporal lobe in the regulation of sexual behavior.³⁶⁻³⁸ Finally, the theories involving dual dysfunction affirm that pedophiles exhibit dysfunction in both regions, dysfunction in the temporal regions that would cause the perturbation of the sexual urges and changes in the frontal region that would cause the behavioral disinhibition.³⁹ These theories predict that, in pedophilia, the neural alterations are found in the volume of the gray matter of the different structures defended by each. But a number of reports give little support to these theories,³⁶ since the authors observe contradictory results if only the anatomy indicated by these theories is explored and other regions are not taken into account.⁴⁰⁻⁴² Moreover, other studies indicate that the evidence provided to support these theories may be the result of a methodological artifact, associated with the larger sample size (greater statistical power) of the studies that demonstrate differences versus those that do not.⁴³

In order to become familiar with the findings provided by modern neuroimaging techniques, a literature search was carried out in MEDLINE, using a combination of the key words "pedophilia" and "brain", limited to articles published within the last five years. The search identified a total of 13 articles. The author selected for inclusion those articles in which the structure and functional activity of the brain of the pedophile was studied specifically by means of magnetic resonance (MR) techniques. In accordance with these criteria, a selection was made of six articles that involved different lines in the study of the neural alterations of the pedophile that range from the study of the cerebral morphology, based both on the abovementioned neuroanatomic theories and on the study of the entire brain, to the study of neural function during emotional and sexual arousal.

The first study of pedophilia using MR employs voxel-based morphometry to study the differences in cortical gray matter in regions of interest, and tests the frontal-dysexecutive theory. The results showed that pedophiles had a lesser volume of gray matter in the frontostriatal circuits and the ventral striatum, which extended into

the nucleus accumbens and orbitofrontal cortex.³² Thus, according to these findings, pedophiles have the same difficulty in inhibiting repetitive behaviors as individuals with obsessive-compulsive disorder.³² Along this line, another study, in which similar techniques were employed, also looks for differences in specific areas. In this case, the search is carried out in portions of the limbic system, such as the amygdala, and in the gray matter of structures related to the development of sexual behavior, such as the hypothalamus. In pedophiles, there was a significant decrease in the volume of the right amygdala and a bilateral reduction of the gray matter of the hypothalamus, septal regions, substantia innominata and bed nucleus of the stria terminalis.⁴⁴ These structural deteriorations, in regions that are critical to sexual development, may be implicated in the pathogenesis of pedophilia.⁴⁴

One disadvantage to limiting the analysis to the regions predicted by the neuroanatomical theories is that possible differences in other regions would be overlooked, while the disadvantage to analyzing the whole brain is the need for a greater number of samples to compensate for the low statistical power of each comparison.⁴³ Moreover, another possible disadvantage that could influence the results is that, in the preceding studies, pedophilic offenders are compared with individuals who are not delinquents and, thus, the structural changes observed could be due to other factors, such as delinquency in general, the chronic stress of being jailed, etc., and not to the pedophilia itself.

A recent investigation that takes these problems into account studies the possible structural changes associated with pedophilia by means of the analysis of the entire brain. Moreover, it compares a group of pedophilic sex offenders with a similar group of delinquents who have no sexual offenses in their history. Negative associations were encountered between pedophilia and the volumes of bilateral white matter of the parietal and temporal lobes. The regions with the lowest volume of white matter were adjacent to two major groups of fibers: the superior fronto-occipital fasciculus and the right arcuate fasciculus. No difference was observed in the gray matter or in the volume of cerebrospinal fluid.⁴⁵ Thus, we see that, upon increasing the sample size, controlling for possible confounding factors and making comparisons with the whole brain, no differences are observed in the regions of gray matter predicted by the neuroanatomical theories; rather, these differences appear in the white matter, in fasciculi that connect cortical regions that respond to sexual signals.

As the above results lead us to wonder how these structural differences can affect brain function in the presence of sexual signals, functional neuroimaging studies are performed. Thus, neural activity was investigated, by means of functional MR, during emotional and erotic stimulation using images from the International Affective Picture System, in a group of pedophiles and a control group. It was observed that the pedophiles responded less to visual erotic stimulation in three regions: dorsolateral prefrontal cortex, hypothalamus and periaqueductal gray matter. However, in nonerotic emotional processing, they exhibited a less marked functional response in structures such as the amygdala, hippocampus and dorsomedial prefrontal cortex.⁴⁶ The reduced activation of these regions

Table 2 Neuroimaging studies of the neural alterations found in pedophiles

Authors	Year	Sample	NI	Most noteworthy findings
Schiffer, et al	2007	18 pedophiles and 24 healthy controls (homosexuals and heterosexuals)	SMR	Lesser volume of gray matter in frontostriatal circuits and ventral striatum
Schiltz, et al	2007	15 pedophiles and 15 healthy controls (homosexuals and heterosexuals)	SMR	Lesser volume of gray matter in right amygdala and bilaterally in hypothalamus, septal regions, substantia innominata and bed nucleus of the striae terminalis
Cantor, et al	2008	65 pedophilic offenders and 65 delinquents with nonsexual offenses (homosexuals and heterosexuals)	SMR	Lesser volume of bilateral white matter in parietal and temporal lobes (principally in superior fronto-occipital and right arcuate fasciculi)
Walter, et al	2007	13 pedophiles and 14 healthy controls (both groups consisting of heterosexuals)	FMR	Reduced activation of dorsolateral PFC, hypothalamus, dorsomedial periaqueductal gray matter (in the presence of erotic visual stimulation), and of amygdala, hippocampus and dorsomedial PFC (in the presence of nonerotic emotional visual stimulation)
Schiffer, et al	2008	8 pedophiles and 12 healthy controls (both groups consisting of heterosexuals)	FMR	Reduced activation of orbitofrontal cortex and dorsolateral PFC during visual sexual stimulation
Schiffer, et al	2008	11 pedophiles and 12 healthy controls (both groups consisting of homosexuals)	FMR	Increased activation of thalamus, globus pallidus and striatum

FMR: functional magnetic resonance; NI: neuroimaging technique; PFC: prefrontal cortex; SMR: structural magnetic resonance.

in pedophiles indicates an alteration that may contribute to the modification of sexual interest toward adults.

However, in order to determine whether the same structures respond in the same way in the brains of pedophiles and nonpedophiles, it would be necessary to employ designs in which each type of subject would be exposed to the stimulus that arouses him or her sexually: children and adults, respectively. Thus, two later investigations on the part of the group of Boris Schiffer, using functional MR, compare the activation patterns in heterosexual and homosexual pedophiles when presented with stimuli that are sexually interesting to them.

In the first of these works, the authors found that the cerebral response of the heterosexual pedophiles to heteropedophilic visual stimuli is comparable to the cerebral response of heterosexual men to heterosexual stimuli. This response includes the activation of different limbic structures (amygdala, cingulate gyrus and hippocampus), substantia nigra, caudate nucleus, anterior cingulate cortex, different thalamic nuclei and association cortex. However, heterosexual men of the control group exhibited a cerebral response in the orbitofrontal cortex during visual sexual stimulation; this frontal response was not observed in the pedophiles who, moreover, showed an abnormally reduced activity in the dorsolateral prefrontal cortex.⁴⁷ In the second article, the authors study the pattern of cerebral

activation in homosexual pedophiles and homosexual controls, during visual sexual stimulation, using for this purpose photographs that are sexually stimulating and emotionally neutral to the two groups. In both, the sexually arousing images activated cerebral areas involved in the visual processing of emotional stimuli (occipitotemporal and prefrontal cortexes), but during the presentation of these images, there was a significant activation of areas such as the thalamus, globus pallidus and striata only in the group of pedophiles.⁴⁸

Thus, with respect to the brain function of control subjects and pedophiles, the results of these latter studies appear to demonstrate that, in the presence of stimuli that are sexually relevant for each group, the central processing of these stimuli is comparable in the two, while the pattern of cerebral activation exhibited differs. The major findings of the preceding studies are summarized in Table 2.

Conclusions

The studies consulted show that pedophilia is related to different indicators of changes in neurodevelopment, such as a low IQ, higher prevalence of left-handedness and shorter stature. When pedophiles are compared with different groups, they systematically exhibit a lower IQ,

which is lower the younger the victim, a higher proportion of left-handedness and a shorter physical height or stature. In addition, there are other factors, described in different reports, which also appear to indicate the possible presence of neurodevelopmental changes in pedophilia.

With respect to the neural findings, the morphometric study with the greatest statistical power demonstrates in pedophiles a lesser volume of the white matter that connects cortical regions that respond to sexual signals. The presence of this type of structural change also points in the direction of problems during neural development and is the most solid proof supporting said hypothesis. The functional findings, which complement the structural changes, show that, in pedophiles, there is a central processing of visual sexual stimuli similar to that of the controls, but with a different pattern of brain activation, consisting of a greater activation of subcortical regions versus a lesser activation of prefrontal cortical regions. Neuroimaging studies show pedophilia to be a disorder characterized by a partial disconnection within a network of recognition of relevant sexual stimuli and by a dysfunctional brain activation in the presence of these stimuli.

The abovementioned indicators do not cause pedophilia, but predict a correlation between the two, since the neurodevelopmental changes predispose the individual to develop both pedophilia and the indicators (that is, low IQ, left-handedness, shorter physical size, lesser volume of white matter, etc.). We should suppose that the neurodevelopmental problems are not the only causes of pedophilia, but only can contribute to the risk of developing this disorder. Thus, it can be stated that there is no determinant explanation for the reasons that lead a person to pedophilia, but that the results of these studies suggest that the origin can be found, in part, in brain dysfunctions produced by adverse events occurring during neurodevelopment. However, these anomalies are problems that do not free these individuals from being responsible for their acts.

With respect to the different studies reviewed, some of them do not include a comparison with a control group of healthy subjects and, thus, the changes can be related to variables other than their preference for minors. It would be more advisable to include, in the different reports cited,^{19,20,22,23,45} a group of healthy subjects and consider the possibility that the alterations be related to aggressiveness or to the type of sex offense committed (rape, molestation, etc), regardless of whether it is done to minors or adults. On the other hand, the results obtained in works with greater statistical power indicate that investigations involving a larger sample size would aid in the discovery of other possible differences. According to the structural findings, future research in the neuropathology of pedophilia should focus on the study of the white matter, using more specific techniques, like diffusion tensor imaging, which has begun to be applied to the study of neuropsychiatric alterations.

In conclusion, the results of studies of this type open the door to a new perspective on pedophilia and can provide the bases for the development of more sophisticated diagnostic tools and new therapeutic approaches to the treatment of this disorder.

Conflict of interest

The author declares that he has no conflicts of interest.

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