Should Parents Allow Their Children to Use Smart Phones and Tablets? The Issue of Cognitive Performance

Mortazavi S. A. R. 1,2, Haghani M. 2, Zarei S. 3, Rastegarian N. 4, Alighanbari N. 5, Haghparast M. 6, Darvish L. 7*

ABSTRACT
Mobile phones, mobile phone base stations, cordless phones and power lines are among the main sources of our daily exposures to radiofrequency electromagnetic fields (RF-EMF). Today, a large proportion of children aged eight and under has used smartphones and tablets for media activities such as playing online games, watching videos or using different applications. Over the past several years, our society has witnessed a rapid growth both in the percent of children who regularly use smartphones and tablets and the time spent using these devices. Expanded access of children to these mobile devices and the games that make mobile phones attractive to young users are believed to be the key factors that increased the time spent by children for using mobile devices. In IR Iran, students are not allowed to use mobile phones in schools. On the other hand, although students do not have access to Wi-Fi in schools, as Wi-Fi provides efficient access to the Internet on the campus, Wi-Fi routers are widely used. The rapid growth of mobile phone use has raised global public concerns especially for children. Focusing on the issue of cognitive performance, this paper is aimed at answering the following question: Should parents let their children use smartphones and tablets?

Keywords
Non-Ionizing Radiation, Electromagnetic Fields, Children, Mobile Phone Use, Cognitive Performance

Introduction
Today, children are among the frequent users of mobile devices such as smartphones and tablets. Mobile phones, mobile phone base stations, cordless phones and power lines are among the main sources of our daily exposures to electromagnetic fields. The rapid growth of wireless technology use has raised global public concerns especially for children [1]. Children and teenagers now communicate nearly twenty four hours a day and they are among the largest groups of smartphone users. Interestingly, smartphones and tablets can be observed in the hands of children younger than 2 years of age [2]. Surfing the web, checking social networks and playing games are the main reasons which cause the frequent use of mobile phones and tablets by children. Focusing on the issue of cognitive performance, this paper discusses the following question: Should parents let their children use...
smart phones and tablets?

**Children and Communication Technology**

According to American Academy of Pediatrics (AAP), children in America spend about seven hours a day on entertainment media (activities such as watching TV, using laptop/desktop computers, talking on the phone and using other electronic devices). AAP also states that studies conducted so far reveal that excessive media use in children may cause adverse health effects such as attention problem, school difficulties, sleep and eating disorders and obesity. AAP believes that even in case of high-quality content, children and teens should not use entertainment media more than one or two hours per day. AAP also suggests that children should spend more time on outdoor playing, reading, hobbies and using their imaginations in free playing. On the other hand, now, in many countries wireless fidelity (Wi-Fi) routers are greatly used in children schools [3].

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Over the past several years, our research team has performed experiments on the health effects of exposure of animal models and humans to different sources of electromagnetic fields such as cellular phones [4-11], mobile base stations [12], mobile phone jammers [13,14], laptop computers [15], radars [5], dentistry cavitrions [16], MRI [10,17] and Helmholtz coils [18]. Our research team has also shown that exposure to some common sources of electromagnetic fields, through increased release of mercury from dental amalgam restorations [19], might be linked to higher incidence of diseases such as speech problems [20]. Based on our findings, we also hypothesized that these exposures through increased release of mercury from amalgam fillings, can be associated with higher incidences of ADHD or Autism spectrum disorder (ASD) [19,21].

**Children Studies**

Current data on the effect of EMFs on cognitive functions in children are both very limited and controversial. Haarala et al. in a study performed in 2005, investigated the effects of a GSM mobile phone on the cognitive function of 16 boys and 16 girls aged 10-14 years. These researchers were not able to show any significant differences between the real and sham exposure phases in reaction time. They concluded that RF-EMFs created by an active mobile phone cannot facilitate cognitive functions [22].

Preece et al. in the same year examined whether a GSM mobile phone exposure could alter the cognitive functions in 18 children aged 10-12 years. The results of their experiment showed that mobile phone radiation was not associated with a reduction in reaction time [23]. It is worth mentioning that their previous study that was performed with a more powerful analogue handset had indicated a significant effect on reaction time as an increase in speed (a decrease in reaction time) [24]. In a more recent study performed in Iran, 60 elementary school children aged 8-10 years were asked to perform reaction time and short term memory test in real and sham mobile phone exposure phases. The differences between students’ reaction times after a 10 min. talk period and after a 10 min sham exposure (switched off mobile) period were not statistically significant. However, short-term memory scores after the talk phase were significantly higher than that of the sham exposure period. This study clearly showed that in elementary school students, short-term exposure to mobile phone RF radiation caused better performance of their short-term memory.
Possible Biopositive Effects of RF-EMFs

In spite of the fact that there are known detrimental effects associated with exposure to RF-EMF radiation, under some special circumstances (short term- low-level exposures), these radiations may cause some potential beneficial effects [25]. It is well documented that low doses of ionizing radiation may induce some beneficial effects such as stimulating the activation of special repair mechanisms. We have previously shown that low levels of RF-EMFs as a non-ionizing radiation, can also induce stimulatory/beneficial effects. It was reported by our team that the visual reaction time of university students significantly decreased after a 10 min exposure to radiofrequency radiation emitted by a mobile phone [6]. It was also previously shown that short-term exposure of elementary school students to RF radiation might lead to better performance of their short-term memory [26]. On the other hand, it has also been shown that occupational exposures to radar radiations decreases the reaction time in radar workers [27].

Furthermore, some recent reports have indicated that RF radiation may have a role in protecting against cognitive impairment in Alzheimer’s disease [28,29]. Furthermore, it has been shown that pre-exposure of mice to radiofrequency radiation emitted by a GSM mobile phone increased their resistance to a subsequent Escherichia coli infection [30,31]. This phenomenon may have very important applications in long term space missions. On the other hand, we showed that exposure to microwave radiation might induce a significant survival adaptive response after exposure to lethal doses of gamma rays [32]. Adaptive response can be defined as a reduction in the detrimental effects of exposure to a high dose of radiation and/or a toxicant after a pre-exposure to low level radiation. Mortazavi et al. have previously documented the evidence indicating that both ionizing [33-4] and non-ionizing [32, 41-43] radiations can induce adaptive response.

Possible Detrimental Effects of RF-EMFs

In a recent study conducted on children aged 9-11 years, spot electric field measurements within 100kHz-6GHz were performed in the vicinity of children’s houses. Assessing neuro-cognitive and behavioral functions showed that the majority of the cognitive and behavioral parameters were not affected by RF exposure. However, children who lived in areas with higher RF exposure levels had lower scores for verbal expression or comprehension and higher scores for internalizing and total problems, and obsessive-compulsive and post-traumatic stress disorders. These researchers concluded that although a proportion of their findings showed that low-level environmental RF-EMF exposure adversely affects children’s cognitive and behavior development. Due to study limitations and as the majority of neurobehavioral functions were not altered, a firm conclusion could not be drawn [44].

Warille et al. in 2015 reviewed the literature on the health effects of the exposure of children to low levels of electromagnetic fields (EMF) generated by electrical power sources and mobile phones. They reported that some evidence shows that human exposure can cause cognitive and behavioral impairments. Warille et al. concluded that due to rapid spread of wireless devices, it is now very important to increase the public awareness of potential health effects and to safeguard healthy brain development of children [45].

Chinese researchers in 2015 performed a study to assess the potential gender-dependent effects of the exposure to microwave radiation on cognitive dysfunction. They investigated that in utero exposure to microwave radiation (9.417-GHz) during pregnancy in mice alters the behavior of animals. Findings of this study showed that male offspring revealed decreased
learning and memory. However, female mice were not affected. Therefore, they claimed that the adverse effects of microwave radiation are gender-dependent [46].

Another study that was aimed at assessing the effects of RF-EMF emitted by mobile phones on the event-related brain oscillatory electroencephalogram (EEG) responses in children performing an auditory memory task revealed that RF-EMF emitted by mobile phones could affect children’s brain oscillatory responses during cognitive processing [47]. Regarding the effects of RF-EMF on children’s cognitive performance, Feychting stated that in spite of the existence of different symptoms and effects on cognitive function in adults, these studies cannot confirm that the observed symptoms are caused by RF-EMF [48].

Considering non-cognitive effects, in a study conducted by Byun in Korea, 422 children at 27 elementary schools in 10 different cities were tested and they were followed up 2 years later. Parents of the children were administered a questionnaire including ADHD rating scale, questions regarding mobile phone use and socio-demographic factors. This study showed that the ADHD symptom risk was significantly linked to mobile phone use for voice calls. These researchers concluded that there was an association between simultaneous exposure to lead and RF from mobile phone use and increased ADHD symptom risk [49].

In another study performed in Denmark, the Danish National Birth Cohort enrolled pregnant women and they were interviewed during gestation, and when the children were 6 months, 18 months and 7 years of age. To investigate a possible relationship between cell phone use and hearing loss, multivariable-adjusted logistic regression, marginal structural models (MSM) with inverse-probability weighting and doubly-robust estimation [50] were used. Although weak associations between cell phone use and hearing loss were observed, altogether, the analyses which included data from 52,680 children, could not show that cell phone exposure adversely affected their hearing [51].

Rapid advances in information and communication technologies (ICT) have made schools to employ the latest educational technologies and progressively use these technologies in their curriculum. Whether wireless technologies can be a part of the school ICT, now is a challenging worldwide issue. Although current exposure standards for RF-EMFs were basically set three decades ago to prevent possible thermal effects, currently used mobile phones which do not normally induce significant thermal effects may be linked to adverse health effects such as impairment of the nervous system, sleep problems, hearing and reproductive health problems and increased cancer risk [52]. There is now a debate over this point that manufacturers test their wireless devices at a distance that is much greater than the distance between these devices and children’s bodies creating exposure level far in excess of the tested levels [52].

Conclusion

Nowadays in many countries, there are warnings about children mobile phone use [53]. Radiofrequency electromagnetic radiation is a Class 2B (possible). It is widely believed that children are more susceptible to radiation at least in some regions of the electromagnetic spectrum [54]. It has been reported that children absorb more radiofrequency radiation than adults [53]. Moreover, some individuals are hypersensitive to RF-EMFs [55] and this hypersensitivity may cause more problems in children. As long-term effects of the children’s exposures to RF EMF emitted from mobile phones and other wireless technologies are not fully understood, overexposure to phones and other wireless technologies should be avoided to protect their cognitive performance. In this light, setting time limits for cell phone use by children is highly recommended. Moreover, in
Children and Mobile Phone Use

Each country authorities should adopt radiation standards which protect children’s health and well-being.

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Conflict of Interest
None Declared.

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