Article

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Effects of parent–child interaction training on children who are excessively exposed to digital devices: A pilot study

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Abstract

Objective: In the last decade, the use of digital devices among children has increased. This study examines the effects of parent–child interaction training on the amount of time children use digital devices, conflict and closeness in parent–child relationships, executive functions, and the electroencephalogram absolute power in children who excessively use the digital devices.

Method: The sample group consisted of 12 children (24 to 47 months) who spent more than half of their waking hours using digital devices. Parents were trained to intensive interaction with the child for two months. Electroencephalogram absolute power, parent–child interaction, the amount of time children use digital devices, and children's executive function skills were assessed.

Results: Parent–child intensive interaction reduces the use of digital devices; decrease the conflicts and increase the closeness in parent–child relationships;

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decrease executive functioning problems; and increase the absolute power of alpha and alpha 2 (F3), beta 1 (F3), and beta and beta 2 (F3, Fp2).
Conclusion: These findings provide evidence of the negative effects of the excessive use of digital devices in children, the importance of parent–child interaction, and its positive impacts on cognitive and brain functions in children. It might contribute to better understand the importance of parent–child interaction in the early years.

Keywords
parent–child interaction, excessive use of digital devices, executive functioning, electroencephalography

Introduction

In the last decade, the use of digital devices among children has increased. The study by Kabali et al. showed that approximately 97% of zero- to four-year-old children use smartphones.[1] In addition, Chang et al. found that about 39% of Korean children aged two to five years watch television almost every day.[2] Ruest et al. reported that about 17% of children use digital devices for about 6 h a day.[3] Another study by Duch et al. reported that 68% of children younger than three years use digital devices such as TVs, DVDs, and video games daily.[4] Although it is clear that young children are regularly using digital devices, the American Academy of Pediatrics has recommended that children under the age of two years should not use digital devices.[5]

In early childhood, parents and environmental experiences play a vital role in the child's development.[6–9] Conversely, previous studies have shown that the use of digital devices reduces the quantity and quality of the parent–child interactions and deprives the child of the social environment.[10–13] Indeed, when digital devices are on, parents are less responsive, less sensitive, and are not engaging their child.[14] Similarly, the child's attention is also attracted to the appealing visual and auditory effects of these devices.[11,12,15] Mendelsohn et al. have shown that child exposure to digital devices reduces parent–child verbal interaction.[16] Nathanson and Rasmussen studied the impact of watching television compared to reading books and playing games on the interaction between mother and children aged 16 to 72 months. They showed that the mother–child interaction was reduced when watching television compared to reading books and playing with toys.[17] Despite some parents' beliefs, very young children cannot learn through digital devices as well as from their caregivers due to the lack of symbolic skills, attention, and memory. Also, the transfer of knowledge from digital devices to daily life is difficult for very young children.[18] Therefore, it seems that digital devices have more entertaining functions than education and learning functions.[19–22]

In the early ages, environmental experiences and parent–child interactions are very important because the development of prefrontal cortex and cognitive abilities is directly related to these experiences.[23–32] Nelson et al. have shown that the peak in the formation of new synapses is about 15 months, and survival or pruning of these nerve connections is determined by the frequency of their activation.[33] In this age, children's extreme use of digital devices may be like environmental deprivation during critical periods and has negative effects on brain development.[34] The parent–child interaction also affects the prefrontal cortex areas of the brain which are bases of executive function skills.[24,26,35] The quality of parent–child interaction plays an important role in the development of executive function skills.[23,25,27,36] Hammond et al. have shown that parental scaffolding (a method that helps child learn more by playing with a parent) improves a child's executive function skills.[37] Conversely, many studies have shown that extreme use of digital devices is correlated with executive function problems in children.[38–40] It seems that there is an inverse relationship between the amount of time children use digital devices with parent–child interaction.[41–44] Parent training is one of the most effective, in both outcome and cost, interventions for children.[45–48] Given the background knowledge that we have, the aim of this study is to investigate the effect of parent–child interaction training on the amount of time children use digital devices, conflict and closeness in parent–child relationships, executive functioning, and brain electrophysiological activities.

Methods

This was a quasi-experimental design. This study was conducted in Tehran Autism Center and Children's Medical Center in Tehran, Iran. Twelve young children who had excessive exposure to digital devices and their parents who referred to Tehran Autism Center were selected. A total of 12 parents with children aged two to four years were recruited for this study. After the selection of subjects, parents were invited for a meeting and were explained about the research (the goals of the study, expectations of participants, etc.). Parents completed demographic information, a lifestyle checklist, parent–child interaction, and executive function questionnaires. The questionnaires were completed by parents three times (pretest, posttest, and follow-up). The follow-up was held two months after the last session of intervention. Child electroencephalographic (EEG) data were recorded twice (pretest and posttest) in the Tehran pediatric hospital.

Participants

The research sample group included 12 children aged two to four years who used digital devices for more than half of their waking hours. These children were selected from a group of children who were referred to the Tehran Autism center. Inclusion criteria included the lack of the diagnosis of psychiatric, neurologic, and metabolic disorders. Exclusion criteria included failure to attend parent–child interaction training sessions and receiving drug or other interventions simultaneously with this study.

Behavioral data collection

Lifestyle checklist

To assess a child's lifestyle, a checklist was created for parents to document what the child was doing every 5 min. With this method, we measured the amount of time the children were asleep, awake, using digital devices, and interacting with parents for three times (pretest, posttest, and follow-up).

Child–Parent Relationship Scale-Short Form

This self-report scale assessed mother's/father's perception of their communication with the child.[49] In this study, we used a short form of this scale that includes closeness and conflict subscales. High scores in closeness indicate a mother's perception, a high degree of warmth, and emotional and close relationship with her child, and high conflict scores also indicate a higher degree of discord.[50] This scale has demonstrated reliability and validity in previous study.[50] In this study, internal consistency for the two subscales is high (Cronbach's $\alpha = 0.83$ for closeness and 0.63 for conflict subtests).

Behavior Rating Inventory of Executive Functioning-Preschool Version

The Behavior Rating Inventory of Executive Function-Preschool Version[51] (BRIEF-P) is a standardized rating scale developed to provide a window into everyday behaviors associated with specific domains of executive functioning in children ages 2 to 5.11 years. The BRIEF-P consists of a single Rating Form, designed to be completed by parents, teachers, or other caregivers, with 63 items in five nonoverlapping scales. The executive functions in this scale are divided into nine factors. The five clinical subscales consisted of inhibition, shifting (ability to move freely from one activity or situation to another), emotional control, working memory, and planning/organization. Also, BRIEF-P included Inhibitory Self-Control Index that is composed of the Inhibit and Emotional Control subscales, the Flexibility Index is composed of the Shift and Emotional Control subscales, and the Emergent Metacognition Index is composed of the Working Memory and Plan/Organize subscales. BRIEF-P total score makes Global Executive Composite scale. The validity and reliability of this scale have been shown in previous studies.[52–54] In this study, internal consistencies for all subscales are high (Cronbach's $\alpha = 0.80$ until 0.97).

EEG data collection

A 19-channel EEG-1200 (Neurofax, Nihon Kohden, Tokyo, Japan) was used to collect electrophysiological data. Data were recorded in the sedate mode with 500 Hz sampling rate and 22 electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1., O2, A1, and A2), which were placed on the skull according to the international 10–20 system electrode placement. In this study, reference was the average of A1 and A2 electrodes. In pretest and post-test, subjects were sedated with Clonidine.

Intervention

The parent–child interaction training intervention is a child-centered program aimed at increasing the quantity and quality of parent–child communication activities while reducing the use of digital devices by the child.[55,56] 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).

This intervention was taught to parents in small groups of three parents, weekly sessions for two months (eight sessions, and the duration of each session was 90 min).

Statistical analysis

Subjects were assessed three times (pretest, posttest, and follow-up) with behavioral tools and assessed twice (pretest–posttest) by EEG. Behavioral data were analyzed by repeated measures analysis of variance with SPSS-22 software.[57] Also, EEG data were preprocessed and processed by MATLAB 2013 software[58] and the EEGLAB plugin[59] and analyzed using paired t test in MATLAB 2013 software.

Results

In this study, 12 children aged two to four years (mean = 33.33 months, standard deviation = 9.95) participated. The mean and standard deviation of the mothers' age was 35.50 ± 1.88 years of the fathers' age was 32.17 ± 19.3 years.

Behavioral results

In this study, we first studied the effect of parent–child education on the lifestyles of children. To examine the significance of changes observed in the lifestyles of children, repeated measures analysis of variance was used. Table 1 shows the mean and standard deviation of the wake time, duration of child exposure to digital devices, and total duration of parent–child interaction during one day in three times (preintervention, postintervention, and follow-up). Table 1 also presents the results of repeated measures analysis of variance.

Table 1 shows that the parent–child interaction training had significant effects on the use of digital devices by children, resulting in an increase in the parent–child interaction. However, the children waking hours had no significant changes. The intervention effect size on reducing the use of digital devices and improving the parent–child interaction was large. Table 2 presents the results of the least significant differences (LSD) by post hoc test for multiple comparisons.

According to Table 2, in the posttest and follow-up measurement stage, the use of digital devices had significantly decreased, and the parent–child interaction had significantly increased, but this diffrence was not significant between posttest and follow-up stages. This finding suggests that, even after two months after the end of the intervention, the changes were sustained.

Table 3 demonstrates the results of repeated measures to examine the effect of the intervention on the closeness and conflict between the parent and child. Table 4 shows the results of post hoc test and paired comparison.

Table 3 shows that parenting training increased the closeness between the parent and child and reduced the conflict between them. These changes were significant and the effect size was medium.

Results showed that the closeness and conflict between parent and child had significant improvement after the intervention. In follow-up, the increase in closeness and decrease in conflicts persisted.

Table 1. Descriptive statistics and the results of repeated measures for lifestyle.

Life style	Time	*M* (h)	*SD*	*SS*	*MS*	*df*	*F*	*p*	η^2
Awake	Pretest	12.50	1.09	0.06	0.03	2	0.04	0.96	0.004
	Posttest	12.50	0.90						
	Follow-up	12.58	1.10						
Digital devices	Pretest	7.27	1.11	397.24	337.33	1.18	422.21	0.0001	0.97
	Posttest	0.17	0.25						
	Follow-up	0.29	0.40						
Interaction	Pretest	0.79	0.45	512.37	256.19	2	491.88	0.0001	0.98
	Posttest	8.66	0.89						
	Follow-up	8.92	0.90						

M: mean; *SD*: standard deviation; *SS*: sum of squares; *MS*: mean square; η^2: partial eta squared.

Table 2. Results of LSD post hoc test and lifestyle changes multiple compressions.

Life style	Time		*MD*	*SE*	*p*
Awake	Pretest	Posttest	0	0.27	1
	Pretest	Follow-up	−0.08	0.41	0.84
	Posttest	Follow-up	−0.08	0.33	0.81
Digital devices use	Pretest	Posttest	7.11	0.31	0.0001
	Pretest	Follow-up	6.98	0.35	0.0001
	Posttest	Follow-up	−0.12	0.12	0.34
Interaction	Pretest	Posttest	−7.87	0.25	0.0001
	Pretest	Follow-up	−8.12	0.24	0.0001
	Posttest	Follow-up	−0.25	0.37	0.51

MD: mean difference; *SE*: standard error.

Table 3. Descriptive statistics and the results of repeated measures for parent–child interaction (CPRS-SF).

Parent–child interaction	Time	*M*	*SD*	*SS*	*MS*	*df*	*F*	*p*	η^2
Closeness	Pretest	25	5.59	301.39	265.64	1.13	15.99	0.001	0.59
	Posttest	30.42	3.55						
	Follow-up	31.67	2.77						
Confilict	Pretest	20.58	4.46	118.39	109.08	1.08	13.91	0.003	0.56
	Posttest	17.17	4.39						
	Follow-up	16.42	3.78						

CPRS-SF: Child–Parent Relationship Scale-Short Form; *M*: mean; *SD*: standard deviation; *SS*: sum of squares; *MS*: mean square; η^2: partial eta squared.

Table 4. Results of LSD post hoc test and parent–child interaction (CPRS-SF) changes multiple compressions.

Parent–child interaction	Time		*MD*	*SE*	*p*
Closeness	Pretest	Posttest	−5.42	1.50	0.004
	Pretest	Follow-up	−6.67	1.50	0.001
	Posttest	Follow-up	−1.25	0.45	0.02
Conflict	Pretest	Posttest	3.42	1.05	0.008
	Pretest	Follow-up	4.17	0.98	0.001
	Posttest	Follow-up	0.75	0.25	0.01

CPRS-SF: Child–Parent Relationship Scale-Short Form; *MD*: mean difference; *SE*: standard error.

Table 5. Descriptive statistics and the results of repeated measures for executive functions (BRIEF-P).

Executive functions	Time	*M*	*SD*	*SS*	*MS*	*df*	*F*	*p*	η^2
Inhibition	Pretest	36.50	8.32	500.67	447.20	1.12	26.30	0.0001	0.71
	Posttest	29.67	8.01						
	Follow-up	27.83	7.65						
Shifting	Pretest	18.50	6.11	92.39	46.19	2	4.36	0.02	0.28
	Posttest	14.58	3.80						
	Follow-up	16.33	4.94						
Emotional control	Pretest	19.50	7.20	150.39	127.19	1.18	5.48	0.03	0.33
	Posttest	15.25	4.99						
	Follow-up	15.08	4.17						
Working memory	Pretest	37.83	9	695.39	347.69	2	22.91	0.0001	0.68
	Posttest	30.83	8.51						
	Follow-up	27.25	7.58						
Planning/ organization	Pretest	21.67	5.55	180.50	90.25	2	11.53	0.0001	0.51
	Posttest	17.67	5.16						
	Follow-up	16.42	5.25						
ISCI	Pretest	56	13.46	1478.17	1258.68	1.17	27.60	0.0001	0.71
	Posttest	43.42	11.45						
	Follow-up	41.58	10.45						
FI	Pretest	38	11.60	450.17	225.08	2	7.59	0.003	0.41
	Posttest	29.83	8.27						
	Follow-up	31.42	8.73						
EMI	Pretest	59.50	14.38	1580.22	790.11	2	20.96	0.0001	0.66
	Posttest	48.50	13.39						
	Follow-up	43.66	12.14						
GEC	Pretest	132	31.55	6344.39	6259.70	1.05	22.89	0.0001	0.67
	Posttest	106.83	26.94						
	Follow-up	101.58	26.06						

ISCI: Inhibitory Self-Control Index; FI: Flexibility Index; EMI: Emergent Metacognition Index; GEC: Global Executive Composite; BRIEF-P: Behavior Rating Inventory of Executive Functioning-Preschool Version; *M*: mean; *SD*: standard deviation; *SS*: sum of squares; *MS*: mean square; η^2: partial eta squared.

Table 5 presents the results of repeated measure for examining changes in children's executive function skills. Table 6 shows the results of paired comparisons.

As shown in Table 5, F test results for all components of executive functions are significant. The greatest effect of the intervention was seen on the inhibition and self-control index, the smallest effect was noted on the shifting subscale.

According to Table 6, the mean of inhibition, working memory, metacognition, and total score of executive function scale from the pretest to posttest and

Table 6. Results of LSD post hoc test and executive functioning (BRIEF-P) scores changes multiple compressions.

Executive functions	Time		*MD*	*SE*	*p*
Inhibition	Pretest	Posttest	6.83	1.46	0.001
	Pretest	Follow-up	8.67	1.52	0.0001
	Posttest	Follow-up	1.83	0.42	0.001
Shifting	Pretest	Posttest	3.82	1.02	0.003
	Pretest	Follow-up	2.17	1.68	0.22
	Posttest	Follow-up	−1.75	1.19	0.17
Emotional control	Pretest	Posttest	4.25	1.95	0.05
	Pretest	Follow-up	4.42	1.59	0.02
	Posttest	Follow-up	0.17	0.73	0.82
Working memory	Pretest	Posttest	7	1.79	0.002
	Pretest	Follow-up	10.58	1.78	0.0001
	Posttest	Follow-up	3.58	1.10	0.008
Planning /Organization	Pretest	Posttest	4	1.11	0.004
	Pretest	Follow-up	5.25	1.28	0.002
	Posttest	Follow-up	1.25	1.01	0.24
ISCI	Pretest	Posttest	12.58	2.63	0.001
	Pretest	Follow-up	14.42	2.39	0.0001
	Posttest	Follow-up	1.83	0.89	0.06
FI	Pretest	Posttest	8.17	2.45	0.007
	Pretest	Follow-up	6.58	2.52	0.02
	Posttest	Follow-up	−1.58	1.58	0.34
EMI	Pretest	Posttest	11	2.75	0.002
	Pretest	Follow-up	15.83	2.86	0.0001
	Posttest	Follow-up	4.83	1.76	0.02
GEC	Pretest	Posttest	25.17	5.75	0.001
	Pretest	Follow-up	30.42	5.93	0.0001
	Posttest	Follow-up	5.25	1.04	0.0001

ISCI: Inhibitory Self-Control Index; FI: Flexibility Index; EMI: Emergent Metacognition Index; GEC: Global Executive Composite; BRIEF-P: Behavior Rating Inventory of Executive Functioning-Preschool Version; *MD*: mean difference; *SE*: standard error.

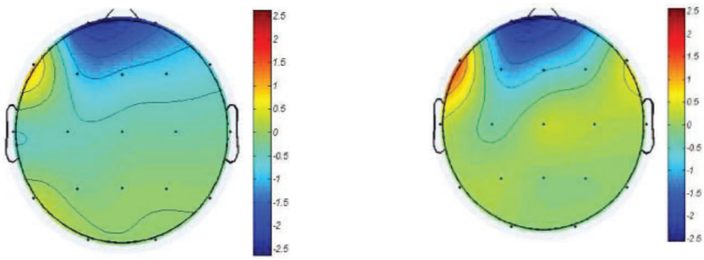
posttest to follow-up has been reduced. The shifting skill showed a significant improvement after the intervention, but in the follow-up, this component has retrogression. Emotional control, self-control, and flexibility indexes also had significant improvements after the intervention.

Electrophysiological results

To examine effects of the intervention on EEG absolute power of *delta*, *theta*, *alpha*, *alpha 1*, *alpha 2*, *beta*, *beta 1*, and *beta 2* frequency bands, paired *t* test was used (Table 7). The topographic EEG changes are shown in Figures 1 and 2.

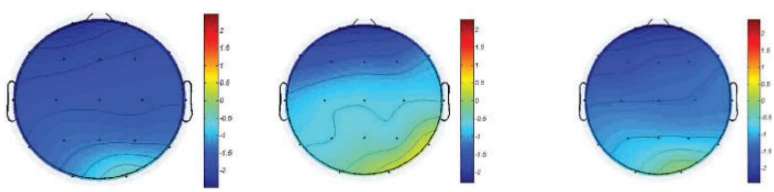
Table 7. Results of *t* test for the effect of the intervention on absolute power of the frequency bands.

EEG frequency band	Channel	*t*	*p*
Alpha			
Alpha	F3	−2.23	0.04
Alpha 2	F3	−2.37	0.03
Beta			
Beta	Fp2	−2.26	0.04
	F3	−2.17	0.05
Beta 1	F3	−2.10	0.05
Beta 2	Fp2	−2.35	0.03
	F3	−2.11	0.05



Alpha 2 *Alpha*

Figure 1. Change in the absolute power of the *alpha* and *alpha 2* bands.



Beta 2 *Beta 1* *Beta*

Figure 2. Change in the absolute power of the *beta*, *beta 1*, and *beta 2* bands.

Table 7 shows the significant increase in absolute power of the *alpha*, *alpha 2*, *beta*, *beta 1*, and *beta 2* bands in the F3 channel after two-month intensive interaction. Table 7 also shows that the absolute power of *beta* and *beta 2* in the Fp2 channel has increased significantly. The topographic EEG absolute power changes are shown in Figures 1 and 2.

Discussion

In this study, we investigated the behavioral and electrophysiological changes correlated with parent–child interaction training in children who had excessive exposure to digital devices. The result showed that parent–child interaction training is associated with a reduction in the amount of time children use digital devices, improved parent–child interaction, improved executive function skills, and EEG absolute power changes in the brain's frontal area.

As expected, the results showed that parent–child interaction training increased the closeness and reduced conflict between parent–child. These findings lend support to existing research documenting the importance of parent–child interaction and the reduction in preschool children's screen time.[10–12,14–17,20,22] It seems that in addition to the attractiveness of digital devices for children, lack of parental skills is one of the important factors for extreme exposure of children to digital devices. When parents are not sensitive, responsive, and available, the child is more occupied with digital devices. Essentially, digital devices replaced parents.

In this case, by training parents to interact with the child, parents are encouraged to spend more time with their children and enjoy being with their child. When the child communicates with the parent, he/she seems to find that it is more interactive and enjoyable than interacting with digital devices. As a result, parent–child interaction training can increase the closeness and reduce the conflict between parents and child and reduce the exposure of children to digital devices.[44]

The results of this study also showed that with parent–child interaction enhancement and reducing the exposure of children to digital devices, executive function skills have improved. This finding is consistent with the previous studies that have shown that extreme use of digital devices and the reduction in parent–child interactions have a negative impact on children executive function skills.[23,25,36,37] Sosic-Vasic et al. have shown that parenting behaviors, such as responsiveness, have a positive and significant correlation with executive function skills.[27] The mechanism of the parent–child interaction effect on the childrens' executive function skills can be grouped into the theoretically derived dimensions such as scaffolding and parental stimulation. As emphasized in sociocultural theories, parental scaffolding (e.g., verbal or physical guidance) involves deliberate efforts by parents using either verbal or nonverbal actions to help children engage with a challenging activity. Subsequently working through these challenges can improve childrens' executive function skills.[32] This classification (parental scaffolding) also includes autonomy support or granting parents' encouragement of children's opinions, choices, decisions, and problem-solving as important tools to enhance cognitive skills in children. Also, parental stimulation involves providing children with opportunities to develop cognitive skills through enriched interactions including reading to children.[13]

The study demonstrated that improvement in parent–child interaction and reduction in a child's use of digital devices has led to a significant increase in absolute power of alpha and beta EEG band in the frontal lobe of the brain of children. This finding is consistent with the findings of previous studies that have shown that parent–child interactions affect the children brain.[24,26,30,31,34,35] This increase in the alpha and beta in the frontal area of the brain is coincident with the positive changes seen in the children's executive function skills in this study. It is possible that an increase in alpha and beta bands has led to improvement in children's executive functioning skills, social interactions, and school performance. During ages of critical brain development, such as in preschoolers, environment is very influential. Parent–child interaction and environmental enrichment can affect the frontal lobe of the brain. In comparison to other parts of the brain, the frontal lobe has more long-term maturation.[24] Long periods of frontal development make it possible for human beings to acquire complex cognitive abilities through experience. On the other hand, the brain becomes vulnerable to negative experiences. At early ages, a child's exposure to positive sensory stimulation and social experiences can lead to healthy development of his/her frontal cortex. Therefore, enriching the parent–child relationship at an early age can cause useful changes in the brain frontal area, which is more flexible than other parts of the brain. It seems that extreme exposure of children to digital devices at early ages, that is, during critical periods of brain development, can weaken parent–child relationships; decrease emotional, social, and cognitive learning opportunities; and can lead to the abnormal brain development. It is possible to avoid this abnormal development by training parents thereby helping the child develop cognitive abilities and healthy brain development.

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