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Magnetic Resonance Techniques in Study of Sexual Stimuli Processing in Paedophilia

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1. Introduction

The sexual aggression of children is a major public health and criminological issue and a paedophilic crime causes considerable public concern. Paraphilias are deviant sexual behaviors that have common clinical features: sexual fantasies leading to sexual urges and, ultimately, to the deviant sexual behavior. In these group of disorders is include the paedophilia (American Psychiatric Association [APA], 2000). Paedophilia is defined as a psychiatric disorder characterized by intense sexually arousing urges and behaviours focused on the sexual activity with a prepubescent child (APA, 2000; Fagan et al., 2002). The ICD-10 defines paedophilia as a sexual preference for children, boys or girls or both, usually of prepubertal or early pubertal age (World Health Organization [WHO], 2010).

The Diagnostic and Statistical Manual of Mental Disorders, define a paedophile as an individual who fantasizes about, is sexually aroused by, or experiences sexual urges toward prepubescent children (generally <13 years) for a period of at least 6 months. Paedophiles are either severely distressed by these sexual urges, experience interpersonal difficulties because of them, or act on them (diagnostic criteria, according to the DSM-IV-TR, are shown in Table 1), usually come to medical or legal attention by committing an act against a child because most do not find their sexual fantasies distressing or ego-dystonic enough to voluntarily seek treatment. The clinical diagnosis of paedophilia is based on a specific act, it usually is not solely the result of intoxication or caused by another state or condition (APA, 2000).

Paedophiles are subdivided into several classifications. One of the first classifications divided to the paedophiles in two groups, group “exclusively” attracted to children (exclusive paedophile) or attracted to adults as well as children (nonexclusive paedophile group) (APA, 2000). Other categorization of paedophiles is based in if they are attracted to only male children (homosexual paedophilia), female children (heterosexual paedophilia), or children from both sexes (bisexual paedophilia).

The course of paedophilia is usually long term and has yet no cure. The onset of paedophilia usually occurs during adolescence. Occasional paedophiles begin their activities during middle age but this late onset is uncommon. The frequency of behavior associated with paedophilia varies with psychosocial stress . As the paedophile's stress levels increase, the frequency of his or her acting out generally rises also. Various treatments are available. The medical treatments (medications anti-androgens, luteinizing hormone-releasing hormone agonists, female hormones, antidepressant) and psychological treatments (aversive

behavior therapy and cognitive-behavioral therapy) are aimed at reducing or preventing the expression of paedophilic behavior and to reducing the prevalence of child sexual abuse (Drapeau et al., 2005; Rosler & Witztum, 2000; Schober et al., 2005). The prognosis of successfully ending paedophilic habits among persons who practice paedophilia is not favorable. Paedophiles have a high rate of recidivism; that is, they tend to repeat their acts often over time. Paedophiles offer rationalizations or excuses that enable them to avoid assuming responsibility for their actions. They may blame the children for being too attractive or sexually provocative. They may also maintain that they are "teaching" the child about "the facts of life" or "love". This cognitive distortions made that paedophile behavior is maintained (Mihailides et al., 2004; Ward et al., 1997). Paedophiles may engage in a wide range of sexual acts with children. These activities range from exposing themselves to children (exhibitionism), undressing a child, looking at naked children (voyeurism), or masturbating in the presence of children to more intrusive physical contact, such as rubbing their genitalia against a child (frotteurism), fondling a child, engaging in oral sex, or penetration of the mouth, anus, and/or vagina (APA, 2000; Cohen & Galinker, 2002).

- 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.

Table 1. DSM-IV-TR criteria for the diagnosis of paedophilia.

In relation to sex preference of the victims, the ratio of girls to boys is 11:1 among (male) paedophiles in contrast to 20:1 among (male) adults committing sex crimes like rape. The homosexual attraction is greater in paedophiles than in other adults involved with sexual crimes with nearly a 2:1 difference (Freund & Watson, 1992). With respect to the choice of children as the object of sexual desire, the distinction has been made between paedophiles and hebephiles, depending on the age of the children. Individuals who engage in sexual activities with pubescent teenagers under the legal age of consent (ages 13-16 years) are known as hebephiles (attracted to females) or ephebophiles (attracted to males) (Blanchard

& Barbaree, 2005; Stone et al., 2000) The term hebophilia or hebephilia is generic term to describe sexual interest in either male or female pubescent children ((Blanchard & Barbaree, 2005; Blanchard et al., 2000; Danni & Hampe, 2000; Stone et al., 2000). The hebophiles tend to be more interested in having reciprocal sexual affairs or relationships with children, are more opportunistic when engaging in sexual acts, have better social functioning, and have a better posttreatment prognosis than paedophiles (Danni & Hampe, 2000; Stone et al., 2000). Other subclassification of paedophilia known as infantophilia, which describes individuals interested in children younger than 5 years (Greenberg et al., 1995). These distinctions are important in understanding current research about paraphilias, selection criteria for studies of sexual behavior and for future diagnosis criteria of paedophilia or pedohebephilic disorders (table 2 shown the future diagnosis criterias of this disorder, where are included criteria of paedophilia and hebephilia).

- A. Over a period of at least six months, one or both of the following, as manifested by fantasies, urges, or behaviors:
1. Recurrent and intense sexual arousal from prepubescent or pubescent children.
2. Equal or greater arousal from such children than from physically mature individuals.
- B. One or more of the following signs or symptoms:
1. The person has clinically significant distress or impairment in important areas of functioning from sexual attraction to children.
2. The person has sought sexual stimulation, on separate occasions, from either of the following:
a. Two or more different children, if both are prepubescent.
b. Three or more different children, if one or more are pubescent.
3. Repeated use of , and greater arousal from, pornography depicting prepubescent or pubescent children than from pornography depicting physically mature persons, for a period of six months or longer.
- C. The person is at least age 18 years and at least five years older than the children in Criterion A or Criterion B.
- Specify type:
Pedophilic type: sexually attracted to prepubescent children (generally younger than 11).
Hebephilic type: sexually attracted to pubescent children (generally age 11 through 14).
Pedohebephilic type: sexually attracted to both.
- Specify type:
Sexually attracted to males.
Sexually attracted to females.
Sexually attracted to both.
- Specify if:
In remission (no distress, impairment, or recurring behavior and in an uncontrolled environment): state duration of remission in months: ____.
In a controlled environment.

Table 2. Futures DSM-V criteria for the diagnosis of Pedohebephilic Disorder
(Recommendation of American Psychiatric Association for to rename Paedophilia to Pedohebephilic Disorder; APA, 2011).

In the field of personality, individuals with this disorder generally experience feelings of inferiority, isolation or loneliness, low self-esteem, internal dysphoria, and emotional immaturity. They have difficulty with mature age-appropriate interpersonal interactions, particularly because of their reduced assertiveness, elevated levels of passive-aggressivity, and increased anger or hostility (Egan et al., 2005; Huprich et al., 2004; Vandiver, 2006; Vandiver & Kercher, 2004). Finally, has been found other differences between paedophilia and control groups. This differences shown that paedophiles presented: a lower intelligence (an area of controversy), a slight increase in the prominence of left-handed individuals, impaired cognitive abilities, neuroendocrine differences, and brain abnormalities, particularly frontocortical irregularities and/or differences (Blanchard & Barbaree, 2005; Bogaert, 2001; Cantor et al., 2005; Tost et al., 2004).

1.2 Neuroanatomic theories in paedophilia: brief description

The role of neurological factors and neuropsychological functioning are being integrated in theories of sexual offending (Ward & Beech, 2006). In this disorder, from a neuropsychiatric and neuropsychological perspective, different neuroanatomic theories exist that involve to different cerebral regions in paedophilia.

- a. On one hand, the Frontal-Dysexecutive Theories associate sexual offending with dysfunction of frontal cortex and behavioural disinhibition. Proponents of this theory cite studies that show that heterogeneous groups of sexual offenders perform poorly on tests that assess executive functioning, tests as for example: Verbal Fluency, Digit Span, Tower of London, Porteus Mazes, Stroop, Trail-Making, and Wisconsin Card Sort (Dolan et al., 2002; Kelly et al., 2002; Stone & Thompson, 2001; Valliant et al., 2000).
- b. Other group is of the Temporal-Limbic Theories that implicate in the regulation of sexual behaviour to temporal lobe structures or give a role to these structures in behavioural disinhibition. The theorists of this point of view cite the associations between temporal lobe epilepsy and paraphilia and between temporal lobe lesions and the hypersexuality exhibited in Kluver-Bucy Syndrome (Hucker et al., 1986; Lilly et al., 1983; Mendez et al., 2000).
- c. These two previous approximations have joined in the Dual Dysfunction Theories, in which is defends that the paedophilic men suffer from dysfunction both in temporal regions (causing sexual urges) and in frontal regions (causing behavioural disinhibition) (Cohen et al., 2002).

1.3 Justification and objective

Human sexual arousal is a multidimensional experience comprising physiological and psychological processes. Is known that in normal sexual functioning the frontal and temporal cortices are involved in the modulation of drive, initiation, and sexual activation, subcortical structures including the hippocampus, the amygdala, the septal complex and the hypothalamus are implicated in the modulation of sexual behaviours and genital responses. Modern imaging techniques allow the in vivo observation of brain activation correlated with sensory or cognitive processing and emotional states (Krueger et al., 2005) Today the neuroimaging studies in normal sexual functioning confirmed the involvement of inferior temporal cortex, the orbitofrontal cortex, the inferior and superior parietal lobules, the cingulate cortex, the anterior cingulated cortex, the insula, and the hypothalamus in the processing of visual sexual stimuli (Arnou et al., 2002; Bocher et al., 2001; Ferrettiet al., 2005;

Hamann et al., 2004; Holstege et al., 2003; Karama et al., 2002; Mouras et al., 2003; Redoute et al., 2000). In summary, that the cortical and subcortical structures are implicated in the regulation of sexual arousal and in the processing of visual sexual stimuli.

Currently the available data concerning the links between brain anomalies and deviant sexuality, between them the paedophilia has been obtained by means of four main approaches:

1. Neuropsychiatry, the study of acquired psychiatric disorders following brain damage.
2. Structural neuroimaging.
3. Neuropsychological assessments.
4. Functional neuroimaging of sexual offenders compared with nonsexual offenders and the general population.

Of this four approaches, especially the neuroimaging studies have a great potential to identify relevant brain networks and affected structures and for to estimate the brain activation and functioning during the processing of visual information in paedophilia. Previous studies with computed tomography find that the child molesters have less dense skulls and lower cerebral blood flow values (Hendricks et al., 1988). Recent studies show that the functional response patterns of the brain to sexual stimuli contain sufficient information to predict individual sexual orientation with high accuracy, and suggest that the neuroimaging techniques could be a good methods for the diagnosis of the paraphilic disorders, for example paedophilia (Ponseti et al., 2009). Though the neuroimaging studies are very small and very recent in this disorder and the application of these technologies in paedophilia has lagged behind in comparison with others psychopathologies. For what little is known about brain function in paedophilia, the structures involved in sexual behaviour and in the sex stimuli processing in this disorder. For this reason, from a neurological perspective, the aims of this review are to summarize the findings from structural and functional magnetic resonance studies in paedophilia realized up to the date and to present a summary of how is the neurological activation during sex images processing in people with this disorder.

2. Selection methods of magnetic resonance studies

2.1 Methods of literature review

The search of works was performed in different databases. The databases used were Pubmed, PsycINFO, Scopus and Cochrane. There has been no restriction in the years to search or on the type of document sought. The terms used for search were: "pedophilia" and "paedophilia" searched in conjunction with the terms "brain" and "neuroimaging". The search terms were limited to title, abstract and keywords.

2.2 Inclusion criteria

1. Works in which they studied people with diagnosis of paedophilia, according to the diagnostic criteria of the DSM.
2. Works in which they studied the structure or function of the brain in paedophilia by neuroimaging techniques, specifically by structural and functional Magnetic Resonance Image. This criterion allowed to reject works that used other types of techniques that were not specifically neuroimaging techniques.

3. Works that were using as variable of interest the results of the structural and functional techniques to compare paedophiles with other groups (group of control or groups of other sexual aggressors and delinquents in general).
4. Works that were contributing empirical original information published in English, rejecting theoretical previous works, neuropsychological studies and studies of clinical case.

2.3 Procedure

The search was realized during September, 2010. Once recovered all the works was reviewed with the aim to analyze if they are complying with the criteria of incorporation. They were checked also by the aim to extract the pertinent information.

2.4 Codification of the results

From each of the works the following information was extracted:

1. Authors and year of publication.
2. Sample and Groups. From that was extracted the number of participants, sex and groups in which was divided the sample (in case such that division is existing).
3. Magnetic resonance technique used. It was gathered information about the technique of neuroimage used in the study.
4. Type of design used for the study. It was gathered information about the type of design used in the study, for example if they were experimental, quasi-experimental, and descriptive, among others.
5. Principal obtained findings. Were extracted the principal results contributed by the work.

3. Results

3.1 Findings of magnetic resonance studies applied to sex stimuli processing in paedophilia

The detailed procedure gave a total of only 7 documents that were complying with the criteria of incorporation. All the documents were articles published in scientific journals. All these works was gathered in two different principal subject matters:

1. Structural or functional studies.
2. Works that study regions of interest or brain in total.

The structural studies were 3 and functional studies 4. The works that study regions of interest was 6 and works that study of the brain in total was 1. Respect to the design, the total of the studies have an experimental design. The type of sample has been organized on the basis of a two category:

1. The type of groups that they include.
2. The sexual orientation of the people included in the sample.

In all the works the sex of the participants was masculine. The works that include group control (of healthy controls and not offenders) was 6 and the works that include other groups of delinquents (non sex offenders) was 1. On the other hand, the works that included homosexuals sample was 1, heterosexuals 2 and both (homosexuals and heterosexuals) was 4. The principal results obtained in every work are described of general form immediately afterwards (a brief summary of the same ones can observe in the table 3).

	Number of studies	% of the Review
Brain Study		
Total Brain	1	14.29
Region of Interest	6	85.71
Technique		
MR functional	4	57.14
MR Structural	3	42.86
Design		
Experimental	7	100
Others	0	0
Sample		
Control Group:	7	100
Healthy Control	6	85.71
Others (non sex offenders)	1	14.29

Table 3. Brief description and % of the studies included in the review.

3.2 Structural magnetic resonance studies

The results of the structural magnetic resonance studies that study regions of interest, as frontal and temporo-limbic structures, showed that paedophiles had a lesser volume of gray matter in the frontostriatal circuits and the ventral striatum, which extended into the nucleus accumbens and orbitofrontal cortex (Schiffer et al., 2007).

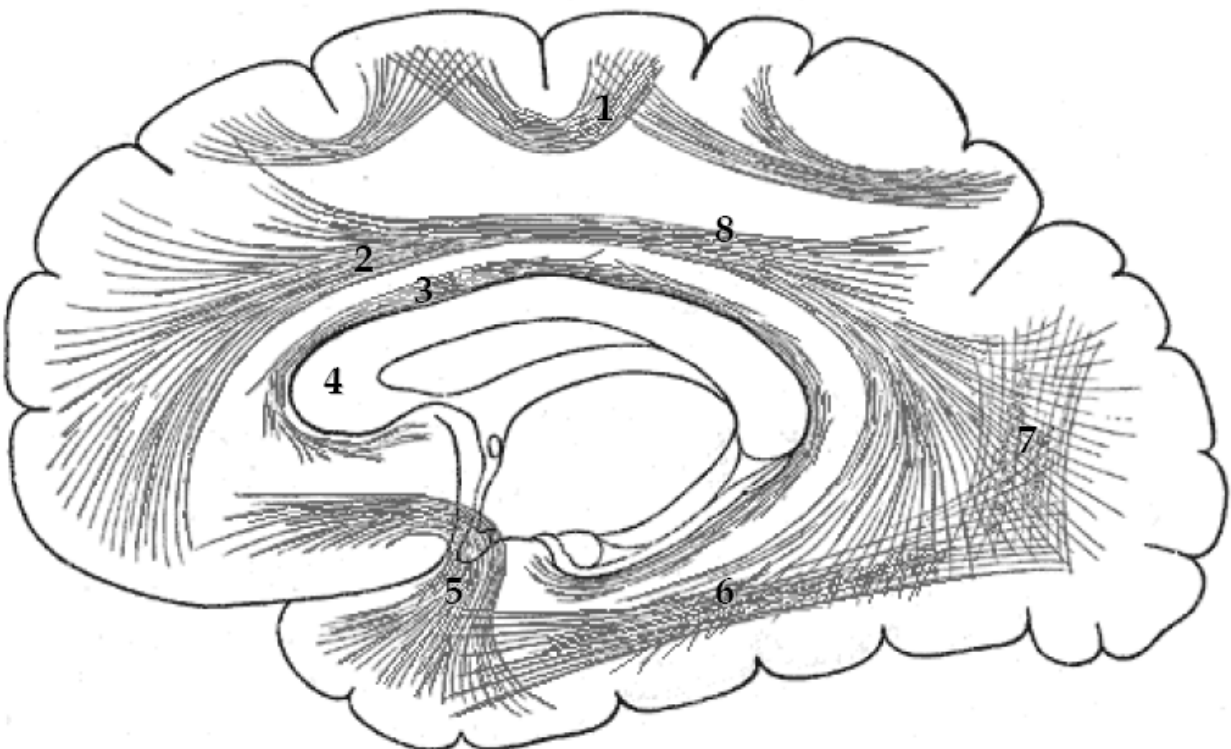
Authors-year	N Groups (n)	Sex orientation	Study	Findings in paedophiles
Schiffer <i>et al.</i> (2007)	42 P (18), HC (24)	Hetero and homosexuals	sMRI of ROI	Lesser volume of gray matter in ventral striatum, OFC and cerebellum
Schiltz <i>et al.</i> (2007)	30 P (15), HC (15)	Hetero and homosexuals	sMRI of ROI	Lesser volume of gray matter in subcortical regions (amygdala, hypothalamus and septal regions)
Cantor <i>et al.</i> (2008)	130 P(65), NO (65)	Hetero and homosexuals	sMRI of TB	Lesser volume of white matter in parietal and temporal lobes

HC = Healthy Controls Group, N = Total Sample, NO = Nonsexual Offenders Group, OFC = Orbitofrontal Cortex, P = Paedophiles Group, ROI = Regions of Interest, TB = Total Brain.

Table 4. Brief summary of the different sMRI studies in paedophilia.

Another study also looks for differences in specific areas. This investigation study portions of the limbic system, such as the amygdala, and in the gray matter of structures related to the development of sexual behaviour, such as the hypothalamus. In paedophiles, 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 (Schiltz et al., 2007) (A brief summary of this studies can be seen in table 4).

The study with more statistical power realized up to the date, and that compares the brain in your totality; find negative associations between paedophilia 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 fibres: the superior frontooccipital fasciculus and the right arcuate fasciculus. No difference was observed in the gray matter or in the volume of cerebrospinal fluid (Cantor et al., 2008) (Figure 1 shown a schema of brain white matters tracts. In this figure can observed the tracts of white matters affected in paedophilia, according to the Cantor et al., 2008).



Brain White Matter Tracts: 1) Arcuate Fasciculus (Short Fibres), 2) Superior Fronto-Occipital Fasciculus, 3) Cingulum, 4) Corpus Callosum, 5) Uncinate Fasciculus, 6) Inferior Longitudinal Fasciculus, 7) Perpendicular Fasciculus and 8) Superior Longitudinal Fasciculus. The white matter fibres affected in paedophilia are structures 1 and 2 (Cantor et al., 2008).

Fig. 1. Brain White Matter Tracts.

3.3 Functional magnetic resonance studies

On the other hand the functional neuroimaging studies during emotional and erotic stimulation find the following results. In a one of this studies is compared a group of paedophiles and a control group using emotional and erotic pictures. It was observed that the paedophiles responded less to visual erotic stimulation in three regions: dorsolateral

prefrontal cortex, hypothalamus and periaqueductal gray matter. However, in no erotic emotional processing, they exhibited a less marked functional response in structures such as the amygdala, hippocampus and dorsomedial prefrontal cortex (Walter et al., 2007). A later research studies specifically the amygdale. Since the amygdala activation is central for emotional valuation, arousal, and salience this study investigate the amygdala activation, with functional magnetic resonance, in response to pictures of adults and children in paedophiles (exclusively attracted to boys) and in a control group (heterosexual). The controls showed less amygdala activation to pictures of children compared to adults. The activation profile was reversed in subjects with paedophilia, who exhibited significantly more activation to children than adults (Sartorius et al., 2008).

Another research compare if the cerebral response of the heterosexual paedophiles to heteropaedophilic visual stimuli are comparable to the cerebral response of heterosexual men to heterosexual stimuli. This response included the activation of different limbic structures (amygdala, cingulated gyrus and hippocampus), substantia nigra, caudate nucleus, anterior cingulated 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 similar in the paedophiles that showed an abnormally reduced activity in the dorsolateral prefrontal cortex (Schiffer, Paul et al., 2008). Finally, other research studied of the pattern of cerebral activation in homosexual paedophiles and homosexual controls, during visual sexual stimulation. For this purpose was using photographs that are sexually stimulating and emotionally neutral to the two groups. In both groups finding that 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 paedophiles (Schiffer, Krueger et al., 2008).

Authors-year	N Groups (n)	Sex orientation	MRI Study	Findings in paedophiles
Walter <i>et al.</i> (2007)	27 P (13), HC (14)	Heterosexuals	fMRI of ROI	Reduced activation in hypothalamus and lateral PFC
Sartorius <i>et al.</i> (2008)	20 P (10), HC (10)	Hetero (HC) Homosexuals (P)	fMRI of ROI	Increased activation in amygdala
Schiffer, Paul <i>et al.</i> (2008)	20 P (8), HC (12)	Heterosexuals	fMRI of ROI	Reduced activation of OFC and dorsolateral PFC
Schiffer, Krueger <i>et al.</i> (2008)	23 P (11), HC (12)	Homosexuals	fMRI of ROI	Increased activation of thalamus, globus pallidus and striatum

HC = Healthy Controls Group, N = Total Sample, NO = Nonsexual Offenders Group, OFC = Orbitofrontal Cortex, P = Paedophiles Group, PFC = Prefrontal Cortex, ROI = Regions of Interest.

Table 1. Brief summary of the different fMRI studies in paedophilia.

4. Discussion

Paedophilic and non paedophilic men exhibit a frontal and subcortical activation during processing of sexually relevant stimuli. The paedophiles show more activation in subcortical regions during sex relevant images processing (in hippocampus, amygdala, thalamus, septal areas), regions that are implicated in the modulation of sexual behaviours and genital responses. The activation of these subcortical areas is more intense in paedophiles in comparison to controls that exhibit more activation of prefrontal cortex, the essential structure in the control of the information processing and to co-ordinate behaviour and inhibition of urges impulses.

The findings of the neuroimaging studies in paedophilia suggest that paedophilic and non paedophilic men may differ more fundamentally in the brain function during processing of sexually relevant stimuli. They differ in the brain areas that are activated and not in the brain areas that are implied. In paedophilia this different neural activation in comparison with healthy controls men (without paedophilia) could be owe principally to an alterations in the association fibres of brain that connect different cortical and subcortical areas that realize visual processing or to a structural alteration in neural areas that are important in the development of sexual behaviour (for example in the frontal cortex, amygdala, hypothalamus and septal regions). Too the data of the structural studies could indicate an atypical brain development in paedophiles that could lead to an atypical processing in relation to sexual stimuli and sexual behaviour. But it is necessary to be cautious in the interpretation of the results of these studies. Since some of these works, as the study of Walter et al. (2007) finds a differential activation of subcortical regions in relation to other works that find different evidence. For what it is very necessary to increase the knowledge in this field with new studies.

The results of these studies offer a new perspective on paedophilia and can provide the bases for the development of more sophisticated diagnostic tools and new therapeutic approaches to the treatment of this disorder. Although in relation with the methodology of the works realized up to the date, will be of importance that future studies include a more number of persons with diagnosis of paedophilia, for what works with greater statistical power would be desirable to observe if the findings continue being after of to increase the sample. Also future researchs with a larger sample size would aid in the discovery of other possible differences.

Regarding the groups to include in later studies, would be suitable the incorporation of different groups as sexual non-paedophile aggressors group and of other groups of offenders for if there is some type of alteration that can be due to the sexual aggression or the delinquency in general. Finally, the study of the entire brain might be a method of study more succeeded to try to discover possible differences that the studies that have centred on regions of interest could have overlooked. It is necessary to bear in mind that the area of study, for the social repercussions that carries among other things, is a difficult area for planning some type of study and especially for obtaining the necessary sample.

5. Conclusion

In conclusion and although are necessary more studies in this area; people with this disorder seem to show an atypical brain development and respect to your brain function in

comparison with control subjects, 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 groups, while the pattern of cerebral activation exhibited differs.

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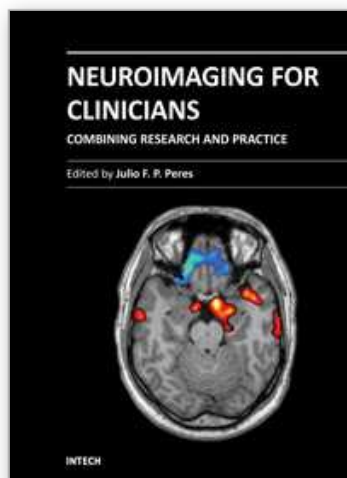
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Neuroimaging for clinicians sourced 19 chapters from some of the world's top brain-imaging researchers and clinicians to provide a timely review of the state of the art in neuroimaging, covering radiology, neurology, psychiatry, psychology, and geriatrics. Contributors from China, Brazil, France, Germany, Italy, Japan, Macedonia, Poland, Spain, South Africa, and the United States of America have collaborated enthusiastically and efficiently to create this reader-friendly but comprehensive work covering the diagnosis, pathophysiology, and effective treatment of several common health conditions, with many explanatory figures, tables and boxes to enhance legibility and make the book clinically useful. Countless hours have gone into writing these chapters, and our profound appreciation is in order for their consistent advice on the use of neuroimaging in diagnostic work-ups for conditions such as acute stroke, cell biology, ciliopathies, cognitive integration, dementia and other amnesic disorders, Post-Traumatic Stress Disorder, and many more

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