Arch Sex Behav
DOI 10.1007/s10508-013-0198-6

LETTER TO THE EDITOR

Functional Neuroimaging of Sexual Arousal: A Preliminary Meta-Analysis Comparing Pedophilic to Non-Pedophilic Men

Ariane Polisois-Keating · Christian C. Joyal

Introduction

Because men with pedophilia present, on average, lower IQ and neuropsychological performance than non-pedophilic men (Cantor, Blanchard, Robichaud, & Christensen, 2005; Joyal, Black, & Dassylva, 2007) as well as structural anomalies of cerebral grey matter regions (Schiffer et al., 2007; Schiltz et al., 2007) or white matter tracts (Cantor et al., 2008; Cantor & Blanchard, 2012), a growing number of functional brain imaging studies have attempted to identify distinct patterns of brain activation associated with sexual arousal in pedophiles (e.g., Poeppl et al., 2011; Ponseti et al., 2012).

However, an important distinction should be made between neurological substrates of sexual deviance and neurological substrates of sexual arousal. It remains possible that patterns of brain activation associated with sexual arousal would be similar in pedophiles and non-pedophiles when each group is presented with their corresponding stimuli. Functional brain imaging studies comparing pedophilic and non-pedophilic men often report contrasts based on non-pedophilic stimuli (e.g., Ponseti et al., 2012; Walter et al., 2007). Although that approach is invaluable to confirm a diagnosis of pedophilia, it is well known that patterns of brain activity can serve to identify sexual preference (Costell, Lunde, Kopell, & Wittner, 1972), but this says little concerning the pattern of brain activation associated with sexual arousal in pedophiles. As noted by Seto (2008), "There is an intriguing possibility that the same areas of the brain are involved in processing of sexual stimuli by pedophiles and nonpedophiles" (p. 39). In order to test that possibility, brain activation in pedophiles and non-pedophiles should be compared during presentation of their preferential sexual stimuli. This was the main goal of the present meta-analysis.

A. Polisois-Keating · C. C. Joyal (✉)
Département de Psychologie, Université du Québec à Trois-Rivières, 3351, boul. des Forges, C.P. 500, Trois-Rivières, QC G9A 5H7, Canada
e-mail: christian.joyal@uqtr.ca

C. C. Joyal
Philippe-Pinel Institute of Montréal, Montreal, QC, Canada

Method

A literature review (search engines: Web of Science, Google Scholar, Medline, and Dissertations and Theses) identified seven ($k = 7$) studies published in English until the year 2012 on functional brain imaging (PET and fMRI) comparing sexual arousal in pedophilic and non-pedophilic men (Cohen et al., 2002; Poeppl et al., 2011; Ponseti et al., 2012; Sartorius et al., 2008; Schiffer et al., 2008a, 2008b; Walter et al., 2007).

This meta-analysis was based on Activation Likelihood Estimation and conducted with GingerAle 2.3 (http://brainmap.org/ale/). First, three-dimensional stereotaxic coordinates of regional brain activation during the corresponding sexual arousal condition (exposure to child stimuli for pedophiles and adult stimuli for non-pedophiles) and the neutral condition were extracted from each study. When that information was not provided in the article, authors were contacted via email.

Neuroimaging data from 58 pedophiles and 65 non-pedophiles were entered in the meta-analysis. Significant differences in brain activation between the sexual arousal condition and the neutral condition were calculated for each group based on their preferences. Because no findings of deactivation were reported, only foci of activation were analyzed. The coordinates of foci referring to Talairach space were then converted to coordinates in the MNI space using the program included in GingerALE 2.3. The false discovery rate method was employed to correct for multiple comparisons at a significance threshold of $p < .05$, and the cluster threshold was set at 200 voxels (mm). Finally, both

Published online: 02 October 2013

Table 1 Significant clusters of brain activation related with sexual arousal (sexual > non-sexual conditions)

Cluster (volume)	Region	BA	Side	Coordinates of maxima (MNI x, y, z)		
Non-pedophiles (adult stimuli)						
1 (1,056 mm^3)	Fusiform gyrus	19	L	−44	−78	12
	Middle occipital gyrus	18	L			
	Cerebellum	NA	L			
2 (1,016 mm^3)	Middle occipital gyrus	19	R	36	−76	28
	Superior occipital gyrus	19	R			
3 (784 mm^3)	Fusiform gyrus	19	R	44	−76	−12
	Cerebellum	NA	R			
4 (696 mm^3)	Anterior cingulate	24	L	−4	6	40
5 (384 mm^3)	Fusiform gyrus	37	L	−30	−46	−16
6 (336 mm^3)	Amygdala	NA	L	−26	−2	−26
7 (328 mm^3)	Substantia nigra	NA	R	18	−24	−6
Pedophiles (child stimuli)						
1 (1,368 mm^3)	Middle occipital gyrus	18	R	38	−86	2
	Inferior occipital gyrus	19	R			
2 (1,040 mm^3)	Middle frontal gyrus	9	R	50	12	34
3 (888 mm^3)	Inferior occipital gyrus	19	L	−44	−84	4
	Middle occipital gyrus	19	L			
4 (632 mm^3)	Anterior cingulate	25	R	2	14	−6
	Caudate head	NA	R			
	Caudate head	NA	L			
5 (424 mm^3)	Superior parietal lobule	R	32	−56	60	
6 (376 mm^3)	Fusiform gyrus	37	L	−52	−58	−12
7 (360 mm^3)	Hippocampus	NA	L		−26	−36
8 (264 mm^3)	Substantia nigra	NA	L	−10	−20	−10
9 (224 mm^3)	Cerebellum	NA	L	−34	−84	−12
10 (200 mm^3)	Insula	13	R	34	18	10

BA Brodmann areas, *NA* not applicable, *MNI* Montreal Neurological Institute

data sets (significant activations in pedophiles and non-pedophiles) were contrasted (between-group comparisons) in both directions (pedophiles > non-pedophiles and non-pedophiles > pedophiles).

Results

In non-pedophilic controls, the sexual (adult) > non-sexual contrast revealed significant activations in: the fusiform gyrus, the occipital cortex, the cerebellum, the anterior cingulate cortex, the amygdala, and the substantia nigra (in decreasing order of magnitude; *n* of foci = 81; *n* of significant clusters = 7; see Table 1). In the pedophilic group, the corresponding contrast (sexual children > non sexual stimuli) revealed significant clusters of activation in: the occipital cortex, the anterior cingulate cortex, the fusiform gyrus, the cerebellum, and the substantia nigra (in decreasing order of magnitude). Thus, these clusters were significantly activated in both groups. In the pedophilic group, the *n* of foci (102) and the *n* of significant clusters (10) were slightly higher, and the middle frontal gyrus, the superior parietal lobule, the hippocampus, and the insula were also significantly activated during the sexual condition (Table 1). However, between-group comparisons failed to reveal any significant difference in either direction (pedophiles > non-pedophiles or non-pedophiles > pedophiles).

Discussion

The goal of this preliminary study was to explore whether the nature and magnitude of regional brain activation associated with sexual arousal differed between pedophilic and non-pedophilic men when each group was exposed to their preferential sexual stimuli. Although based on only 123 participants, the pattern of activation did not seem to differ significantly between the groups. All activated brain regions associated with sexual arousal in the non-pedophilic group were also found in the pedophilic group and no significant differences emerged between the groups; however, the number of significant foci was higher in the pedophilic group.

This result might either reflect anomalies of the brain in response to sexual arousal (undetected here because of a lack of power) or a stronger response to sexual stimuli. Although further imaging studies are warranted, there are some reasons

to lean toward the second possibility. First, it is well known from theoretical accounts (e.g., Kafka, 2003), clinical observations (e.g., Seto, 2008), and neuroimaging investigations (e.g., Ponseti et al., 2011; Sartorius et al., 2008; Schiffer et al., 2008a, 2008b) that pedophiles typically show higher levels of sexual interest for a larger array of stimuli then men from the general population. Thus, higher magnitude and foci of brain activation might simply reflect higher brain activation (or the other way around). Second, additional clusters of brain activation found in the present study among the pedophilic group represented regions related to sexual arousal in the general population (the middle frontal gyrus, the superior parietal lobule, the hippocampus, and the insula) (Stoléru, Fonteille, Cornelis, Joyal, & Moulier, 2012). On the contrary, most of the brain regions related to the cognitive/perceptual component of the sexual arousal model (Stoleru et al., 2012) were not found to be more or less activated in pedophiles (i.e., cortical areas associated with appraisal and categorization of stimuli as sexual incentive: the orbitofrontal, the inferotemporal, the inferior parietal, and the pre/supplementary motor frontal cortices). Thus, the hypothesis that pedophiles present neural anomalies of brain regions associated with cognitive or perceptual categorization of sexual stimuli was not supported by the present results.

Still, no decisive conclusions can be drawn from this preliminary study as it was based on only 58 pedophiles and six heterogeneous studies based on different types of participants (i.e., heterosexual and homosexual pedophiles, exclusives and non-exclusives), different stimuli (i.e., child pornography vs. child nudity vs. non-nude children) and different contrasts (i.e., with and without comparisons with child stimuli). Only future meta-analyses involving similar studies with more participants will generate solid conclusions about the neurological networks associated with sexual arousal in pedophilia.

References

Cantor, J. M., & Blanchard, R. (2012). White matter in pedophiles, hebephiles, and teleiophiles [Letter to the Editor]. *Archives of Sexual Behavior, 41*, 749–752.

Cantor, J. M., Blanchard, R., Robichaud, L. K., & Christensen, B. K. (2005). Quantitative reanalysis of aggregate data on IQ in sexual offenders. *Psychological Bulletin, 131*, 555–568.

Cantor, J. M., Kabani, N., Christensen, B. K., Zipursky, R. B., Barbaree, H. E., Dickey, R., et al. (2008). Cerebral white matter deficiencies in pedophilic men. *Journal of Psychiatric Research, 42*, 167–183.

Cohen, L. J., Nikiforov, K., Gans, S., Poznansky, O., McGeoch, P., Weaver, C., et al. (2002). Heterosexual male perpetrators of childhood sexual abuse: A preliminary neuropsychiatric model. *Psychiatric Quarterly, 73*, 313–336.

Costell, R. M., Lunde, D. T., Kopell, B. S., & Wittner, W. K. (1972). Contingent negative variation as an indicator of sexual preference. *Science, 172*, 718–720.

Joyal, C. C., Black, D. N., & Dassylva, B. (2007). The neuropsychology and neurology of sexual deviance: A review and pilot study. *Sexual Abuse: A Journal of Research and Treatment, 19*, 155–173.

Kafka, M. P. (2003). Sex offending and sexual appetite: The clinical and theoretical relevance of hypersexual desire. *International Journal of Offender Therapy and Comparative Criminology, 47*, 439–451.

Poeppl, T. B., Nitschke, J., Dombert, B., Santtila, P., Greenlee, M. W., Osterheider, M., & Mokros, A. (2011). Functional cortical and subcortical abnormalities in pedophilia: A combined study using a choice reaction time task and fMRI. *Journal of Sexual Medicine, 8*, 1660–1674.

Ponseti, J., Granert, O., Jansen, O., Wolff, S., Beier, K., Neutze, J., et al. (2012). Assessment of pedophilia using hemodynamic brain response to sexual stimuli. *Archives of General Psychiatry, 69*, 187–194.

Sartorius, A., Ruf, M., Kief, C., Demirakca, T., Bailer, J., Ende, G., et al. (2008). Abnormal amygdala activation profile in pedophilia. *European Archives of Psychiatry and Clinical Neurosciences, 258*, 271–277.

Schiffer, B., Kruger, T. H. C., Paul, T., de Greiff, A., Forsting, M., Leygraf, N., et al. (2008a). Brain response to visual sexual stimuli in homosexual pedophiles. *Journal of Psychiatry and Neuroscience, 33*, 23–33.

Schiffer, B., Paul, T., Gizewski, E., Forsting, M., Leygraf, N., Schedlowski, M., et al. (2008b). Functional brain correlates of heterosexual paedophilia. *NeuroImage, 41*, 80–91.

Schiffer, B., Peschel, T., Paul, T., Gizewski, E., Forsting, M., Leygraf, N., et al. (2007). Structural brain abnormalities in the frontostriatal system and cerebellum in pedophilia. *Journal of Psychiatric Research, 41*, 753–762.

Schiltz, K., Witzel, J., Northoff, G., Zierhut, K., Gubka, U., Fellmann, H., et al. (2007). Brain pathology in pedophilic offenders: Evidence of volume reduction in the right amygdala and related diencephalic structures. *Archives of General Psychiatry, 64*, 737–746.

Seto, M. C. (2008). *Pedophilia and sexual offending against children: Theory, assessment, and intervention*. Washington, DC: American Psychological Association.

Stoléru, S., Fonteille, V., Cornélis, C., Joyal, C., & Moulier, V. (2012). Functional neuroimaging studies of sexual arousal and orgasm in healthy men and women: A review and meta-analysis. *Neuroscience and Biobehavioral Reviews, 36*, 1481–1509.

Walter, M., Witzel, J., Wiebking, C., Gubka, U., Rotte, M., Schiltz, K., et al. (2007). Pedophilia is linked to reduced activation in hypothalamus and lateral prefrontal cortex during visual erotic stimulation. *Biological Psychiatry, 62*, 698–701.