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ORIGINAL ARTICLE

Quality of interactive media use in early childhood and child development: a multicriteria analysis☆,☆☆

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Abstract
Objectives: (1) To develop an index that allows the measurement of the quality of interactive media used by children in early childhood. (2) To verify whether there is an association between the index and cognitive development, expressive language, and fine and gross motor development.
Methods: A quantitative, cross-sectional, exploratory study with 103 children, aged 24 to 42 months, evaluated by the Bayley Scale of Infant and Toddler Development. The criteria for the index were selected from the literature: (1) media use by parents; (2) time of daily media use; (3) media type; (4) what do you use the media for; (5) who do you use the media with (6) monitoring (limits time, content, interacts during use); (7) purpose of use; (8) parents' opinion of the media. For development of the multicriteria index, the multi-attribute utility theory was applied, and Spearman correlation and simple linear regression ($p < 0.05$) were used to verify the association between the index and child development.

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Results: The index showed a positive and significant correlation with child development in the following domains: language ($r = 0.40$, $p < 0.001$), cognitive ($r = 0.23$, $p = 0.04$), and fine motor $= 0.22$, $p = 0.04$). Simple linear regression analysis showed that the use of interactive media accounts for 22% of language development ($p < 0.001$).
Conclusion: The multicriteria index developed to verify the quality of interactive media used by children in early childhood showed that it has the potential to be used. The positive and significant associations between the quality of interactive media use and child development was verified, mainly regarding language.

PALAVRAS-CHAVE
Desenvolvimento infantil;
Aplicativos Móveis;
Qualidade

Qualidade de uso de mídias interativas na primeira infância e desenvolvimento infantil: uma análise multicritério

Resumo
Objetivos: (1) Elaborar um índice que possibilite mensurar a qualidade de uso de mídias interativas por crianças na primeira infância. (2) Verificar se há relação entre o índice e o desenvolvimento cognitivo, linguagem expressiva, motor fino e grosso.
Métodos: Estudo quantitativo, transversal, exploratório, com 103 crianças de 24 a 42 meses avaliadas pela *Bayley Scale of Infant and Toddler Development*. Os critérios para o índice foram selecionados a partir da literatura: (1) uso de mídias pelos pais; (2) tempo de uso de mídia/dia; (3) tipo de mídia; (4) para que usa a mídia; (5) com quem usa a mídia (6) acompanhamento dos pais (limita tempo, conteúdo, interage durante); (7) objetivo do uso; (8) opinião dos pais sobre a mídia. Para a elaboração do índice multicritério foi aplicado o *Multi-Attribute Utility Theory* e para verificar a relação entre o índice e o desenvolvimento infantil a análise de Correlação de Spearman e Regressão Linear Simples ($p < 0,05$).
Resultados: O índice apresentou correlação positiva e significativa com o desenvolvimento infantil nos domínios: linguagem ($r = 0,40$, $p < 0,001$), cognitivo ($r = 0,23$, $p = 0,04$), motor fino ($r = 0,22$, $p = 0,04$). A análise de regressão linear simples demonstrou que o uso de mídias interativas explica 20% do desenvolvimento da linguagem ($p < 0,001$).
Conclusão: O índice multicritério elaborado para verificar a qualidade das mídias interativas em crianças na primeira infância mostrou ter potencial para aplicação. Constatou-se a relação positiva e significativa entre a qualidade de uso de mídias interativas e o desenvolvimento infantil, principalmente para a linguagem.

Introduction

Society has experienced a profound lifestyle change, intensified in recent times with the advent of technology. Media use has become common among people, incorporated into life habits in different age groups and social contexts.[1]

There is extensive literature related to the use of television[2] and a contemporary emergence of studies that address the impacts of interactive media, a technology considered to be recent.[3–5] Interactive media is understood as technology that responds with content to the users' actions, making dialog and participation possible.[3] It can also be said that how this technology impacts child development is still little known.[4,5]

The family environment is an important predictor of child development, because it is the family's responsibility to provide a favorable environment, adequate stimuli, and learning material.[6] Currently, in addition to books and toys, there is also interactive media.[1,3] However, there is little evidence on how to best use these devices. Studies show that excessive use can lead to dependence, compulsive use, and difficulty in social interaction.[1,7] However, some argue that, when used with diligence, it could represent a resource for child development stimulation.[3,8]

Thus, the aim of the present study was to develop an index that synthesizes the criteria presented in the literature, which makes it possible to measure the quality of interactive media use by children in early childhood, *i.e.*, children from 0 to 3 years of age. It also intended to verify if there is an association between the quality of the developed index and the children's development in different domains. The results of the present study are expected to promote discussion and help both parents and specialists regarding the rational use of interactive media.[9–11]

Methods

This was a quantitative, cross-sectional, exploratory study, approved by the Research Ethics Committee (Opinion No. 1830742). Children with typical development, aged between 24 and 42 months, enrolled in public and private institutions in 2016 in a small Brazilian municipality, were eligible for the study. This study excluded children that: (a) did not use interactive media (smartphone/tablet); (b) whose parents provided incomplete answers to the interactive media questionnaire; (c) had a medical diagnosis of congenital/acquired disease that might interfere with the cognitive, motor, or language performance; (d) did not participate in the child development assessment (parental decision or child's refusal).

For the sample size calculation, the authors considered a prevalence of mobile interactive media use of 67% among children aged 2 and 3 years in the study population[12] with a desired accuracy of 10%, 95% confidence interval, and study design effect = 1. Considering the population of 432 children, an adjustment for a finite number was performed, resulting in 72 children.

In order to understand the habits related to interactive media use, a questionnaire was applied, based on the literature[3–5,7,9–11] (Supplementary Material). Additionally, a sociodemographic questionnaire and the Brazilian Criteria of Economic Classification (Critério de Classificação Econômica Brasil [CCEB]) were applied for economic classification.[13]

Child development was measured using the third edition of the Bayley Scale of Infant and Toddler Development (Bayley-III)[14] used in clinical practice and in research[15] for the evaluation of child development. For the study, the following scales were applied: cognitive development, expressive language, and fine and gross motor development, scored based on the sum of tasks performed by the child, generating crude scores. Aiming at standardizing the scores of the different applied scales, it was decided to use the equivalent age, which represents the average age in months in which a given total crude value is typical. Moreover, Milne et al.[16] consider that the standardized scores of the Bayley-III scale overestimate the children's development and encourage the use of equivalent age as an alternative.

The questionnaires about the use of interactive media and the CCEB were sent home in the children's backpacks and answered by their parents. The Bayley-III was applied in the school environment, by four evaluators, after training and verification of the inter-examiner reliability, with an intraclass correlation index of 0.95%.

The multi-attribute utility theory (MAUT) was used, known as the multicriteria decision aid, which is a tool used in case of multiple factors in the evaluation process, making it possible to identify, characterize, and combine different variables.[17,18] The stages of MAUT are described as follows:

Criteria selection

According to the MAUT, the selected criteria must faithfully represent what will be evaluated.[17] Therefore, in the present study, the selected criteria were based on the literature and are shown in Table 1 (first column).

Table 1 Phases of the multi-attribute utility theory for the quality of interactive media.

Criteria	Possible answers	Assigned score
Media use by parents	- Yes	1
	- No	0
Time of media use/day in minutes	- ≥2 h (120 min)	1
	- <2 h	Time in minutes/120 min
Media type	- Tablet	1
	- Smartphone	1/2
What do you use the media for?	- Playing games	1
	- Use of educational applications	1
	- Read stories/listen to songs	1/4
Who do you use the media with?	- Parent/adult caregiver	1
	- Another child	1/2
	- Alone	0
Parental monitoring	- Time limit	1/3
	- Content limit (inappropriate)	1/3
	- Stimulates, interacts, plays together	1/3
Purpose of use	- Recreation or stimulate the development	1
	- Distract in public/at home	0
Parent's opinion of the media	- Positive	1
	- Does not have an opinion	1/2
	- Negative	0

Establishing a usefulness scale for the scoring of each criterion

This phase aims to compare the quantifications of the selected criteria on the same ordinal scale. In the present study, the selected criteria obtained responses that were quantified according to the attributes described in Table 1 (second column). At this stage, the responses were converted into numeric variables by means of an increasing ordinal scale ranging from 0 to 1 (third column of Table 1).

For the first criterion, ''media use by parents,'' the child scored 1 if the parent used the media as a model.[1,19,20] The second criterion, ''daily time of interactive media use,'' the time of 2 hours was considered as the reference, according to the American Academy of Pediatrics (AAP).[9] For the third criterion, ''media type,'' it was decided to assign a higher score to the tablet in relation to the smartphone, considering that its screen size facilitates media use and favors interactive activities.[21,22] The fourth criterion, ''what do you use the media for,'' scored 1 when the child used it for interactive activities, such as playing games and 0.25 for passive activities but with a certain possibility of interaction, such as watching stories/listening to music.[3,11]

For the fifth criterion, ''who do you use the media with,'' it is known that children in early childhood make better use of media through parental mediation.[23,24] Therefore, it received a total score if the child used the media with an adult (parents),[23,24] and half if he/she used it with another child.[24] The child scored 0 if he/she used the media alone. For the sixth criterion, ''monitoring,'' it measured whether an adult limited media use time, inappropriate content, and whether the parent encouraged/interacted with the child during media use. In this case, the total score was given to those who answered affirmatively for all items, and proportionally received a lower score if the answer was affirmative for one or two of the items. As for the seventh criterion, ''purpose of use,'' the children whose parents answered that they used the resource to stimulate development or to favor recreation scored 1, and they scored zero when it was used to distract them (regulate behavior) in public/at home.[3] Finally, ''the parents' positive opinion of the media'' scored 1 point, since when parents believe the use of interactive media favors development, they tend to encourage the child to use it more frequently. The parent who declared having no opinion about media use scored 0.5.[1]

For the study, equal weights were used for the different criteria, assuming that each selected factor has the same degree of relevance in the process of quality of media use by children.

Calculation of the multicriteria index

The multicriteria index refers to the weighted sum of the different evaluations of criteria. As in this study the weights considered for each criterion were the same, an average was calculated of the evaluations of all the criteria for each participating child, to calculate the multicriteria index. The final multicriteria score for each child ranged from 0 to 1 point. Eq. (1) shows how this calculation was performed (n = number of evaluated criteria):

$$multicriteria\ index_{child\ i} = criteria\ \ evaluation\ \ 1_{child\ \ i}\ \ weight_{criterion\ \ 1} + \cdots + criteria\ \ evaluation\ \ n_{child\ \ i} weight_{criterion\ \ n} \quad (1)$$

Validation of results

At this step, it is verified whether the utilized multicriteria methodology met the proposed objective.[17] In the present study, the authors aimed to verify whether children with higher values in the multicriteria index had better developmental results. For this purpose, a correlation analysis was performed between the multicriteria indices and the Bayley-III development scales. As the variable multicriteria index did not have a normal distribution, a Spearman correlation analysis was performed.

Then, those variables that had a correlation >0.20 were submitted to a simple linear regression analysis aiming to verify how much the multicriteria index could explain the studied domains of child development.

For the sample calculation, this study used OpenEpi (Open Source Epidemiologic Statistics for Public Health, Vesion 3, www.OpenEpi.com). The Excel program (Microsoft, WA, USA, 2010) was used to formulate the multicriteria model; subsequently, the data were transferred to SPSS software (IBM SPSS Statistics for Windows, Version 19.0, NY, USA), to perform the analysis of Spearman's correlation and the simple regression analysis ($p < 0.05$). The calculation of the statistical power of the study was performed using the software GPower 3.1 (G Power, Heinrich-Heine-Universität Düsseldorf, Germany).

Results

The supplementary figure shows the detailed composition of the sample. A total of 104 children from seven public and two private schools participated in this study. For each Bayley-III subscale, the sample composition was different, considering that not all children performed the full scale.

The median of the children's chronological age was 36 (23–42) months, distributed similarly between the genders, and the majority attended public day care centers. Most families were in classes C and B and the mothers were adults. As for maternal schooling, more than half have at least completed high school education. There was a predominant use of smartphones in relation to tablets, and although the median use of media was less than 60 min a day, the range of media use time was broad (Table 2).

After calculating the multicriteria index for each child, a correlation analysis of the quality of media use was performed with the results obtained in the Bayley-III development scales (Fig. 1).

The median of equivalent ages for the cognitive, language, fine motor, and gross motor scales of Bayley-III were, respectively, 35 (23–42) months, 39 (20–42) months, 40 (23–42), and 33 (21–42) months.

The children who achieved higher values of the multicriteria index reached higher scores in the language

Table 2 Sociodemographic and media use characteristics.

Characteristics (n = 104 children)		
Economic classification, *n* (%)	Level A	7 (6.7)
	Level B	36 (34.6)
	Level C	47 (45.2)
	Level D-E	14 (13.5)
Gender, *n* (%)	Male	47 (45.2)
	Female	54 (54.8)
Mother's age, years	Up to 20	6 (5.8)
	Equal to or older than 20	98 (94.2)
Maternal schooling *n* (%) (*n* = 103 children)[a]	Up to 4th grade of elementary school	2 (1.9)
	Complete elementary school	18 (17.3)
	Complete high school	49 (47.1)
	Complete College/university	24 (23.1)
	Complete postgraduate school	10 (9.6)
School type, *n* (%)	Private	32 (30.8)
	Public	72 (69.2)
Smartphone use, *n* (%)	Does not use	12 (11.5)
	Uses	92 (88.5)
Tablet use, *n* (%)	Does not use	65 (62.5)
	Uses	39 (37.5)
Daily time of use in minutes Median (minimum-maximum)		45 (10–480)

[a] Undeclared child's maternal data.

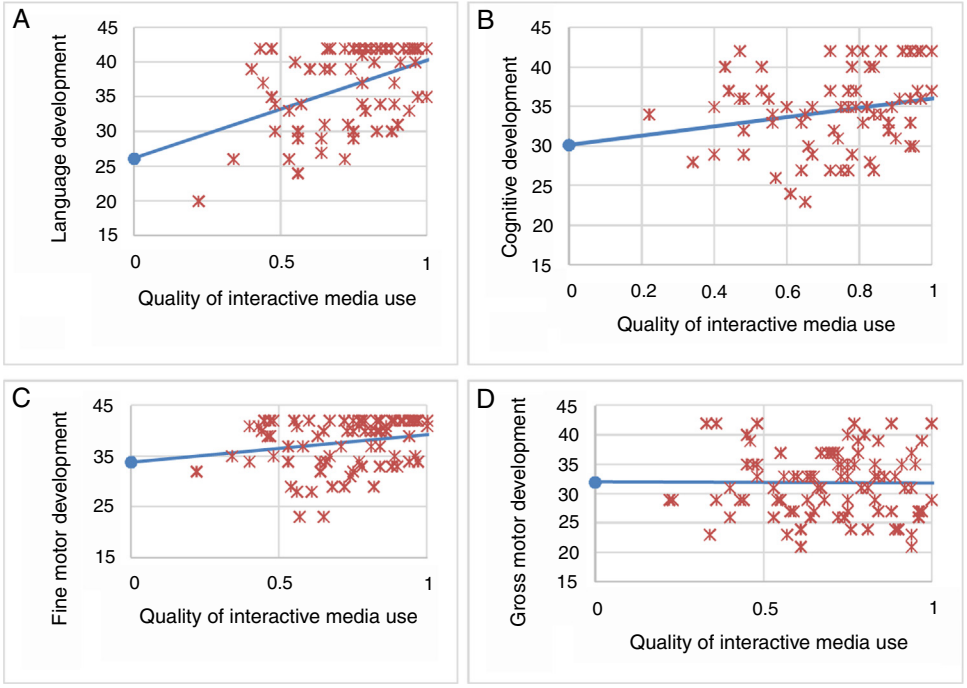

Figure 1 Correlation between the child's development and the quality of interactive media use.
Y-axis, Equivalent age on the Bayley scales in the different domains of child's development; *X*-axis, multicriteria analysis of the quality of interactive media use. (A) Moderate correlation between language development and quality of interactive media use. (B) Low correlation between cognitive development and quality of interactive media use. (C) Low correlation between fine motor development and quality of interactive media use. (D) Absence of correlation between gross motor development and quality of interactive media use.

(Fig. 1A), cognitive (Fig. 1B), and fine motor (Fig. 1C) scales. For language, the correlation between the variables was statistically significant ($p < 0.001$), positive, and moderate ($r = 0.40$), with a statistical power of 91%. For the fine motor scale, the correlation between the variables was statistically significant ($p = 0.04$), positive, and weak ($r = 0.22$), with a statistical power of 55%. For the cognitive scale, the correlation between the variables was statistically significant

Table 3 Simple linear regression analysis of Bayley-III with the multicriteria index.

Child development – Bayley III	Multicriteria of the quality of interactive media use			
	r^2	$b \pm$ SE	β	p
Cognitive scale	0.05	5.85 ± 3.16	0.22	0.07
Language scale	0.20	14.07 ± 3.65	0.44	0.00[a]
Fine motor scale	0.04	5.39 ± 2.98	0.20	0.07

r^2, coefficient of determination; b, straight-line coefficient; SE, standard error; β, standardized coefficient; p, statistical significance.
[a] Significant at the level of <0.001.

($p = 0.04$), positive, and weak ($r = 0.23$), with a statistical power of 53%. Fig. 1D shows the correlation between the multicriteria indices and the gross motor scale. No statistically significant correlation ($r = 0.01$) was found ($p = 0.9$), indicating that no association was found between quality of interactive media use and gross motor development.

Table 3 shows the results of the simple linear regression analysis. It can be observed that the multicriteria index explains 20% of the performance in the language scale. For the cognitive and fine motor domains, the coefficient of determination was not statistically significant.

Discussion

This study's aim was to create an index that synthesizes criteria for the quality of interactive media used by children in early childhood, considering that children have access to interactive media at an increasingly early age.[3] Unlike the computer, which requires visual coordination and manual skills to handle the keyboard and mouse, interactive media has been shown to be more accessible, and at 2 years of age the child has the capacity to make interactive and purposeful use,[4] although improvement in terms of accuracy and speed regarding the touching of the screen occurs during childhood.[4,10]

Most of the participants in the study belonged to the middle class, followed by the upper-middle class in the economic classification, and studied in public schools. Considering the objectives of the present study, those children who did not use interactive media were excluded. However, it is known that although interactive media are increasingly accessible to all ages and economic classes,[1] economically disadvantaged children still have less access to this type of media.[10,12] Most mothers were adults and had at least completed high school education. Many of these indicators point to a higher quality of care and the promotion of a more favorable environment for child development.[6]

The AAP[10] recommendation, in addition to discouraging the use before 2 years of age, limits the total screen time to two hours a day starting at 2 years of age. The Brazilian Society of Pediatrics (SBP),[25] in turn, recommends that the time of exposure to the screens for the age group of 2 to 5 years should be up to one hour per day. In the present study, the median time in minutes of children's use of media was within the recommendations of the AAP and SBP, although the time frame was broad, and some children used the media for up to eight hours. Studies carried out in other countries report that most children at 2 and 3 years of age exceed the recommended use time.[4,5]

The multicriteria index showed the potential to evaluate the quality of media use, since in the validation phase it demonstrated statistically significant and positive correlation with the domains of language, cognitive, and fine motor development, with a high study power for the former and moderate for the latter two. It should be noted that the observed correlations were weak to moderate, possibly justified by the fact that child development is a multifactorial construct, with dynamic interactions between aspects of the environmental context and genetics.[6]

Regarding cognitive development, early contact with media can promote the development of digital literacy skills, important for the cognitive aspects of development.[26] Huber et al.,[27] studying children from 4 to 6 years of age playing the Tower of Hanoi puzzle in the physical version and another group using the touchscreen version of the puzzle, found significant improvement in the task resolution, regardless of the version (touchscreen *vs.* physical version). The authors concluded that children are able to transfer learning from touch-screen devices to the world of real objects.

Regarding the aspect of the media benefits in the development of fine motor skills, a controversy remains.[22,26,28] In an experimental study, the authors compared the development of fine motor skills in children who used tablets with those who performed fine motor activities in the real context. The researchers found that fine motor accuracy and manual dexterity improved in children who did not use the tablet, when compared to those who used it. The authors justified it with the fact that real-life actions such as grabbing objects, drawing, and handling, involve greater muscle strength, coordination, and dexterity in relation to fine motor activities on the tablet.[28]

However, other authors found an association between tablet use and improvement in fine motor skills.[22,26] Price et al.[26] highlighted similarities between the virtual environment of the tablet screen and the physical environment of the painting canvas. The authors found similar movements in both environments, such as tapping, circular lines, and straight lines. Moreover, the virtual environment allowed greater opportunity for the repetition and continuity of movements. Thus, the authors emphasize the importance of movement training in the virtual environment to learn the preparatory skills for painting in the physical context.

As for the gross motor development, no correlation was found with the quality of interactive media use. In general, the literature points out that there is an inverse association between the development of gross motor skills and the use of media, since the assessed interactive media activities offer a reduced repertoire of exploration of environmental

physical spaces, which is a negative factor for gross motor skill.[1]

The domain of child development that showed the greatest correlation with the multicriteria index was language, and the index of determination showed that the quality of the interactive media use can predict the child's language development by 20%. This result is interesting, because the literature shows studies that associate media exposure to language development delay.[3] However, this fact can be justified because the aforementioned studies mainly used television as the media source. The present research focused on the quality of interactive media use that, unlike TV, allows interaction and communication between the child and the device.[3] Thus, through interactive games, applications, and educational devices, these media contribute to activities that precede literacy skills and increase vocabulary.[8,11,29]

A study performed with American children, aged between 2 and 12 years, using a touchscreen application, found that children learned new object names while touching or dragging an object across the screen.[29] Another study points out that children using e-books learn to read equally well, and sometimes more than those using printed books.[8] The findings suggest that interactivity[30] and content may be more important factors to be considered than simply ''screen time,'' which reinforces the importance of the quality of interactive media use for young children.

In this sense, the multicriteria analysis meets a current demand in the care of the pediatric population, regarding the construction of parameters that indicate the quality of the media use. The model and the parental beliefs regarding the media use,[19,20] the media type and the purpose of its use,[11,21] and the interaction with other people during the use, especially the parents,[8,23,24] are criteria to be considered before providing these devices to young children, who are positively or negatively influenced by the resources they use.

As study limitations, the fact that the study design does not allow a cause-effect association must be mentioned. However, the present study shows potential in this topic for the performance of future experimental research that will provide further supporting evidence. Another point to highlight was the use of a questionnaire, which potentiates a memory and social desirability bias; however, this has been the resource used in most studies.[4,5,11,22]

The present multicriteria index, designed to assess the quality of interactive media used by children in early childhood, has shown potential for its application. A positive and significant association was observed between the quality of interactive media use and children's development in the domains of language, cognition, and fine motor development, especially regarding language.

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Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jped.2018.11.015.

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