EFFECT OF MOBILE DEVICES USAGE ON CENTRAL AUDITORY PROCESSING IN CHILDREN.

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ABSTRACT

Background: *Mobile phones are being widely used throughout the world. Electromagnetic waves generated from mobile phones have raised concerns as they may have adverse effects on auditory system and scholastic achievement in children owing to the daily use of mobile phones.*

Aim of the work: *To examine the central auditory processing abilities in school-aged children who use mobile phones and play video games.*

Patients and Method: *Study population: 50 normal hearing children with age ranging between 6 and 12 years. Inclusion criteria: Normal hearing sensitivity and normal middle ear function, IQ within normal limits, users of mobile phones and playing video games.*

Study Procedure: Full history taking from parents and History of scholastic achievement, Psychometric evaluation: using Stanford-Binet Intelligence Scale fifth edition (SB5), Basic audiological evaluation, Parents - administered sheet for history of mobile phone use, Parents - administered Questionnaire for screening of CAPD. Central Auditory Processing Evaluation by central auditory test battery which includes the following tests: Speech Intelligibility In Noise (SPIN), Arabic Dichotic digit test (DD) (version I& II), Auditory fusion test- revised (AFT-R), Memory tests, Auditory Vigilance test

Results: *Most of children were playing video games on the mobile phones, racing games were the most favorite played games. Most of children had abnormal Speech in Noise test, Dichotic Digits test I, II, Memory tests (memory for sequence), Auditory Vigilance test. Duration of mobile phone use per day is significantly negatively correlated with results of central auditory processing correct tests scores.*

Conclusion: *Mobile phones and video games have a negative impact on central auditory processing abilities which have an impact effect on attention, memory and academic performance.*

Keywords: *Central auditory processing, Smart phones, Video games, electromagnetic waves*

INTRODUCTION

There is a link between prolonged mobile phone use and serious health problems[(1)]. World Health Organization's scientific panel classified mobile phone radiation as 'possibly carcinogenic'. Also excessive use of mobile phones is known to cause headache, deleterious effects on concentration and attention, memory loss and depression[(2&3)]. Video game playing has

become one of the main leisure activities for children and adolescents. mobile phones represent one of the tools for video games. the effect of video games playing was variable in literature. As central auditory pathway is responsible for the processing the auditory information, examining central auditory processing abilities is considered as an integral part of the detection of difficulties listening in background noise, following oral instructions, and understanding rapid or degraded speech in the presence of normal peripheral hearing, etc. [4] .To the best of author knowledge, there is no study investigated effects of mobile devices usage and video games playing on central auditory processing in school-aged children.

AIM OF THE WORK

To examine the central auditory processing abilities in school-aged children who use mobile phones and play video games.

PATIENTS AND METHODS

Study Setting: Audiology units of Ain-Shams University Hospitals

Study Period: From September 2019 to july 2020.

Study population: 50 normal hearing children with age ranging between 6 and 12 years.

Inclusion criteria: Normal hearing sensitivity and normal middle ear function, IQ within normal limits, co-operative child, Users of mobile phones and playing video games.

Exclusion criteria: Child with abnormal neurological or medical conditions, Child with recurrent otitis media with effusion, IQ below average.

Ethical consideration: The protocol was ethically approved by the ENT department board, the research Ethical Committee, Faculty of Medicine Ain Shams University. The date of Research ethics committee approval was on 18/8/2019 (FMASU M S 213/2019).

Methods: All participants in this study were submitted to the following: Full history taking from parents and history of scholastic achievement, psychometric evaluation: using Stanford-Binet Intelligence Scale fifth edition (SB5) with average score[5], otological examination, basic audiological evaluation including pure- tone Audiometry in the frequency range 250-8000Hz, Speech Audiometry: including speech reception threshold (SRT) using Arabic bisyllabic words for children and word discrimination score (DS) using Arabic Kindergarten Phonetically Balanced (PB-KG) words[6] and Immitancemetry.

Parents - administered sheet for history of mobile phone use was filled by the parents, it consisted of 11 questions, 3 questions were open ended (respondent were allowed to provide own answer), 5 questions were close ended (respondent were allowed to select one or multiple responses), 3 questions were partially close ended (yes or no answer). Sometimes parents needed help for some questions to be cleared; it took about 15 minutes to be fulfilled. Parents - administered Questionnaire for screening of CAPD[7], it consisted of 27 questions which were partially close ended questions (yes or no answer) including listening, learning, memory, language &behavioral question-aires. Central Auditory Processing Evaluation: The central auditory test battery includes the following tests: Speech Intelligibility in Noise (SPIN), Arabic Dichotic digit test (DD) (version I& II), Auditory fusion test- revised (AFT-R), Memory tests (Recognition Memory, Memory for Content, Memory for Sequence), Auditory Vigilance test

Data Management and Analysis: Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA).

RESULTS:

The results of the demographic characteristics of the study group showed that the mean age of the study group was 8.98± 1.91 years ranging from 6 - 11.9 years and male gender was the dominant (58%).

Concerning the mobile phone history, most of children in the study group played video games using mobile phones and computer or laptop. Racing & violent games were the most favorite type of games. Thirty-six percent of children had moderate to poor scholastic achievement.

Parents questionnaire concerning the central auditory processing abilities revealed that 82% of parents have concern about the memory of the children, lack of attention and concentration in 76% and impulsivity in 32%.

Table (1): Comparison between Study groups & Norms of Speech In Noise test& Dichotic Digits test

P – value		Norms		Study groups						Age groups	Central auditory processing tests
Left ear	Right ear	Left ear	Right ear	Left ear			Right ear				
		Mean±SD	Mean±SD	Mean±SD	Abnormal	Normal	Mean±SD	Abnormal	Normal		
0.000 HS	0.000 HS	96.2±3.6	96.2±3.6	78.9 ± 14	78.9%	21.1%	79.5 ± 15.5	78.9%	21.1%	6-8y	Speech In Noise test
0.000 HS	0.000 HS	97.9±3.3	97.9±3	76 ± 12	90.9%	9.1%	78.2 ± 12.7	81.8%	18.2%	>8-10y	
0.000 HS	0.000 HS	98.4±3.2	98.4±3	84 ± 13.6	80%	20%	88 ± 12.2	65%	35%	>10 – 12y	
0.226 NS	0.286 NS	87 ±12.6	93 ± 3	92 ±11.3	15.8%	84.2%	95±8	5.3%	94.7%	6-8y	Dichotic Digits test (version I)
0.598 NS	0.540 NS	89.3 ± 7	94 ± 5.7	91 ± 9.7	45.5%	54.5%	93±7.9	45.5%	54.5%	>8-10y	
0.185 NS	0.333 NS	97 ± 6.7	98 ± 4.5	93 ±11.6	35%	65%	95.8±9.2	35%	65%	>10 – 12y	
0.444 NS	0.254 NS	80 ± 7	89 ± 6.4	82 ± 11.7	36.8%	63.2%	85.8 ± 8.7	57.9%	42.1%	6-8y	Dichotic Digits test (version II)
0.569 NS	0.088 NS	84.6 ± 6.8	91.5 ± 7	83 ± 11.4	27.3%	72.7%	86.1 ± 9.8	45.5%	54.5%	>8-10y	
0.007 HS	0.001 HS	92.3 ± 5.4	96 ± 6.5	83 ± 13.6	60%	40%	86± 10.5	75%	25%	>10 – 12y	

The majority of children had abnormal SPIN test and DDT version I&II in both ears of all age groups. There was highly statistically significant difference between both ears of all age groups & norms in SPIN test, no statistically significant difference between both ears of all age groups & norms in DDT version I however; in DDT version II there was highly statistically significant difference between both ears of age group III & norms.

Table (2): Comparison between Study groups & Norms of auditory vigilance test& Memory tests

Central auditory processing tests	**Age groups**	**Study groups**			**Norms**	**P – value**
		Normal	Abnormal	Mean±SD	Mean±SD	
Auditory vigilance test	6-8y	57.9%	42.1%	41.7 ± 7.29	45.6 ± 1.38	0.007 **HS**
	>8-10y	27.3%	72.7%	39.9 ± 5.61	47.4 ± 1.89	0.000 **HS**
	>10 –12y	30%	70%	41.2 ± 6.28	48.6 ± 1.04	0.000 **HS**
Recognition memory test	6-8y	73.7%	26.3%	10.16± 0.96	10 (0.7)	0.554 **(NS)**
	>8-10y	63.6%	36.4%	9.73 ± 1.1	10.4 (0.4)	0.020 **(S)**
	>10 –12y	75%	25%	10.15± 1.23	10.6 (0.5)	0.138 **(NS)**
Content memory test	6-8y	68.4%	31.6%	4.63 ± 0.6	5.1 (0.6)	0.019 **(S)**
	>8-10y	90.9%	9.1%	4.91 ± 0.3	5.5 (0.5)	0.001 **(HS)**
	>10 –12y	65%	35%	5.55 ± 0.69	5.9 (0.4)	0.057 **(NS)**
Sequential memory test	6-8y	15.8%	84.2%	3.16 ± 0.37	4.5 (0.5)	0.000 **(HS)**
	>8-10y	36.4%	63.6%	4.27 ± 0.65	5 (0.5)	0.002 **(HS)**
	>10 –12y	45%	55%	4.40 ± 0.60	5.2 (0.4)	0.000 **(HS)**

In auditory vigilance test, the majority of children of age group I had normal test results but age groups II & III showed abnormal results when compared to control groups. There was highly statistically significant difference between control& study groups regarding age groups I & II& III of the auditory vigilance test. All the memory tests showed a significant percentage of children with test abnormality however the highest abnormality was founded in the sequential memory. There was statistically significant difference between age group II & norms in recognition memory and highly significant difference between age group II & norms and statistically difference between age group I & norms in memory for content. However, there was highly significant difference among all age groups & norms in memory for sequence test

Table (3): Comparison between Study groups & Norms of **AFT-R**

Age groups	Normal	Abnormal	Mean± SD of Study group					Mean± SD of Norms	P-value				
			250 Hz	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**		**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
(6-8)	73.7%	26.3%	13.4 ± 3.5	13. ± 3.9	13.3± 4.1	14 ± 4.3	14.1 ± 4	15(1)	0.06 **(NS)**	0.05 **(S)**	0.08 **(NS)**	0.29 **(NS)**	0.33 **(NS)**
(>8-10)	72.7%	27.3%	13±4	12.3± 4	12.3 ± 3.8	13.6 ± 5.2	13.4 ± 4.5	12.5(1)	0.63 **(NS)**	0.81 **(NS)**	0.80 **(NS)**	0.34 **(NS)**	0.39 **(NS)**
(>10– 12 **)**	55%	45%	14.3± 4.7	15 ± 5	15± 5.8	14.8± 5.6	15.6± 5.3	12.5(1)	0.09 **(NS)**	0.03 **(S)**	0.04 **(S)**	0.08 **(NS)**	0.01 **(S)**

As regards AFT-R, less frequent abnormalities were detected in the younger age groups I&II however 45% of the older age group III have abnormal test results. There was statistically significant difference between age group I, III & norms in **500Hz** and statistically significant difference between age group III & norms in **1000Hz**, **4000Hz**.

Correlations studies were applied to examine the relations between results of central auditory processing tests and duration of mobile phone use in hours per day.

Table (4): Correlation between duration of mobile phone use in hours/day and results of Speech In Noise test& Dichotic Digits test

Central auditory processing tests	How long has he used these games in hours/ day					
	Number of children	Mean ± SD	Range	Test value	P-value	Sig.
SPIN test in right ear	Normal=13	2.4 ± 1.68	1 – 5	-1.834•	0.073	NS
	Abnormal=37	3.6 ± 2.21	1 – 8			
SPIN test in left ear	Normal=9	2.3 ± 1.68	1 – 5	-1.564•	0.129	NS
	Abnormal=41	3.5 ± 2.19	1 – 8			
DDT version I in right ear	Normal= 37	2.8± 1.84	1 – 8	-2.565•	0.014	S
	Abnormal= 17	4.5± 2.50	1 – 8			
DDT version I in left ear	Normal= 35	2.8± 1.79	1 – 8	-2.523•	0.015	S
	Abnormal=15	4.4± 2.52	1 – 8			
DDT version II in right ear	Normal= 19	1.7± 1.19	1 – 5	-4.722•	0.000	HS
	Abnormal= 31	4.19±2.06	1 – 8			
DDT version II in left ear	Normal= 28	2.45±1.83	1 – 8	-3.333•	0.002	HS
	Abnormal= 22	4.3± 2.09	1 – 8			

•: Independent t-test

There was statistically significant correlation between duration of mobile phone use in hours /day and results of DDT.

Table (5): Correlation between duration of mobile phone use in hours/day and results of auditory vigilance test& Memory tests

Central auditory processing tests	How long has he used these games in hours/ day					
	Number of children	Mean ± SD	Range	Test value	P-value	Sig.
Auditory vigilance test	Normal= 20	2.5± 2.22	1 – 8	-2.201•	0.033	S
	Abnormal= 30	3.8± 1.95	1 – 8			
Recognition memory test	Normal= 36	2.8± 1.83	1 – 8	-2.366•	0.022	S
	Abnormal= 14	4.4± 2.53	1 – 8			
Memory for content	Normal= 36	3.1 ± 2.03	1 – 8	-0.712•	0.480	NS
	Abnormal= 14	3.6 ± 2.45	1 – 8			
Memory for sequence	Normal=16	2.5 ± 1.67	1 – 6	-1.684•	0.099	NS
	Abnormal=34	3.6 ± 2.27	1 – 8			

•: Independent t-test

There was statistically significant correlation between duration of mobile phone use in hours /day of and results of recognition memory test and auditory vigilance test.

Correlations studies were applied to examine the relations between results of central auditory processing tests and concern of parents about memory, concentration, attention, scholastic achievement.

Table (6): Correlation between concern of parents about memory, concentration, attention, scholastic achievement and results of SPIN test & DDT

Central auditory processing tests		Concern of Parents about				
		Memory	Concentration	Attention	Scholastic achievement	Nill
SPIN in right ear	Normal	23.1%	46.2%	30.8%	15.4%	38.5%
	Abnormal	56.8%	75.7%	70.3%	43.2%	8.1%
	P-value	0.037	0.050	0.012	0.072	0.010
	Sig.	S	NS	S	NS	S
SPIN in left ear	Normal	22.2%	44.4%	11.1%	22.2%	44.4%
	Abnormal	53.7%	73.2%	70.7%	39.0%	9.8%
	P-value	0.087	0.094	0.001	0.342	0.010
	Sig.	NS	NS	HS	NS	S
DDT version I in right ear	Normal	48.6%	59.5%	56.8%	27%	18.9%
	Abnormal	46.2%	92.3%	69.2%	61.5%	7.7%
	P-value	0.877	0.029	0.430	0.026	0.342
	Sig.	NS	S	NS	S	NS
DDT version I in left ear	Normal	45.7%	57.1%	57.1%	22.9%	20.0%
	Abnormal	53.3%	93.3%	66.7%	66.7%	6.7%
	P-value	0.621	0.012	0.529	0.003	0.239
	Sig.	NS	S	NS	HS	NS
DDT version II in right ear	Normal	21.1%	42.1%	42.1%	10.5%	42.1%
	Abnormal	64.5%	83.9%	71%	51.6%	0%
	P-value	0.003	0.002	0.043	0.003	0.000
	Sig.	HS	HS	S	HS	HS
DDT version II in left ear	Normal	32.1%	53.6%	53.6%	10.7%	28.6%
	Abnormal	68.2%	86.4%	68.2%	68.2%	0%
	P-value	0.011	0.014	0.295	0.000	0.006
	Sig.	S	S	NS	HS	HS

There was a significant correlation between SPIN test and concern of parents about memory & attention and a significant correlation between DDT and concern of parents about memory, concentration, attention& scholastic achievement.

Table (7): Correlation between concern of parents about memory, concentration, attention, scholastic achievement and results of auditory vigilance test & memory tests

Central auditory processing tests		Concern of Parents about				
		Memory	Concentration	Attention	Scholastic achievement	Nill
Auditory Vigilance	normal	30%	35%	30%	15%	40%
	abnormal	60%	90%	80%	50%	0%
	P-value	0.038	0.000	0.000	0.012	0.000
	Sig.	**S**	**HS**	**HS**	**S**	**HS**
Recognition memory	normal	36.1%	66.7%	58.3%	25%	22.2%
	abnormal	78.6%	71.4%	64.3%	64.3%	0.0%
	P-value	0.007	0.746	0.700	0.009	0.054
	Sig.	**HS**	NS	NS	**HS**	NS
Memory for content	normal	33.3%	61.1%	50%	30.6%	22.2%
	abnormal	85.7%	85.7%	85.7%	50%	0%
	P-value	0.001	0.094	0.021	0.198	0.054
	Sig.	**HS**	NS	**S**	NS	NS
Memory for sequence	normal	25%	62.5%	56.2%	18.8%	25%
	abnormal	58.8%	70.6%	61.8%	44.1%	11.8%
	P-value	0.026	0.567	0.710	0.081	0.234
	Sig.	**S**	NS	NS	NS	NS

There was a significant correlation between auditory vigilance test and concern of parents about memory, concentration, attention & scholastic achievement, and a

significant correlation between memory tests and concern of parents about memory, attention & scholastic achievement.

AFT have no significant correlation with duration of mobile phone use in hours /day & concern of parents about memory, concentration, attention& scholastic achievement.

DISCUSSION:

Mobile phones and video games have drastic effect on academic performance in school-aged children [8]. In the present work, history of mobile phone and video game usage were taken from parents, children play more using mobile phones than computers or laptop as they are the cheapest, more accessible and mostly available in most homes. Regarding the type of games, violence and racing games were the most favorite games, this is because they are most attractive for children. This agreed with Lenhart et al Who reported that most of children played combined games and racing games were the most common [9]. In addition, Anderson & Bushman reported that Children who play more violent video games are more likely to have increased aggressive thoughts, feelings, and behaviors, and decreased prosocial helping [10].

As regard central auditory processing tests, in the present study, most of the children had abnormal scores in SPIN test across all age groups; (78.9% of age group I, 81.8% in group II and 65% in age group III) **(table 1)**. Speech in Noise test used for testing selective auditory attention ability, which is important for many life situations.

The available published literature (Wu et al) found that action video games (AVGs) have been shown to enhance visual and auditory attention after the experience of quickly; recognizing targets (e.g., in shooter games), responding to opponents (e.g., in fighting games) or changing formations (e.g., in sports games)[11]. A possible explanation for this difference than the present study is that Wu et al measured visual and auditory attention which is not the case of the present study which focus on selective auditory attention which has verbal loads.

Binaural integration was tested by DDT version I & II in the present study, the test showed low scores in all age groups **(table 1)**. This could be explained by the affection of the memory reported by the parents as the DDT especially version II needs memorization of the four digits. There was statistically significant correlation between DDT version I & II of the test (both ears) and duration of use of mobile phone in hours/day **(table 4)**, Accordingly, the duration of mobile phone use was the factor that showed an impact on the binaural integration ability.

As regard temporal processing ability, AFT encountered abnormality in all age groups; being highest in the older age group up to 45% **(table 3).** This finding is unexpected as with increase age the maturation process of the CNS takes place and performance would be better. Nevertheless, the effect of prolonged duration of mobile phone use on the temporal resolution ability may have a negative impact in older children.

Unfortunately, we didn't find any research studying the effect of video games on auditory temporal resolution. A lot of research explored the temporal visual resolution and other visual perception abilities suggesting that expert video game players (VGPs) showed enhanced visual attention and visuospatial abilities, but what underlies these enhancements remains unclear.

In the present study all age groups were affected in all memory tests being more in sequential memory **(table2)**. Also in the parents' point of view who reported that

the memory was the most affected ability in the children.

In agreement with the present study previous studies have presented conflicting evidence concerning the effects of mobile phone use and video games on memory. It was reported that highly arousing media impaired memory immediately after use, as video games interfere with memory consolidation[12]. However, excessive mobile phone use was related to poorer accuracy on working memory and associative learning tasks[13].

On the other hand, Haarala et al reported that a 902-MHz mobile phone did not affect short-term memory in humans [14], also there were no effects on performance of an auditory and visual memory task, using both CW (continuous wave) and PM RF (pulse- modulated radiofrequency) exposure [15]. As regard the previous studies, it was not known the type of memory measured and the time and duration of exposure to mobile phone and video games.

Additionally, in the present study it was found that there was a correlation between duration of mobile phone use and central auditory abilities as memory and attention **(table 5)**. Duration of mobile phone use and screen exposure were more than the recommended time **(table 4&5)**. The World Health Organization (WHO) guideline recommends no screen exposure to children less than 2 years old and not more than 1 hour of screen time to children of 2–4 years of age [16], furthermore the American Academy of Pediatrics (AAP) guidelines, the recommended screen time for children above the age of 2 years is less than one hour per day [17]. As it was reported from the literature that the duration of mobile phone use has an impact on health of the children [18,19] and there were no studies on the auditory attention and memory, so it could be extrapolated that the duration of mobile phone and screen time exposure has an impact on the central auditory abilities as it was obvious in the attention and memory abilities.

Attention is one of the main cognitive domains in which video games are involved. Sustained attention, or vigilance, has been defined as the aspect involving continuous processing of information over time. Auditory vigilance test was used for testing sustained attention cognitive ability. **(Table 2)** showed that majority of the children had abnormal auditory vigilance test results in all age groups. Additionally, in the present study there was statistically significant correlation between auditory vigilance test and duration of mobile phone use in hours/day **(table 5)**. Abramson et al reported that excessive mobile phone use may be related to an impulsive response style of children. In this context, impulsive response style or 'impulsive behavior' refers to the tendency of children to respond before they know the correct answer. Corresponding to this, children who used mobile phones more were faster but less accurate on a number of tasks, suggesting that they may be more impulsive than other children, favoring a quick, and not accurate solution [13]. This was in agreement with the present study and may explain the reduced scores in auditory vigilance test.

In the present study the results of central auditory processing tests have a significant correlation with the concern of parents about memory, concentration, attention and scholastic achievement **(table 6, 7)**, also from the parents' point of view it was found that 36% of children had moderate to poor scholastic achievement. In the present study this could be attributed to the affection of the attention and memory. Another explanation that the children too involved in the video game playing to do their homework.

In addition, the results of the present work agreed with other studies who reported that the effects of exposure to all media content such as TV, movies, and excessive video game playing was correlated with a

lack of concentration, increased inattention and poor educational outcome [20, 21]. Time spent playing games was a negative predictor of academic performance and that those who played video games more often had poorer grades than those who played less [22, 23].

Finally, from the present work it could be concluded that the children who excessively use mobile phone and video games usually have poor scholastic achievement and they should be assessed for the central auditory processing abilities. The central auditory processing deficit is un seen disability, so decreasing the time of usage of mobile phones and all technology including video games and central remediation program would improve the central processing ability which in turn has an impact on the scholastic performance of those children.

Conclusions:

Using mobile phones and video games have a negative impact on central auditory processing abilities. Duration of mobile phone use per day is significantly affecting the central auditory processing abilities, which in turn have a negative impact on scholastic performance of the children.

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تاثير استخدام الاجهزة المحمولة على المعالجة السمعية المركزية فى الاطفال: العنوان

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المقدمة: تستخدم الهواتف المحمولة على نطاق واسع فى جميع أنحاء العالم. أثارت الموجات الكهرومغناطيسية المتولدة من الهواتف المحمولة مخاوف لأنها قد يكون لها اثار ضارة على الجهاز السمعى والتحصيل الدراسى لدى الأطفال بسبب الاستخدام اليومى للهواتف المحمولة.

هدف البحث: فحص قدرات المعالجة السمعية المركزية لدى الأطفال في سن المدرسة ممن يستخدمون الهواتف المحمولة ويلعبون ألعاب الفيديو.

المرضى والطرق: ٥٠ من الأطفال ذوى السمع السليم الذين تتراوح أعمارهم بين ٦ و ١٢ عامًا. معايير الاشتمال: الاطفال ذوى السمع الطبيعى ووظيفة الاذن الوسطى طبيعية, اختبار معدل الذكاء ضمن الحدود الطبيعية, من مستخدمي الهواتف المحمولة وممن يلعبون العاب الفيديو. اجراءات الدراسة: التاريخ المرضى كاملا مأخوذ من الوالدين وتاريخ التحصيل الدراسى, التقييم النفسى: استخدام الاصدار الخامس من مقياس الذكاء ستانفورد بينيه, تقييم سمعى مبدئى, صحيفة مدارة للاباء عن تاريخ استخدام الاطفال للهواتف المحمولة, استبيان يقدم للاباء لفحص المعالجة السمعية المركزية, تقييم المعالجة السمعية المركزية بواسطة بطارية الاختبار السمعى المركزى للاطفال والتى تشمل الاختبارات التالية: اختبار تفسيرالكلام فى خلفية من الضوضاء للاطفال, اختبارمجموعة الارقام المتلاحمة (الاصداران الأول والثانى), اختبار الالتحام السمعى, اختبارات الذاكرة السمعية, اختبار الانتباه السمعى.

النتائج: كان معظم الاطفال يلعبون ألعاب الفيديو على الهواتف المحمولة, وكانت ألعاب السباق أكثر الألعاب المفضلة. كان لدى معظم الاطفال اضطراب فى اختبار تفسيرالكلام فى خلفية من الضوضاء, و اختبارمجموعة الارقام المتلاحمة الأول والثانى, واختبارات الذاكرة(الذاكرة التسلسلية) واختبار الانتباه السمعى. ترتبط مدة استخدام الهاتف المحمول يوميا بشكل سلبى بنتائج الاختبارات للمعالجة السمعية المركزية.

النهاية: الهواتف المحمولة وألعاب الفيديو لها تأثير سلبى على قدرات المعالجة السمعية المركزية التى لها تأثير على الانتباه والذاكرة والأداء الأكاديمى.