



Neurocognitive Insights into Child Sexual Abuse Perpetrators: Understanding Cognitive and Emotional Profiles: A Case-Control Study

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What's Known

- Child molestation is a crime closely related to pedophilia as a paraphilic disorder. Usually, these criminals perform weaker in cognitive functions than other people.
- The average occurrence of this crime is 11.8% worldwide, which has been reported up to 32.5% in Iran.

What's New

- This is probably the first time in Iran that a neuropsychological approach has been used to assess the perpetrators of sexual abuse of children, and until now very limited information about the cognitive and emotional profile of these criminals has been reported in Iran.
- In this study, we found that the criminals had a poorer neurocognitive function than the control group. Most of the perpetrators of child sexual abuse had a desire for homosexuality. Moreover, the results showed that the simultaneous use of half-naked images of children and teenagers and the polygraph device can be an acceptable way to distinguish between two groups.

Abstract

Background: Child sexual abuse (CSA) is one of the most sensitive crimes in the world. Some perpetrators of CSA suffer from paraphilic disorders, including pedophilia (PE). This research is designed and implemented with the aim of neurocognitive evaluation of CSA perpetrators.

Methods: A case-control study was conducted over a period of 6 months from October 2022 to the end of March 2023 in Shiraz, Iran on the Experimental group (EG) (CSA perpetrators) (n=12) and the Control group (CG) (n=13). During these evaluations, information was obtained about sexual orientation, history of sexual activity, cognitive distortions, and cognitive performance of both groups. Physiological arousal factors were also measured using a polygraph device while participants viewed half-naked digital paintings of immature and adult individuals. Additionally, the study utilized functional near-infrared spectroscopy to measure hemodynamic changes in the left frontal pole (Fp1) and the right frontal pole (Fp2) while participants performed the Stroop task (ST).

Results: Compared to CG, EG showed a greater tendency towards homosexuality in the past (P=0.017), present (P=0.019), and ideal (P=0.022). Using the mini-mental state examination, cognitive distortion was shown more common in the EG group (P=0.001). Additionally, there was a significant relationship between sexual abuse between the ages of 12 and 16 and committing a crime (P=0.041). Cognitive performance during ST was poorer in EG than CG. Moreover, in the statistical comparison between groups, the amount of oxyhemoglobin (HbO) and deoxyhemoglobin (HbR) was significantly different in areas Fp1 (HbO: P=0.006 and HbR: P=0.014) and Fp2 (HbO: P=0.008 and HbR: P=0.005). Based on polygraph data, EG exhibited less emotional control than CG when viewing half-nude images of children (skin conductance: P<0.001 and heart rate: P=0.004).

Conclusion: Based on the results of this study, the CSA perpetrators seem to have a poorer neurocognitive function than the control group.

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Introduction

Abuse and neglect of children of all types are becoming a big problem on a global scale, involving both individual and social

costs. Research has revealed a clear connection between child sexual abuse (CSA) and persistent physical, psychological, and social issues, making it a crucial issue for both human rights and public health.¹ CSA is described by the World Health Organization (WHO) as any sexual activity involving a child that the child does not fully understand, cannot provide informed consent for, or is not developmentally prepared for, and which may violate societal laws or taboos.² Globally, it has been reported that 7.6% of boys and 18% of girls experience CSA.³ Additionally, 8-31% of girls and 3-17% of boys worldwide report having been sexually abused as children.⁴ Although accurate information on the prevalence of CSA in Iran is not available, according to some articles, its prevalence is between 1.5 and 32.5%.⁵

Those who have committed crimes against minors by touching or without physical contact are considered abusive pedophiles. The disorder of pedophilia (PE) is a major risk factor for CSA.⁶

The prevalence of CSA is being increasingly recognized in research, practice, and legislation. According to research looking at parents' knowledge, attitudes, and behaviors in Iran, one-third of parents had little understanding of CSA, but the majority of them had a favorable attitude toward educating their children on how to prevent it.⁷

The effects of child abuse (CA) last throughout their personal life. Abused children are far more prone to abuse their intimate partners as adults, both as abusers and as victims.⁸ According to the 2012 Canadian Community Health Survey, CA was linked to several physical health problems in adulthood, such as arthritis, cancer, high blood pressure, stroke, back problems, bowel disease, migraine headaches, and chronic fatigue syndrome.⁹ Beyond negative effects on physical health, some research suggests that neglect and abuse throughout childhood can result in lifetime psychological health issues such as post-traumatic stress disorder, depression, anxiety, suicidal ideation, suicide attempts, and poor self-esteem.¹⁰

When individuals are sexually aroused by illegal, harmful, or highly unusual stimuli, they are considered to have deviant sexual arousal. Not all sexual offenders have deviant sexual interests or arousal patterns. It is important to note that sexual offenses themselves may be considered deviant behaviors.¹¹

Recent years have seen a rise in the acceptance of the theory that pedophilic desire is caused by a brain abnormality preventing the development of more conventional intellectual and sexual traits.¹² Other findings include higher

rates of non-right-handedness, shorter height, more childhood head injuries, lower intelligence quotients (IQ), and more minor physical abnormalities among forensic/clinical samples of men with pedohebephilic.^{13, 14}

Teleiophilic males conduct at least 50% of sexual offenses against minors,¹⁵ but many pedophilic men never show such behaviors. Using data from the German research on Neural Mechanisms Underlying Pedophilia (NeMUP) and CSA, Gerwin, and others concluded that numerous PE-related traits could also be associated with committing child sex crimes and vice versa.¹⁶

Different methods have been employed to identify sexual interest, including examining criminal histories,¹⁷ self-report questionnaires,¹⁸ plethysmography, and visual reaction times.¹⁹ The literature has mainly concentrated on evaluating deviant sexual arousal as it can be easily measured through physiological (e.g., heart rate) or self-report techniques.²⁰

According to research, penile plethysmography, often known as phallometry, offers considerable sensitivity and high specificity for detecting pedophiles but has faced criticisms for its lack of standards while being widely used.²¹ Moreover, the polygraph is a device commonly called a lie detector. It operates on the assumption that lying triggers a "stress response" in the automatic nervous system. This stress response can be observed in various physiological processes, such as changes in cardiovascular activity, breathing, and sweating, due to an individual's emotional orientation towards an issue of importance. This instrument purported to offer a more comprehensive and precise understanding of an offender's past, deviant interests, and criminal actions.²²

Recording the blood-oxygen-level-dependent (BOLD) signal in functional magnetic resonance imaging (fMRI) when subjects are exposed to sexual stimuli is a less invasive method to determine sexual preferences. Early fMRI research showed that pedophilic sex offenders had higher amygdala responses to pictures of children due to elevated blood oxygen levels than controls.²³ In addition, pedophiles have less activity in the hypothalamus and lateral prefrontal cortex in response to adult sexual cues than controls.²⁴ A prior fMRI research used the BOLD signal in reaction to sexual stimuli, including naked people, genitalia to distinguish pedophilic from non-pedophilic participants with a high degree of accuracy.²⁵

On the other hand, functional near-infrared spectroscopy (fNIRS) is becoming a popular

alternative to fMRI because it is portable and can tolerate motion, opening up new possibilities for brain function investigations in previously inaccessible populations and contexts. Research using fNIRS is expanding rapidly, with studies being conducted on infant neurodevelopment and cognitive functions, such as language and other cognitive and functional fields.²⁶

Indirect tests to assess deviant sexual interests include modified Stroop task (ST), visual reaction time, attentional eye blink, and implicit association tests.²⁰ The ST is a test where participants are asked to identify the color of printed words while ignoring their meaning. If someone takes longer to respond, it suggests that they are more distracted by the word's meaning. Price and Hanson expanded upon previous studies and found that child molesters and rapists were significantly slower to color-name sexual words than a community sample.²⁷ The visual reaction time measurement is a well-known example of indirect testing in PE research, where participants are asked to assess the sexual attractiveness of visual stimuli. This approach is based on the idea that presenting sexual stimuli can cause a delay in information processing, resulting in longer response times, which indicate sexual interest. According to a recent meta-analysis, viewing time enables separation between child sex offenders and nonoffenders, as well as between child sex offenders and other categories of (sexual) offenders. Penile plethysmography and self-report measures had some convergent validity for viewing times, indicating that longer viewing durations for images of children compared to those of adults indicate pedophilic inclinations.²⁸

Another type of indirect test uses unconscious attentional changes toward things with a sexual allure. This sort of test, which employs sexual cues as distractions to ascertain sexual preference, is known as the choice reaction time task. The task makes use of the finding that sexually appealing imagery causes a delay in future cognitive processes connected to sexual content.²⁹

Neuropsychological and neuroimaging studies have sought to uncover personality, cognitive, and neuroanatomical aspects contributing to the development of PE in addition to employing test techniques to identify pedophilic interests. This is the first study in Iran dealing with the subjective and objective evaluation of the perpetrators of sexual abuse of children and assessing their brain function using fNIRS and the cognitive profile of these individuals.

Materials and Methods

Participants

This study was designed with the case-control method and for a period of 6 months. According to the design of this study, the members of the experimental group (EG) were perpetrators of sexual abuse of children who either were serving a prison term or their charges were investigated in the criminal courts of Fars province (Iran), and their crimes were proven during these 6 months (October 2022 to March 2023). During this period, 12 men were referred for the crime of sexual assault on children. An examination of the judicial files of the individuals showed that they were attracted to boys, except for one case, who had a history of raping a girl. All criminals were between the ages of 17 and 35 years old and had no history of committing any other crime except child rape. These participants were referred in cooperation with the child and adolescent counseling unit of the criminal court of Fars province, and the evaluations were conducted at the neuroscience laboratory of Shiraz University of Medical Sciences. The control group members (n=13) were selected during a public call through social networks (Telegram and Instagram). The people in the control group should be between the ages of 18 and 40 years old and also have no criminal history or special neurological or psychiatric diseases.

The exclusion criteria were as follows: I. Schizophrenia II. Bipolar disorder III. Patients with Alzheimer's disease, Parkinson's disease, brain tumors, uncontrolled epilepsy, severe head trauma, and other acute neurological disorders, IV. People with a history of stroke and transient acute ischemia, and V. People with a history of drug and alcohol abuse. Moreover, people should not have engaged in sexual activity and masturbated for at least 24 hours before attending the evaluations, and they should not have smoked or used caffeinated substances for an hour before the evaluations.

Scales

After obtaining written informed consent from the participants, the researcher documented their sexual activities by conducting an interview and using the sexual and physical abuse questionnaire (SPAQ). The SPAQ was translated into Farsi and back-translated into English by two certified external translators. The concordance between the original and back-translated versions was 95%, ensuring high fidelity in translation. The original English version of the SPAQ has been validated with

a Cronbach's alpha coefficient of 0.92.³⁰ Moreover, all participants completed The Klein Sexual Orientation Grid (KSOG) with aim of determining sexual orientation. In this evaluation system, participants are asked to rate their level of homosexuality or heterosexuality on a scale of one to seven for seven statements at three different stages of their life: past (from early adolescence to the previous year), present (within the last 12 months), and ideal (what would be chosen if it were voluntary). The KSOG was translated into Farsi and back-translated into English by two certified external translators. The concordance between the original and back-translated versions was 97%. The original English version of the KSOG has demonstrated strong reliability and validity with a Cronbach's alpha coefficient of 0.88.³¹ Additionally, experimental and control groups were provided with the Bumby molest scale (BMS), a test of child molestation-related cognitive distortions, which is sensitive to cognitive distortions in child sexual criminals. Bumby created the Bumby Cognition Scale II to evaluate the cognitive distortions of males who had sexually molested children. In this scale, 38 items on the scale were rated on a four-point Likert scale, from strongly agree to strongly disagree, which show the most extreme response. Higher ratings indicate potential defenses, mitigations, explanations, or excuses for engaging in sex with children. According to Bumby's estimation, higher scores are associated with more victims and longer periods of time spent on child molestation, respectively. It has been discovered that the scale is vulnerable to cognitive distortions in sexually abusing children. The BMS was translated into Farsi and back-translated into English by two certified external translators, achieving a concordance of 96%. The original English version of the BMS has been validated with a Cronbach's alpha coefficient of 0.867.³² The Persian version of all of them (SPAQ & KSOG & BMS) was administered through interviews conducted by the same investigator to minimize inter-rater variability.

After going through these steps, the participants entered the second phase of the research, where they were asked to sit in front of a 22-inch monitor (Asus A6420) and perform the ST, using the fNIRS device (Made in the Faculty of Electrical and Computer Engineering, University of Tehran, Iran). For this purpose, a valid online test was used at <https://esanj.ir/semantic-stroop-test>, asking participants to choose only the color of the words and touch one of the two options, green or red, located in the lower part of the monitor screen after seeing

the words that were written in red or green and had an emotional or neutral meaning. In this test, in addition to the correct answer when choosing the color of the words, the speed of the participant's reaction time was also important. After performing the ST and recording the hemodynamic response from the Fp1 and Fp2, the same test was repeated in the next stage, 15 min from the previous one, with the difference that digital paintings were shown with 50% resolution in the background of the monitor at the same time as the ST.

The content of each block design included four semi-nude digital paintings (genital organs were covered in the images) of the males or females, which were either stage one or three on the Tanner scale (four block designs in total). The duration of the display and the interval between each image and the next one equaled 3 seconds. Additionally, the interval between each block design and the next one was 20 seconds, and the timing of showing the images matched the timing of the ST. In the end, the results of the ST in both stages were statistically compared in terms of the number of correct and incorrect responses, no answers, and the reaction speed of participants.

In the next phase, the participants under evaluation were asked to stand at a distance of 40 cm from the monitor to measure their excitement level with skin conductance (SC), respiratory rate (RR), and heart rate (HR) while viewing digital paintings of both males and females using the wireless physiological data acquisition system (NeXus-4 - Netherlands). For this purpose, 42-second video packages (block design) were presented, the contents of which (block design) consisted of six half-naked digital paintings (genital organs were covered) of people of a certain gender, one located in stages 1, 3, or 5. The time interval of playing images in each package was 500 milliseconds, and the time interval between each package was set at one min.

At the end of the evaluation process, the researcher took the Mini-Mental State Examination (MMSE) from the subjects. The duration of this test is about 10 min, and part of the cognitive performance of the participants is measured. In this test, 30 is the highest score that a person can get, representing the best cognitive performance in this test.

Statistical Analysis

Qualitative variables were described by frequency (percentage), and quantitative variables by mean and standard deviation. *t* test and Analysis of covariance (ANCOVA) were

used to compare the index between the two groups by establishing the assumptions of the parametric test, while the Fisher's Exact Test was utilized to analyze the data without normal distribution. Moreover, a P value of <0.05 was considered statistically significant. The collected data were analyzed using the SPSS Statistical package (v 22.0.0, IBM-USA).

Ethical Approval

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation [institutional and national] and with the Helsinki Declaration of 1975, as revised in 2000. Written informed consent was obtained from all patients for being included in the study. The ethics committee of Shiraz University of Medical Sciences approved the study under the code IR.SUMS.REC.1401.013.

Results

Subjective Evaluations

Demographic data obtained from the participants showed no significant difference regarding their age (P=0.607) and level of education (P=0.079). Moreover, based on the KSOG questionnaire and the comparison between the sexual orientation of the EG but not in the CG, there were significant changes in the past (P=0.017), present (P=0.019), and ideal (P=0.022). On the other hand, in the intra-group comparison, the rate of changes in the sexual orientation of participants was significant in the EG (P=0.028) but not in the CG (P=0.095).

In the assessment of the BMS, there was a significant difference between the EG and CG (P=0.001). Furthermore, the scores obtained in the MMSE cognitive evaluation test revealed a significant difference between the two groups (P=0.001) (table 1).

The SPAQ results showed that 31% of the CG (n=4) were involved in the first unwanted sexual experiences in childhood and adolescence. On the other hand, 83% of the EG (n=10) were victims of the first unwanted sexual experiences from others. Furthermore, using Fisher's exact test, a significant relationship was found between sexual abuse at the ages of 12 to 16 years old and committing a crime, while this relationship is not significant in any of the age ranges below 6 years, between 6 and 12 years, and above 16 (table 2).

Objective Evaluations

Five components, including "the number of correct answers", "the number of wrong answers", "no answers", "reaction time", and "overall test time", were measured in the statistical comparison of the results of the ST of CG and EG in both stages with and without playing pictures, which revealed no significant differences between the two groups. The results obtained from the stage without playing the images highlighted a significant difference between the EG and CG in the two components of reaction time and the number of unanswered questions. The ANCOVA statistical test was applied in the following to perform statistical comparisons of the data obtained from the two groups at the stage of performing the ST, along with playing the images.

Table 1: Comparison of demographic data, the Klein Sexual Orientation Grid, and the Bumby molest scale between control and experimental groups

Variables	Experimental group (Mean±SD)	Control group (Mean±SD)	P value*	
Age (year)	24.58±3.98	25.38±3.68	0.607	
Education	12.25±2.83	14.61±3.52	0.079	
Bumby molest scale	84.92±5.07	63.06±4.68	0.001*	
MMSE score	26.75±0.76	28.94±0.29	0.001*	
The Klein Sexual Orientation grid	Past	20.25±3.98	13.18±3.97	0.017*
	Present	17.08±3.55	12.18±3.50	0.019*
	Ideal	15.33±3.02	11.81±3.35	0.022*

Years of schooling are used to measure education. *Using independent t test at significance level P<0.05.

Table 2: Comparison of the Sexual and Physical Abuse Questionnaire (SPAQ) between control and experimental groups

Age range	Total percentage of people in the experimental group	Total percentage of people in the control group	P value*
<6 years	0%	0%	-
6-12 years	25%	15%	0.645
12-16 years	58%	15%	0.041
>16 years	8%	15%	1.000

*Using Fisher's exact test at the significance level P<0.05.

Table 3: The results of statistical analysis of the Stroop task data in control and experimental groups

The Stroop task	Control group			Experimental group			Control & experimental groups		
	Mean±SD (without block design)	Mean±SD (with block design)	P value ¹	Mean±SD (without block design)	Mean±SD (with block design)	P value ¹	P value ²	P value ²	F value
Number of correct answers	96.07 ±6.86	90.38 ±3.18	0.005*	94.25 ±9.44	85.91 ±2.38	0.021*	0.583	0.001*	13.839
Number of wrong answers	1.54 ±0.97	1.69 ±0.85	0.673	1.83 ±0.94	2.58 ±0.99	0.002*	0.448	0.038*	4.891
Unanswered number	17.31 ±2.05	22 ±9.51	0.095	19.70 ±2.75	24.82 ±11.69	0.048*	0.026*	0.934	0.007
Reaction time (Milliseconds)	1449.25 ±61.65	1469.23 ±208.52	0.763	1522.82 ±52.26	1640.08 ±243.20	0.024*	0.006*	0.249	1.412
Total test time (Seconds)	84.08 ±7.82	89.54 ±9.47	0.018*	86.09 ±11.07	95 ±7.22	<0.001*	0.618	0.109	2.811

P value¹: P value of dependent samples *t* test; P value²: P value of independent samples *t* test; *Significant (P<0.05)

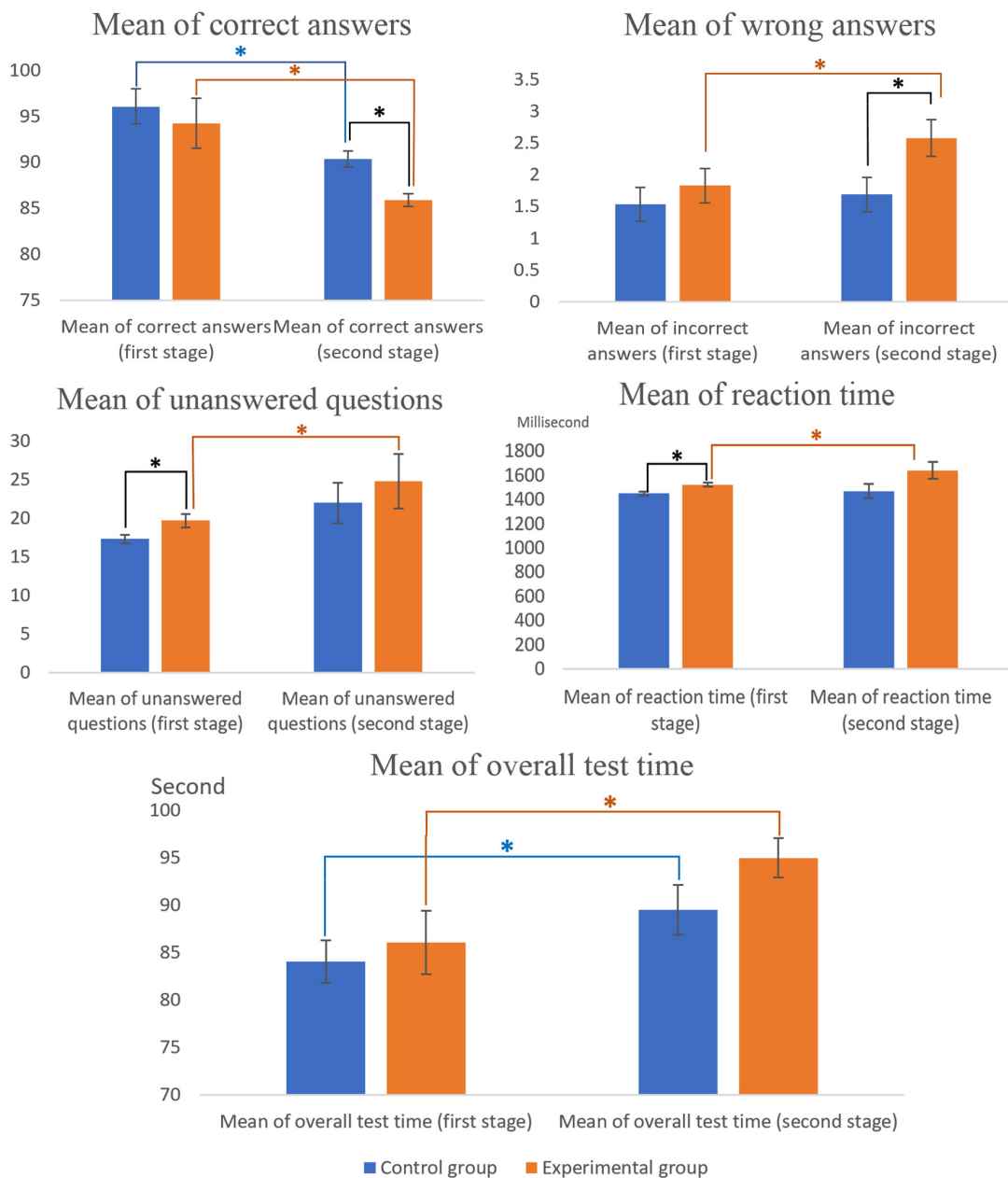


Figure 1: Comparison of the results of the Stroop task between control and experimental groups (*P<0.05).

The results showed a significant difference between the EG and the CG in the number of correct and wrong answers, but no significant differences were reported for the other three components. The intra-group comparisons between the ST phase with and without playing images showed statistically significant differences in all five components in the EG (table 3 and figure 1).

The results obtained by fNIRS and the data recorded while performing the ST without playing the images revealed a significant difference between the two groups concerning deoxyhemoglobin (HbR) levels at the wavelength of 730 nm and oxyhemoglobin (HbO) levels at the wavelength of 850 nm in two Fp1 and Fp2 areas. On the other hand, The ANCOVA statistical test was applied in the following to perform statistical comparisons of the data obtained from the two groups at the stage

of performing the ST, along with playing the images. the statistical comparison of HbR and HbO levels highlighted no significant differences in performing the ST with images in two Fp1 and Fp2 areas. The intra-group comparisons showed insignificant differences between HbR levels at the wavelength of 730 nm and HbO levels at the wavelength of 850 nm in both Fp1 and Fp2 areas when performing the ST with and without images for each participant in the CG. However, the same intra-group statistical comparison led to significant differences for each subject in Fp1 in the EG (table 4).

The statistical comparison of the results recorded by the polygraph machine for the two groups showed a significant difference between the two parameters of SC (P<0.001) and HR (P=0.004) when looking at images related to Tanner stages I and III; but there was no significant difference in the RR parameter (P=0.946).

Table 4: The results of fNIRS and the comparison of the results in control and experimental groups

fNIRS results	Control group			Experimental group			Control and experimental groups		
	Mean±SD (without block design)	Mean±SD (with block design)	P value ¹	Mean±SD (without block design)	Mean±SD (with block design)	P value ¹	P value ²	P value ³	F value
Fp1 Oxyhemoglobin (µM)	18.146±1.647	18.731±1.714	0.376	19.698±1.236	18.829±1.475	0.006*	0.021*	0.351	0.915
Fp1 Deoxyhemoglobin (µM)	17.737±1.562	18.685±1.345	0.111	19.338±0.684	18.660±0.673	0.014*	0.005*	0.481	0.517
Fp2 Oxyhemoglobin (µM)	17.718±2.083	18.874±2.724	0.231	20.187±1.897	19.903±2.541	0.707	0.008*	0.981	0.001
Fp2 Deoxyhemoglobin (µM)	17.993±2.022	19.159±1.921	0.183	20.021±0.683	19.572±1.023	0.097	0.005*	0.883	0.022

µM: Micromolar; P value¹: P value of dependent samples t test; P value²: P value of independent samples t test (Stroop task); P value³: P value of independent samples t test (Stroop task+semi-nude images); *Significant (P<0.05)

Table 5: Results of polygraph device in control and experimental groups

Polygraph results	Tanner stages					
	I and III			V		
	Control group (Mean±SD)	Experimental group (Mean±SD)	P value	Control group (Mean±SD)	Experimental group (Mean±SD)	P value
Mean of skin conductance (µS)	2.55±0.42	4.68±0.38	<0.001*	4.13±0.47	2.72±0.75	0.101
Mean of respiratory rate	18.71±0.45	18.75±0.42	0.946	18.99±0.57	18.17±0.64	0.353
Mean of heart rate	81.82±1.29	88.02±1.67	0.004*	86.97±2.28	85.08±2.20	0.569

µS: Microsiemens; P value: P value of independent samples t test; *Significant (P<0.05)

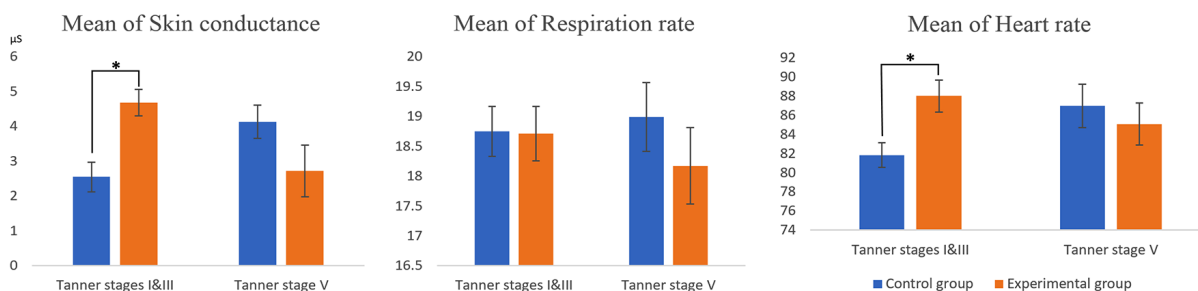


Figure 2: Comparison of the mean of polygraph results between control and experimental groups based on three factors: Skin conductance, Heart rate, and Respiration rate (*P<0.05).

Moreover, no significant difference was observed between the two groups when viewing images related to Tanner stage V (table 5 and figure 2).

Discussion

The results of this study revealed changes in the sexual orientation of the EG compared to the CG over time, highlighting a shift from homosexuality to heterosexuality. However, the CG did not experience such changes and tended to be more heterosexual with a gentle slope. On the other hand, subjects in the EG exhibited a greater desire for homosexuality than those in the CG. This finding is also supported by a previous study, which indicated that individuals who engage in homosexual acts are at least 12 times more likely to sexually abuse children.³³ On the other hand, while studies have indicated that the majority of pedophiles are identified as heterosexual, the findings of this study reveal that most perpetrators of child sexual abuse are homosexual.³⁴ To explain this discrepancy, several points should be considered. Firstly, not all pedophiles engage in sexual abuse against children. Secondly, research shows that most touching victims of sexual abuse are boys, which may lead to a higher likelihood of legal action in these cases.³⁴ Thirdly, in the context of cultural and sociological factors, sexual abuse of girls is often viewed as a greater taboo in Iran. Consequently, families may be less inclined to pursue legal action when the victim is female. These factors contribute to the observed differences in the sexual orientation of perpetrators in this study compared to broader pedophilia research. Because of security and legal reasons, we cannot share the full details of the interviews we conducted, but we can share some general insights. From what we gathered, many participants of EG grew up in families with traditional and religious values, where interactions with the opposite sex were often discouraged. Living in single-sex environments, such as prisons, seems to have influenced their openness to same-sex relationships. This suggests that, in their context, being in a same-sex relationship feels more acceptable, while heterosexual relationships are often seen as inappropriate or socially frowned upon.

The statistical comparisons of the results of the MMSE test and the BMS between the EG and CG were significant, confirming the results of previous studies that indicated people obtaining higher scores in the BMS had more cognitive distortion.^{35, 36} This finding indicates that perpetrators of child sexual abuse should

undergo psychotherapy, neuromodulation, and drug therapy if needed, in addition to serving their judicial sentences. This approach enables criminals to receive the necessary preparation to reintegrate into society and will ultimately enhance public health and safety.

The analysis of the results of SPAQ showed that the EG had experiences of sexual abuse in their childhood and adolescence compared to the CG, which was in line with the results of a previous study revealing that the victims of rape in childhood (especially in boys who were victimized at the age of 12 and above) were sexualized in adulthood and more likely to commit and re-offend.³⁷ This finding is significant in crime prevention because victims of childhood sexual assault can become future perpetrators. By implementing care programs and raising public awareness for teenagers aged 12 to 16, effective measures can be taken to reduce the crime rate.

The intra-group comparisons of the results of the EG between the ST implementation with and without images revealed statistically significant differences, indicating significant effects of semi-naked images of children and teenagers on the individuals' cognitive performance. This effect led to a significant decrease in the concentration, attention, and inhibition power of the EG, which was less in the CG. The similar results found in another study using a modified version of the ST (Pictorial Stroop) confirm the results of this study.³⁸

Furthermore, the statistical comparisons of the results of the two groups showed a significant difference in the two parameters "reaction time" and "number of unanswered questions" when performing the ST without displaying the images, highlighting the weaker cognitive ability of the EG participants. On the other hand, comparisons of the number of "correct answers" and "wrong answers" in the ST when playing images revealed a significant difference between the two groups, highlighting decreased performance due to seeing half-naked images of children and teenagers. The cognition of the criminals was compared to that of CG, confirming the findings of the previous studies.^{27, 39} These findings indicate that perpetrators of child sexual abuse have a diminished ability to control their emotions when interacting with children due to impaired cognitive function.

The statistical analysis of the results of the polygraph data showed a significant difference between EG and CG in the two parameters of SC and HR when viewing pictures of half-naked children and teenagers, revealing a significant increase in the level of emotions in EG. Since

there was no difference in the level of emotions between EG and CG when viewing pictures of semi-nude images of adults, it can probably be concluded that EG is not just suffering from PE, and the images related to half-naked adults also aroused their emotions to such an extent that there was no statistically significant difference with the CG. Children have been raped mostly under the influence of the situation, and this increase in the level of emotions when viewing images of half-naked children and teenagers is probably a result of the memory formed in their minds during their criminal experience.^{27, 39} Moreover, according to the obtained results, perhaps the simultaneous recording of physiological signals such as SC and HR while playing semi-nude images of children can be used as a tool to identify sexual interests.

On the other hand, these changes in the level of emotions were not significant when measuring the function of the respiratory system, which is mainly due to the nature of the respiratory system's functioning regulation both voluntarily and involuntarily, raising the possibility that the participants tried to have voluntary control over the functioning of their respiratory system.

The significance of the statistical analysis of fNIRS data obtained from the ST without playing the images means a significant difference between the EG and CG in the amount of HbO and HbR blood in the Fp1 and Fp2 areas. Thus, according to the results obtained from the ST and the role played, these two areas were considered in the processes related to cognitive functions (e.g., perception, working memory).⁴⁰ This significant difference showed that during the cognitive test, these areas of the brain in the CG work more efficiently and optimally than in the EG and the results are in favor of the CG.

With the significance of the intra-group statistical comparison of the EG in the factors measured in the ST and the statistically significant difference in the amount of HbO and HbR in the Fp1, it can be concluded that probably the weaker performance in the ST is more related to the decrease in activity and blood supply to Fp1.

Moreover, the analysis of fNIRS data in the ST when playing half-naked images showed no statistically significant differences in the HbO and HbR levels in the Fp1 and Fp2 areas. The important point is that in the EG, the means of HbO and HbR decreased, indicating a reduction in blood supply and activity. In contrast, these measures increased in the CG. These results can be interpreted to suggest that the emotional impact of the broadcasted images was likely greater for the subjects in the EG than for those

in the CG. Consequently, the presentation of such images may have led to a decrease in cognitive control in the EG, resulting in reduced blood supply and activity in these two areas. Meanwhile, in the control group, the nervous system appears to have attempted to mitigate the effects of the disturbing stimuli (the half-naked images) by increasing blood supply to these two areas (Fp1 and Fp2). Similar results were obtained in pedophilic males compared to healthy individuals. It was shown that performing the pictorial ST resulted in higher activity levels in the frontal pole.⁴¹ These findings again indicate the importance of therapeutic measures such as neuromodulation for criminals.

This study is likely the first to investigate the neurocognition of perpetrators of child sexual abuse in Iran. Given that implementing such a study is considered a breach of social taboo, the process faced numerous challenges and limitations. Until now, information regarding the cognitive and emotional profiles of these criminals in Iran has been very limited. Moreover, financial constraints hindered using other neuroimaging techniques, such as fMRI.

Conclusion

Understanding child sexual abuse is incredibly complex and often difficult. It is not as simple as just calling perpetrators criminals or labeling them as mentally ill. Many of these individuals may face neurocognitive challenges that influence their behavior. Therefore, it is crucial to consider offering them treatment for these underlying issues alongside their sentences to address the root causes compassionately.

Future studies with larger sample sizes and utilizing novel neuroimaging tools are suggested to provide deeper insights into the structure and function of the nervous system. This approach could lead to more effective measures for crime identification, prediction, prevention, and punishment based on the crime type.

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Authors' Contribution

M.D: Study design, data gathering, data analysis, data interpretation, and drafting the manuscript; M.N: Study design, data gathering, data analysis, data interpretation, and critical reviewing the manuscript; A.A: Study design, data gathering, and data interpretation; S.H.N: Study design, and data gathering; R.Z.N: Data analysis, and data interpretation; E.M.S: Study design, data gathering, data analysis, data interpretation, and reviewing and editing the manuscript. All the reviewed the manuscript and have read and approved the final manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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