Asian Journal of Psychiatry 45 (2019) 7–12

Contents lists available at ScienceDirect

Asian Journal of Psychiatry

journal homepage: www.elsevier.com/locate/ajp

Behavioral and electrophysiological evidence for parent training in young children with autism symptoms and excessive screen-time

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ARTICLE INFO

Keywords:
Excessive screen time
Autism symptoms
Parent training
EEG

ABSTRACT

Recent studies have shown the relationship between excessive screen time and autism symptoms. Unfortunately, there are no studies that evaluated the interventions for children with autism symptoms and excessive screen-time. This paper is a preliminary attempt to examine the effects of parent training on the duration of screen-time, repetitive behaviors and brain electrophysiological characteristics in young children with subthreshold autism symptoms and excessive screen time. Results showed that after the 2 months' parent-child interaction, children's screen-time and repetitive behaviors decreased and EEG ratio power in some channels changed. Our findings suggest that parent training have positive effects on young children with excessive screen-time and autism symptoms.

1. Introduction

Young children's exposure to digital devices (smartphones, tablets, televisions, etc.) has increased in recent years (Chang et al., 2018; Kabali et al., 2015). American Academy of Pediatrics (2016) recommends parents avoid the exposure to digital devices in children younger than 24 months and they limit screen use to 1 h per day for children 2–5 years of age (American Academy of Pediatrics, 2016). Children excessive screen time, especially during critical periods of development can be led to deficits in social behaviors (Cheng et al., 2010; Christakis et al., 2004), changes in brain structures (Takeuchi et al., 2015) and decreasing child-parent communication quality and quantity (Kirkorian et al., 2009; Nathanson and Rasmussen, 2011; Özyurt et al., 2018). Pouretemad in 2000 was one of the first to investigate the associations between Digital Nanning and autism symptoms (Pouretemad, 2000). Digital Nanning is a style of care that digital devices replaced by child active relationship with caregivers and child are exposed to digital devices for more than half of their waking hours (Pouretemad et al., 2017). Also, more recent evidence showed that extreme exposure of digital devices to young children can cause autism symptoms. For example, Hermawati et al (2018) demonstrated the relationship between early electronic screen exposure and autistic-like behaviors in nine children (e.g., language delay, short attention span and hyperactivity) (Hermawati et al., 2018). In Yurika et al. (2018) case study that only looked at the one child, it was found that children's excessive screen time was associated with autistic symptoms (i.e., eye contact difficulties, hyperactivity and language delay) (Yurika et al., 2018). Heffler and Oestreicher (2016) proposed a new model that attempts to explain the relationship between excessive screen time and autism spectrum disorder. They propose environmental exposure to screen time as a factor in the development of autism spectrum disorder (ASD) and specialization of brain non-social pathways (Heffler and Oestreicher, 2016).

It has now been suggested that excessive screen time may lead to social isolation (Bickham and Rich, 2006; Ray and Jat, 2010; Stiglic and Viner, 2019; Taheri, 2013). Recent animal studies have shown that the restricted environments and experiences, early separation of infant from the mother and neonatal isolation can cause autism symptoms and repetitive behaviors (Lewis et al., 2007; Tan et al., 2018; Wu et al., 2014).

Study on the effects of social isolation and deprivation in human was first noted by a group of researchers that focused on children with a history of institutionalization. For example, Rutter et al. (1999, 2007a,b) have found that children raised in institutions are at increased

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https://doi.org/10.1016/j.ajp.2019.08.003
Received 15 January 2019; Received in revised form 9 June 2019; Accepted 3 August 2019

risk for "quasi-autistic" patterns of behavior (Rutter et al., 1999, 2007a,b). Also, these researchers in the English and Romanian Adoptees Study reported that quasi-autism was found in 11.1 percent of previously institutionalized children at 11–12 years of age (Rutter et al., 2007a,b). Another study by Hoksbergen et al. (2005) reported a similar disorder that described as post-institutional autistic syndrome (PIAS) in 16 percent of previously institutionalized children adopted from Romania to the Netherlands at an average of 8 years of age (Hoksbergen et al., 2005). Although children with PIAS and quasi-autism had symptoms overlapping with ASD including social communication difficulties and repetitive behaviors, there were several features in children with PIAS and quasi-autism that differ from those often seen in "ordinary" ASD, such as general trend for decreasing severity of ASD features over time and an equal male: female ratio (compared to the 4:1 male: female ratio seen on ASD) (Levin et al., 2015).

In addition, in a case study, Bartlet and Limsila (1992) reported a typically developing, healthy three-year-old girl in Thailand that exhibited a number of motor stereotypies after being isolated in a cage for six years. In this case, after four years of returning to the community, she showed considerable improvement and her repetitive behaviors were eliminated (Bartlet and Limsila, 1992). Also, Fisher et al. (1997) revealed caregivers reported that about 84% of 46 children that adopted from Romanian orphanages by families in British Columbia had repetitive and stereotyped behaviors and about one year after placement these children with the adopted family, 98 percent of their stereotyped behaviors have shown some improvement or completely resolved (Fisher et al., 1997). Also, the first randomized controlled trial study report on repeated behaviors in children with a history of early institutional care was conducted in 2010 by Bos et al. (Bos et al., 2010) and they have shown that about 60 percent of children in institutional care exhibited stereotyped behaviors and these behaviors significantly decreased after adoption. So, based on the previous findings, in this study, we hypothesized that excessive screen time in early years as a social isolation and environmental deprivation, can cause restricted and repetitive behaviors and other autism symptoms (i.e. communication and social skills). However, this interpretation requires investigation in future research. Restricted and repetitive behaviors (RRBs) is one of the core features of autism spectrum disorder and include a heterogeneous set of behaviors such as intense preoccupations, stereotyped movements, and resistance to change (American Psychiatric Association, 2013).

Although the EEG results in ASD population are heterogeneous, more recent evidence shows that there is a positive relationship between resting-state EEG alpha power (8–13 Hz) and repetitive behaviors (Leno et al., 2018). Another study demonstrated a link between alteration in alpha power in posterior brain regions and preferential attention to details (a specific autism symptom) in individuals with ASD (Mathewson et al., 2012). To the best of our knowledge, the EEG characteristics of children with excessive screen time have not been studied.

Parent training is one of the most effective interventions for young children with autism symptoms (Owen et al., 2019). According Dawson (2008) model, the early behavioral intervention led to adapted patterns of interaction between the child and the environment and reduced autism symptoms (Dawson, 2008). It seems that involvement of parents in implementing intervention strategies (McConachie and Diggle, 2007) including Parent-Child Interaction Therapy (McNeil et al., 2019), especially during the early years, can successfully contribute to improvement in ASD symptoms. Also, parent-child interaction as a possible mediator of early behavioral interventions can be effective in the treatment of autism symptoms (Dawson, 2008). A recent study revealed that after the Positive Parenting Program (Triple P) intervention, the duration of children's screen time decreased (Özyurt et al., 2018). Also, Adams et al (2018) have shown that the responsive parenting intervention reduced infant's screen time and television exposure.

As mentioned above, previous researchers had been limited to investigating the relationship between screen time and autism symptoms and unfortunately, the effects of early interventions such as enhancing parent-child interaction for young children with autism symptoms and excessive screen time has not been studied. In this study we investigated the effects of parent training in the duration of screen time, repetitive behaviors and EEG ratio power of the young children with excessive screen time and autism symptoms. There are elements in this intervention that we hypothesized may affect the autistic symptoms. For example, through the intervention, parents can understand the negative effects of excessive screen time and the importance of environmental enrichment for prevention and treatment of subthreshold autism symptoms in young children. We hypothesized that parent training reduces the children's screen time and repetitive behaviors. We also hypothesized that after intervention, the EEG low/α frequency band power ratio will increase and α/high frequency band power ratio will decrease. This hypothesis is based on findings that alpha frequency band has a positive correlation with repetitive behaviors in children with ASD (Leno et al., 2018).

2. Material and method

2.1. Participants

This was a quasi-experimental design. Among young children that were referred to the Tehran Autism Center from September 2017 to September 2018, 12 young children with subthreshold autism symptoms who had not received an autism diagnosis, and had been exposed to digital devices for more than half their waking hours, together with their parents, were selected as sample groups. Exclusion criteria included the parent's failure to reduce child screen time, failure to attend parent training sessions and if the child was receiving drugs or other interventions simultaneously with the present study. We didn't choose a control group for ethical considerations and small available sample size. The mean and standard deviation of the children's age was 33.33±9.95 months. Also, the mean and standard deviation of the mothers age was 35.50± 1.88 years and for fathers age was 32.17± 19.3 years. Demographic information of participants is presented in Table 1.

2.2. Procedure

This study was conducted in Tehran Autism Center and Children's Medical Center in Tehran, Iran. A total of 12 parents with children with subclinical autism symptoms aged 2–4 years and their parents that referred to Tehran Autism Center were recruited for this study. Assessment included interviews with parents, and clinical assessment of the child. Children were assessed by two Ph.D. degree child clinical

Table 1
Sociodemographic characterization of the study sample.

Variable			Frequency	Percent
Number of children in the family	One child		7	58
	Two child		4	33
	Three child		1	9
Education	High School	Father	2	17
		Mother	4	33
	Undergraduate	Father	4	33
		Mother	1	9
	Master	Father	2	17
		Mother	3	25
	Doctoral	Father	4	33
		Mother	4	33
Economically active	Do not Work	Father	0	0
		Mother	10	83
	Work	Father	12	100
		Mother	2	17
	Retired	Father	0	0
		Mother	0	0

psychologists and a child and adolescent psychiatrist. Also, the children's screen time was determined by parents' reports and lifestyle checklist. Prior to treatment, parents were invited to a meeting in Tehran Autism Center and the research was explained to them (the goals of the study, expectations of participants, etc.). Written consent from the parents was received in order to conduct the study. Parents also completed a Demographic Information Checklist and Repetitive Behavior Scale. The Repetitive Behavior Scale was completed by parents three times (pre-test, post-test, and follow-up). The follow-up was held two months after the last session of intervention. EEG data was recorded two times (pre-test and post-test) in Children's Medical Center in Tehran, Iran. All participants succeeded in reducing their child's screen time and none of them left the study. All procedures were approved by the Shahid Beheshti University ethical committee. This study is registered with the Iranian Registry of Clinical Trials, registration number IRCT20161210031330N3.

2.3. Intervention

All parents were trained to decrease their child's screen time and to have intensive interaction with the child. They received the parent training intervention (Pouretemad, 2000; Rahmati, 2017; Sadeghi et al., 2019). This intervention is based on Focused Playtime Intervention (FPI) (Siller et al., 2013). Parent training intervention involves 8 parent training sessions (one session per week for 2 months, 90 min per session). The principles of this intervention are (a) increasing the hours of parent–child interaction through enjoyable games, productive games, caring activities (such as feeding, bathing, and hugging), reciprocal imitation, and any such interactive activity that is pleasant for the child and parent; (b) arousing the child to communicate with people (instead of objects); (c) prevention (not confronting) of lonely and repetitive activities and the removal of any of a digital device that interferes with the parent–child interaction and encourages the child to be alone with objects; and (d) apply the intervention at all hours of child waking. This intervention has three levels: joining parents and their child to develop an emotional bond between them (first level), parent–child interaction (second level), and bilateral interactions between parent and child (third level). Training sessions were delivered by a highly-experienced licensed clinical psychologist. The intervention was conducted for four groups of parents, which included the parents of 12 children (each group included parents of three children). Both parents (mother and father) participated in the sessions. Parents only attended sessions without their children. The intervention, which covers the session contents and outlines, is described in shown in Table 2.

2.4. Measures

2.4.1. Instruments

2.4.1.1. Life style checklist. To assess the children's lifestyle, we compiled a checklist in which parents had to record at home what their child was doing every 5 min. With this method, we measured the amount of children's sleep, waking time, screen time, and interactions during a day three times (pre-, post- and follow-up). Parents completed this checklist for two days (one day on a weekday and one day on a weekend) in pre-test, post-test and follow-up. We calculated the average hours of screen time and parent-child communication. Parent-child communication includes child's playing with parents, joint action routines, acts of daily living, caring activities (such as feeding, bathing, and hugging), physical plays, productive plays, and all child's communicative and sharing activities with parents. We counting all of the child's connections with the parents as parent-child communication amount.

2.4.1.2. Repetitive behavior scale- revised (RBS-R). RBS-R (Bodfish et al., 2000) is a 43-item informant-based rating scale intended to assess 6 dimensions of repetitive behavior (Stereotyped Behavior, Self-Injurious Behavior, Compulsive Behavior, Ritualistic Behavior, Sameness Behavior, and Restricted Behavior). The sum of the ratings for all of the items in a subscale gives the 'Overall Score'. Lam and Aman (2007) reported internal consistency for the subscales ranges from 0.78 to 0.91 and construct validity for the subscales ranges from 0.68 to 0.98 (Lam and Aman, 2007).

2.4.2. EEG recording

19-channel EEG-1200 (Neurofax, Nihon Kohden, Tokyo, Japan) was used. Data recorded with 500 Hz sampling rate and 19 electrodes, which were placed on the skull according to international 10–20 system electrode placement. Because of subject's poor cooperation, in pre-test and post-test subjects were sedated with Clonidine. The amount of Clonidine was determined based on subject's weight. Subjects less than 10 kg received 0.05 mg, subjects with weight of 10–20 kg received 0.1 mg, and patients with weight of more than 30 kg received 0.15 to 0.2 mg of Clonidine orally (Barzegar et al., 2017). The EEG recording took about 30 min.

2.5. Statistical analysis

Behavioral data were analyzed by repeated measures analysis of variance and Least Significant Differences (LSD) post hoc test with $SPSS_{22}$ software (Corp, 2013). Also, EEG data were pre-processed and processed by MATLAB 2013 software (Release, 2013) and the EEGLAB plugin (Delorme and Makeig, 2004) and analyzed using paired *t*-test in MATLAB 2013 software.

Before performing analysis of variance, to evaluate the sphericity of the data, we used Mauchly's test and to evaluate normality of the data the Kolmogorov–Smirnov Z test was used. A significance level of $p < 0.05$ was used for all statistical comparisons.

3. Results

3.1. Behavioral results

3.1.1. Children's life style

After intervention, the children's screen time significantly decreased from 7.27 h (SD, 1.11) in pretest to 0.17 h (SD, 0.25) in posttest and 0.29 h (SD, 40) in follow-up ($F = 422.21$, $p < 0.0001$, $\eta\ 2 = 0.97$, Power = 1). Whereas, after intervention, parent-child communication significantly increased from 0.79 h (SD, 0.45) in pretest to 8.66 h (SD, 0.89) in posttest and 8.92 h (SD, 0.90) in follow-up ($F = 491.88$, $p < 0.0001$, $\eta\ 2 = 0.98$, Power = 1) (Fig. 1).

3.1.2. Repetitive behavior

Analyses revealed that total scores of repetitive behaviors ($F = 11.59$, $p < 0.01$, $\eta^2 = 0.51$), stereotyped behavior ($F = 18.52$, $p < 0.001$, $\eta^2 = 0.63$), self-injurious behavior ($F = 7.06$, $p < 0.05$, $\eta^2 = 0.39$), compulsive behavior ($F = 8.90$, $p < 0.001$, $\eta^2 = 0.45$), ritualistic behaviors ($F = 5.24$, $p < 0.05$, $\eta^2 = 0.32$), sameness behaviors ($F = 3.96$, $p < 0.05$, $\eta^2 = 0.26$), restricted behaviors ($F = 7.73$, $p < 0.05$, $\eta^2 = 0.41$) declined significantly. The results of LSD test indicated that parents rated their children's repetitive behavior as significantly less severe from pre-test to post-test and from pre-test to follow-up (Table 3).

3.2. Electrophysiological results

Paired *t*-test results indicated a significant increase in EEG ratio power of *theta* Vs *alpha* in Fp1 ($t_{(11)} = -3.07$, $p \leq 0.01$), C4 ($t_{(11)} = -2.78$, $p \leq 0.01$), T8 ($t_{(11)} = -2.18$, $p \leq 0.05$) cannels and *theta* Vs $alpha_2$ in Fp1 ($t_{(11)} = -3.25$, $p \leq 0.01$), C4 ($t_{(11)} = -3.06$, $p \leq 0.01$), T8 ($t_{(11)} = -2.36$, $p \leq 0.05$) cannels. Also, EEG ratio power of $alpha_2$ Vs $Beta_1$ in F4 ($t_{(11)} = 2.36$, $p \leq 0.05$) and Fz ($t_{(11)} = 2.13$, $p \leq 0.05$) channels decreased (Fig. 2).

Table 2
Parent training intervention outlines and contents.

Objective	Session	Activities
Program goals and Check-in	One	• Introducing group members • Discussion about excessive screen time • Discuss the nature of this intervention • Teaching parents to observe and record child's daily life activities and routines
	Two	• Review the Videotape an episode of mother - child interaction • Help parent to develop a profile of the child's symptoms and communication skills
Joining parents and their child to develop an emotional bond between them (first level)	Three	• Training parents to reduce digital devices and managing it • Help parents for manage child's routines (i.e., sleeping, feeding, etc.) • Training simple activities or plays to parents for develop a relationship with the child • communication (e.g. physical play, emotional activities, and sensory paly) • Help parents to find a shared activity • Training parents to increase child eye contact
	Four	• Review the videotape of previous session activities to identify problems and discuss about these. • Talking about parents common issues in last week
Parent–child interaction (second level)	Five	• Training techniques for parents to enhance communication with the child during play with toys • Training parents to develop a special play time routine • Training parents to prevent (not confront) repetitive and non-communicative activities
	Six	• Review the videotape of previous session activities to identify problems and discuss about these. • Talking about parents common issues in last week
Bilateral interactions between parent and child (third level)	Seven	• Training parents to establish shared control over the activities during paly with child • Training parents to take turns in the communicative activities with the child • Training parents to help the child to enhance their imitation skills and imitate parents activities during plays
	Eight	• Review the videotape of previous session activities to identify problems and discuss about these. • Talking about parents common issues in last week

4. Discussion

To the best of our knowledge, this is the first study to investigate the effects of parent training on the duration of screen-time, repetitive behaviors and brain electrophysiological characteristics in young children with autism symptoms and excessive screen time.

Behavioral results showed that parent training decreased children's screen time, increased parent-child communication, and decreased children's repetitive behaviors. These results were consistent with our hypothesis and recent studies that revealed the parent training interventions are effective in reducing children's screen time (Adams et al., 2018; Özyurt et al., 2018). In line with our findings, Dawson (2008) model of risk and prevention for autism (Dawson, 2008) suggested that altered interactions between the infant and his/ her social environment can aggravate potential risk factors for autism and emergence symptoms. It seems that probably parent training helps parents to learn how to reduce children's screen time and communicate with their children. Furthermore, this may lead to improving patterns of interaction between children and their environment, more typical development of neural circuitry during brain plasticity periods and finally prevention of full autism symptoms emergence. However, this interpretation is speculative and requires investigation in future research.

EEG results revealed that after intervention, EEG ratio power of *theta* Vs *alpha* and *theta* Vs $alpha_2$ increased and EEG ratio power of $alpha_2$ Vs $Beta_1$ decreased. Our result was consistent with this hypothesis that after intervention, the EEG low/α frequency band power ratio will increase and α/high frequency band power ratio will decrease. This changes in the EEG ratio power is coincident with the positive changes seen in the children's repetitive behaviors in this study. It is possible that decreased alpha power ratio may therefore exhibit increased sensitivity to environmental novelty, which may favor an aversion to change and a preference for repetitive, stereotyped routines (Leno et al., 2018). In line with this, previous works have reported the correlation between resting-state alpha power with repetitive behaviors (Leno et al., 2018) and extreme attention to detail in individuals with ASD (Mathewson et al., 2012). It seems that in the critical periods in brain development, environmental experiences are very influential on brain development and parent-child interaction and environmental enrichment can effect on the brain and behaviors (Heffler and Oestreicher, 2016). In conclusion, parent training may be effective for decreasing children's screen time and repetitive behaviors and help to realize healthy brain electrophysiological activity in young children with

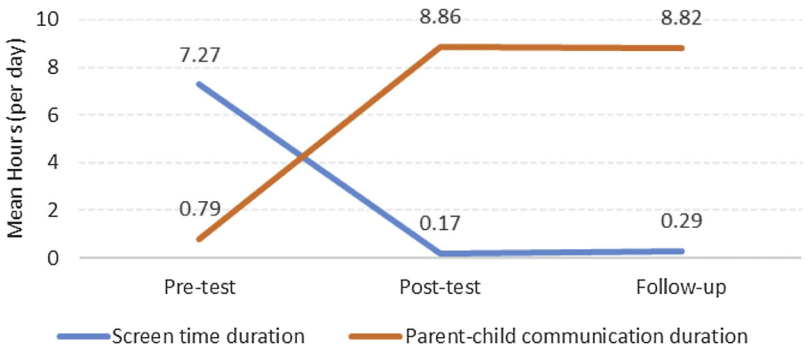


Fig. 1. Changes in duration of children's screen time and communication.

Table 3
Descriptive statistics and the results of repeated measures analysis LSD test for repetitive behaviors.

Repetitive behaviors	Descriptive statistics		Repeated measures test					LSD post hoc test			
	Time	M	SD	F	P	η^2	Pairs	MD	SE	p	Power
Stereotyped Behaviors	Pre-test	11.66	2.84	18.52	0.0001	0.63	Pre/post	1.83	0.77	0.036	0.99
	Post-test	9.83	3.01				Pre/follow	4.08	0.67	0.0001	
	Follow-up	7.58	1.56				Post/follow	2.25	0.57	0.002	
Self-Injurious Behaviors	Pre-test	12.42	4.36	7.06	0.018	0.39	Pre/post	2.42	1.04	0.040	0.71
	Post-test	10	2.41				Pre/follow	3	0.99	0.012	
	Follow-up	9.42	1.93				Post/follow	0.58	0.29	0.067	
Compulsive Behaviors	Pre-test	9.25	3.65	8.90	0.007	0.45	Pre/post	2	0.83	0.034	0.84
	Post-test	7.25	1.86				Pre/follow	3.08	0.92	0.006	
	Follow-up	6.17	1.64				Post/follow	1.08	0.36	0.012	
Ritualistic Behaviors	Pre-test	12.50	4.03	5.24	0.039	0.32	Pre/post	2.33	1.02	0.043	0.58
	Post-test	10.17	2.04				Pre/follow	2.83	1.21	0.039	
	Follow-up	9.67	1.50				Post/follow	0.50	0.34	0.166	
Sameness Behaviors	Pre-test	9.83	4.04	3.96	0.034	0.26	Pre/post	1.17	0.94	0.242	0.65
	Post-test	8.67	3.23				Pre/follow	2.33	0.97	0.035	
	Follow-up	7.50	1.68				Post/follow	1.17	0.47	0.032	
Restricted Behaviors	Pre-test	19.50	9.18	7.73	0.011	0.41	Pre/post	2.66	1.32	0.068	0.79
	Post-test	16.83	5.73				Pre/follow	5.50	1.84	0.012	
	Follow-up	14	3.36				Post/follow	2.83	0.88	0.008	
Total Score	Pre-test	75.17	22.81	11.59	0.004	0.51	Pre/post	12.42	4.86	0.027	0.91
	Post-test	62.75	13.47				Pre/follow	20.83	5.45	0.003	
	Follow-up	54.33	8.44				Post/follow	8.42	1.87	0.001	

Abbreviations: MMean; SDStandard Deviation; SSSum of Squares; MSMean Square; η 2Partial Eta Squared; LSDLeast Significant Differences test; PowerObserved Power.

autism symptoms and excessive screen time.

Even though this study revealed that the parent training decreased children's repetitive behavior and screen time and changed brain electrophysiological characteristics, we must keep in mind that this study is the first step towards enhancing our understanding of the effective interventions for children with excessive screen time and autism symptoms.

We aware that our research may have some limitations. The first is sampling issues. Our sample group was small and it was not possible for us to have a control or a waiting list group (because of ethical considerations and small available sample size). These issues may have effects on our findings validity. In addition, this study consists parents at a high educational level and 83 percent of women were stay-at-home mothers (ten of the twelve mothers). For this reason, these findings need to be generalized with caution to families with different levels of education and socio-economic status.

The second is measurement issues. To assess the average hours of child's screen time and parent-child communication, we used the self-report Lifestyle Checklist which parents had to fill it every 5 min. However, we are not sure that parents have done this carefully. Also, since parents were aware of the goals of this study, there may have been social desirability biases in completing the checklists. However, our EEG findings did not have this limitation. In total, our study limitations highlight the difficulty of collecting data in young children studies.

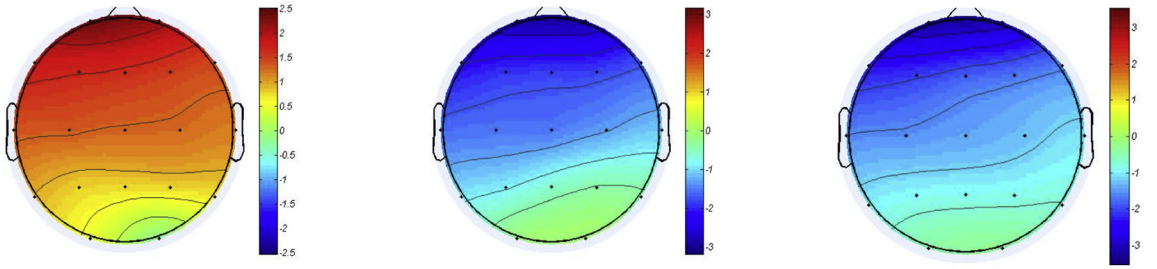
This study is the first step towards enhancing our understanding of effective interventions to reduce young children excessive screen time and autism symptoms and our results should be validated by a larger sample size in the future studies. Also, further investigations are needed to develop the young children screen-time management programs for families.

Financial

The authors received financial support from the Iran National Science Foundation (Number:96004730) and Cognitive Science and Technologies Council of Iran (Number:5490) for the research. All procedures were approved by the Shahid Beheshti University ethical committee. This study is registered with the Iranian Registry of Clinical Trials, registration number IRCT20161210031330N3.

Declaration of Competing Interest

None of the authors have potential conflicts of interest to be disclosed.



$Alpha_2$ (9–13 Hz) Vs $beta_1$(14–21 Hz) *Theta (4–8 Hz) Vs alpha (8–13 Hz)* *Theta (4–8 Hz) Vs $alpha_2$ (9–13 Hz)*

Fig. 2. Changes in the EEG ratio power.

Acknowledgment

We thank the centers of Tehran Autism, Autism Ava and Iranian Pediatrics Centers and the participants in this study. This study was part of a PhD project conducted at Shahid Beheshti University that received funding from the Iran National Science Foundation (Number: 96004730) and Cognitive Science and Technologies Council of Iran (Number: 5490). The authors would like to thank Sjoeholm Andreas Jonas for the English language review.

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