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ORIGINAL ARTICLE

Factors predicting sensory profile of 4 to 18 month old infants

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Received 9 July 2014; accepted 17 November 2014

KEYWORDS

Infant;
Child development;
Environment

Abstract

Objective: To identify environment factors predicting sensory profile of infants between 4 and 18 months old.

Methods: This cross-sectional study evaluated 97 infants (40 females e 57 males), with a mean age of 1.05 ± 0.32 years with the Test of Sensory Functions in Infants (TSFI) and also asked 97 parents and 11 kindergarten teachers of seven daycare centers to answer the Affordances in the Home Environment for Motor Development-Infant Scale (AHEMD-IS). The AHEMD-IS is a questionnaire that characterizes the opportunities in the home environment for infants between 3 and 18 months of age. We tested the association between affordances and the sensory profile of infants. Significant variables were entered into a regression model to determine predictors of sensory profile.

Results: The majority of infants (66%) had a normal sensory profile and 34% were at risk or deficit. Affordances in the home were classified as adequate and they were good in the studied daycare centers. The results of the regression revealed that only daily hours in daycare center and daycare outside space influenced the sensory profile of infants, in particular the Ocular-Motor Control component.

Conclusions: The sensory profile of infants was between normal and at risk. While the family home offered adequate affordances for motor development, the daycare centers of the infants involved demonstrated a good quantity and quality of affordances. Overall, we conclude that daily hours in the daycare center and daycare outside space were predictors of the sensory profile, particular on Ocular-Motor Control component.

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DOI of original article: <http://dx.doi.org/10.1016/j.rpped.2014.11.016>

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PALAVRAS-CHAVE

Lactente;
Desenvolvimento
infantil;
Meio ambiente

Fatores preditores do perfil sensorial de lactentes dos 4 aos 18 meses de idade**Resumo**

Objetivo: Identificar os fatores ambientais preditores do perfil sensorial de lactentes dos quatro aos 18 meses de idade.

Métodos: Estudo transversal com 97 lactentes (40 do sexo feminino e 57 do masculino), com idade média de $1,05 \pm 0,32$, aos quais foi aplicado o Test of Sensory Functions in Infants. Responderam ao questionário Affordances in the Home Environment for Motor Development-Infant Scale 97 pais e 11 educadoras de sete creches, de forma a caracterizar o contexto familiar e de creche, e relacionou-se ao perfil sensorial dos bebês. O AHMED-IS é um questionário que caracteriza as oportunidades no ambiente para crianças entre três e 18 meses de idade. As variáveis que apresentaram uma associação significativa foram incluídas no modelo de regressão linear para determinar os fatores preditores do perfil sensorial.

Resultados: A maioria dos bebês (66%) apresentou um perfil sensorial normal e 34% deles encontram-se em risco ou em déficit (com problemas sensoriais). As oportunidades de estimulação na habitação foram classificadas como suficientes e nas creches foram avaliadas como boas. Os resultados da regressão revelaram que apenas os fatores “horas diárias na creche” e “espaço exterior de creche” influenciaram o perfil sensorial dos bebês, notadamente o controle oculomotor.

Conclusões: O perfil sensorial dos bebês situou-se entre o normal e em risco. O contexto familiar oferece oportunidades de estimulação suficientes e as creches demonstraram ter boas oportunidades. As horas diárias em creche e o espaço exterior em creche foram os preditores do perfil sensorial no controle oculomotor.

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Introduction

Early childhood is a phase of high neuroplasticity and neurological; and psychomotor changes contribute to better child development.^{1,2} Motor development depends on the sensorimotor experiences offered by the environment. Infants understand and better perceive their world³ through varied information from stimuli received by sight, sound, touch and object manipulation. An adequate sensory development is considered when it is in accordance with the sensory integration principles, which are related to the neurological bases and behavioral aspects. An adequate behavior is the result of an effective sensory integration.⁴ Moreover, effective processing of sensory stimuli at cortical level is essential for the development of perceptive-motor, emotional and cognitive functions.⁵ Biological maturation defines the parameters of child development, namely the structural and functional factors, such as body mass, height, strength and coordination; but the environment (physical, cultural and social context) and task demands influence the infant's sensory development.⁶

According to Caçola, Gabbard, Santos and Batistela,⁷ recently there has been an attempt to associate children's sensory development with the environment, more specifically with the affordances, a term introduced by Gibson,^{6,8} which refers to the interaction between the physical context in which the child is inserted and the existing stimulation opportunities (activities and toys), i.e., the way the context objects are organized and used. The evaluation of

affordances is crucial to better adequate these contexts to the children's needs and thus, assist their sensory development.^{9,10} The findings of these studies emphasize that the availability of toys and the characteristics of the physical space promote infants' sensorimotor development in the first years of life,¹¹⁻¹³ as an adequate exposure to stimuli results in good sensory integration.

The family is the first context babies have contact with and it can provide not only stimulation and protection, but also risks for the development of these infants,¹³ as the socioeconomic and cultural characteristics of each family can promote or influence stimulation opportunities for the child.¹⁴ Regarding the childcare context in Portugal, according to Decree No. 262/2011 of August 31st,¹⁵ the mandatory presence of a preschool teacher with the baby occurs only after the acquisition of walking. This legislation places more emphasis on basic hygiene and food, at the expense of stimulation and educational guidance directed at motor development. On the other hand, this decree points out that individualized care should be available according to the capabilities of each child, by providing educational activities, games and motor activities according to the age range and necessities of the children; however, it does not provide a technician that has been trained to implement this type of care. Regarding the physical space of the day-care, the Decree states that the indoor space must be divided into nursery, activity room with appropriate and safe toys, living and meal areas. The outdoor space must have a protected area for toys with wheels and an open

space with equipment to allow climbing, escalating and sliding. Most daycare centers in Portugal do not have an outdoor space, as they were created prior to this Decree. With the emancipation of women and their increasing participation in the workplace, most infants spend most part of their days in daycare (about 8 hours), so it is important to assess this context, as few studies have been carried out on the stimulation affordances for sensorimotor development in daycare and especially comparing them with the affordances at home and the child sensory profile.

Thus, this study sought to determine why some babies without neurological, orthopedic disease or history of prematurity have sensory deficits, which, without an early detection, could result in problems at school age, as well as delays in motor development and behavioral alterations. In this context, the present study has the general objective to verify whether there is an effect of family and childcare affordances on sensory development, identifying environmental factors that can predict the sensory profile of babies aged 4 to 18 months. The following were defined as specific objectives: 1- To characterize the sensory profile of infants; 2 - To characterize the family and childcare environments in relation to affordances; and 3 - To associate the sensory profile of infants with affordances.

Method

This is a cross-sectional study, with three convenience samples. The Institutional Review Board of Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano considered that the study meets the ethical principles of the Helsinki Declaration. Sample 1 consisted of 97 babies, with a mean age of 12 months (mean age 1.05 ± 0.32 years), and the inclusion criteria were: infants aged between 4 and 18 months, of both genders without orthopedic and neurological diseases or preterm infants with gestational age at birth <34 weeks without neonatal complications (Apgar score at 5 minutes ≥ 9 and birth weight $>2,500$ g). Sample 2 consisted of 97 parents (one per baby) and included those individuals that were motivated and interested in participating in the study, after providing informed consent. Finally, Sample 3 consisted of 11 kindergarten teachers from 7 daycare centers located in Vila Real, with each teacher being responsible for coordinating the room/class that babies attended. Prior authorization was required from the daycare centers to participate in the study, as well as availability of teachers that agreed to participate in it.

The tools used in this study were Test of Sensory Functions in Infants -TSFI,¹⁶ Affordance in the Home Environment for Motor Development-Infant Scale (AHEMD-IS) - Infant Scale (3-18 months)⁷ and a short questionnaire to collect information about the infants' physical context and routines, as well as some data on birth and medical care of the child, to complement the sensory profile characterization and environmental contexts.

The sensory profile was evaluated through the TSFI. This test evaluates the processing and sensory reaction in babies aged 4-18 months in the subtests of Subtest 1, Reactivity to

Tactile Deep Pressure; Subtest 2, Adaptive Motor Responses; Subtest 3, Visual-tactile Integration; Subtest 4, Ocular-motor Control; and Subtest 5, Reactivity to Vestibular Stimulation. We used the Portuguese version of the test, validated by Pedrosa and Ribeiro.¹⁷ Its use consisted in the test application as described in the manual, following the order of the items and using the indicated material. The test was applied by a single examiner trained in sensory integration and specifically for this assessment tool. The test was applied at the daycare, with the presence of the daycare teacher and lasting approximately 20 minutes per child. Each item was assessed using a scale of values ranging from 0-1 to 0-3. After each item was scored, the values obtained in each subtest were added and in the end, the scores obtained at each subtest were added, yielding the total test score, ranging between 0 and 49. These values are subdivided according to age, indicating the sensory profile classification between normal (33-49 for 4-6 months, 41-49 for 7-9 months and 44-49 for 10-12/13-18 months), at risk (30-32 for 4-6, 38-40 for 7-9 and 41-43 for 10-12/13-18 months) and deficit (0-29 for 4-6, 0-37 for 7-9 to and 0-40 for 10-12/13-18 months). Data reliability was verified using the intraclass correlation coefficient of the results obtained after the double application of the TSFI to a group of 10 children at the same age range of the group being studied, with values being >0.950 for all indices.

The affordances at home and in daycare were assessed through the self-reporting questionnaire AHEMD-IS, in its Portuguese version, which is the result of a partnership between laboratories studying Motor Development in the United States of America and Brazil. This questionnaire assesses stimulation affordances in infants, leading to motor development promotion through 41 items grouped into three groups: physical space at home (indoor and outdoor), daily activities, and toys (fine and gross motor skills) found at home. Although no scoring system has been validated for this questionnaire, the authors of the tool suggest an unofficial scoring system created by them. Thus, there are two types of response, the dichotomous choice (yes/no), in which the score ranges from 0-1, and the Likert scale, in which one point is assigned to each answer in the same question, starting from zero and going up to the maximum number of choices (0-5 outdoor space, 0-5 indoor space, 0-23 daily activities, with fine motor toys varying at ages younger and older than 12 months 0-15/0-33, as well as gross motor toys 0-18/0-27). The total score of the questionnaire ranges from 0-66/0-93, according to the age of the infants, which is obtained by adding the domains. As for the quantitative score, in some cases the same value may correspond to two different classifications depending on the age (e.g., a score of 30 means weak for a baby aged >12 months, but sufficient for an infant aged <12 months). A qualitative classification was attributed: weak, sufficient and good, with the following cutoffs: weak affordances 0-22 for age <12 months and 0-31 for age >12 months; sufficient affordances 23-44 for age <12 months and 32-62 for age >12 months; good affordances 45-66 for age <12 months and 63-93 for age >12 months. This questionnaire was completed by the daycare teacher; and at home, by the parents.

A short questionnaire was used to collect information about the physical context, infant routines and pregnancy/

delivery information. For a better understanding and confirmation of results obtained with the TSFI, semi-structured interviews were also carried out with the daycare teachers and assistants, as well as with some parents, on the sensorimotor performance of the babies, as well as direct observation of the babies during their daily routines in daycare aiming at ruling out the presence of temporary health problems, such as fever, teething, pain, or others, as these problems could affect test results.

Daycare centers and parents gave their consent to test application, as well as the test authors.

Data analysis was performed using the Statistical Package for Social Sciences, version 19 for Windows. First, the normal distribution of data was verified using symmetry and kurtosis. Based on the cutoffs of the tools, the sensory profile, family and childcare context were characterized regarding the stimulation affordances. Pearson's correlation coefficient was used to verify the association between the independent (biological and sociocultural - neonatal information and AHMED-IS domains) and the dependent variables (sensory profile areas - TSFI subtests). The variables that showed a significant association were included in the linear regression model in decreasing order of r value to determine the predictors.

Results

The TSFI application results showed that babies have, in mean \pm standard deviation, a sensory profile of 43.41 ± 5 , meaning that they are between the normal and at risk parameters. The final scores obtained after applying the TSFI ranged from a maximum value of 49 to a minimum value of 26, with the score of 47 being the one with the highest frequency (16.5%). Only 13 babies reached the maximum score of 49. Most infants are situated within the normal parameter (66%), although 34% showed an "at risk" (11.3%) or even a "deficit" sensory profile (22.7%).

The subtests showed results between "normal" and "at risk" parameters, except for the Adaptive Motor Responses, which, depending on age and cutoffs, showed results in the three classifications. As shown in Figure 1, the subtests that showed the highest mean values and, therefore, closer to the "at risk" and deficit parameters, were Adaptive Motor Responses and Reactivity to Vestibular Stimulation.

Regarding family affordances, mean values of 38.70 ± 6.71 for infants aged <12 months and 54.91 ± 11.15 for those aged >12 months were obtained, which was considered sufficient. The daycare affordances can be classified as good, considering that the mean total value was 69.88 ± 9.39 . Table 1 shows the mean values of affordances for AHMED-IS domains.

At home, the provision of toys for fine and gross motor skills is situated in the sufficient category, with these domains being the weakest ones in the stimulation of child sensory development. The indoor physical space stands out as being the best structured area to promote infant development. In all the evaluated daycare centers, the values obtained showed good opportunities in all domains, with indoor physical space being the one with the highest score. As seen at home, toys for gross and fine motor skills received

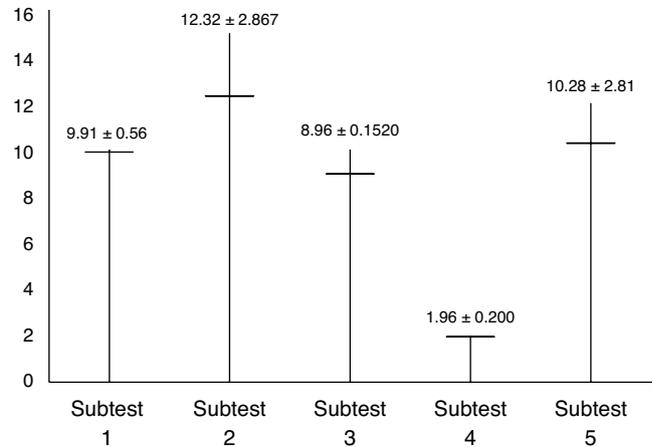


Figure 1 Mean values and standard deviation of the sensory profile per TSFI subtest.

Subtest 1, Reactivity to Tactile Deep Pressure; Subtest 2, Adaptive Motor Responses; Subtest 3, Visual-tactile Integration; Subtest 4, Ocular-motor Control; and Subtest 5, Reactivity to Vestibular Stimulation.

the lowest mean score (19.38 ± 5.449 and 24.63 ± 7.763 , respectively), even though they were classified as being good affordances.

The correlation results indicate an association between hours at daycare ($p=0.009$), daycare area ($p=0.047$), TV time in daycare ($p=0.012$) and outdoor space in the daycare ($p<0.001$) with the Ocular-Motor Control. There were no associations between biological factors and familiar affordances with the sensory profile (Table 2).

Linear regression was performed to verify which variables were predictive of the sensory profile, with the model including only variables with significant association (Table 3). The final model (hours in the daycare, daycare area, TV time in daycare and outdoor daycare space) explained 27.5% of Ocular-motor Control.

According to the model used, it was observed that the hours at the daycare ($p=0.035$) and the outdoor space of the daycare ($p=0.003$) are variables that can predict the sensory profile, being capable of explaining the babies' performance at the Ocular-motor Control subtest. As for the daycare area and the TV time in daycare, they showed no significant association ($p=0.855$ and $p=0.627$, respectively).

Discussion

There are controversial opinions on the effectiveness of the assessment and intervention in sensory integration,¹⁸ but many authors^{3,5,8,11,19} defend the importance of sensory integration in child development promotion. This study aimed to identify environmental factors that could predict the sensory profile of infants aged 4 to 18 months, characterizing the family and daycare context regarding the affordances. The results showed that 66% of the babies had a normal sensory profile. However, 11.3% and 22.7% of them showed at risk and deficit profiles, respectively. These

Table 1 Score according to the Affordances in the Home Environment for Motor Development-Infant Scale of stimulation opportunities at home and at daycare.

Domains	Affordances at home		Affordances at home		Affordances at daycare	
	Babies aged up to 12 months		Babies aged >12 months			
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Outdoor physical space	3.02±1.85	0-5	3.39±1.79	0-5	4.25±1.75	0-5
Indoor physical space	4.09±0.65	2-5	4.24±0.58	3-5	4.25±0.46	4-5
Daily activities	14.65±2.26	10-20	16.04±2.37	10-21	17.37±2.26	3-20
Toys for Gross Motor Skills	9.44±2.50	3-14	13.78±5.19	7-30	19.38±5.45	12-27
Toys for Fine Motor Skills	7.49±3.07	2-14	17.24±6.92	4-39	24.63±7.76	13-32

SD, standard deviation; Min-Max, minimum-maximum.

results justify the referral for a new and more detailed assessment, which must be shared with other health professionals. When problems are identified, and consistent with the instructions found in the TSFI, the infant should undergo specialized therapeutic monitoring, due to the lack of sensorimotor stimulation, or undiagnosed motor development delay.^{6,20,21} The most affected areas, the Adaptive Motor Responses and Reactivity to Vestibular Stimulation, are consistent with those described in the literature,²² having been tagged as areas that are affected in the infants, mainly due to lack of stimulation, either provoked or spontaneous. Reams¹³ also verified that the Adaptive Motor Responses were one of the most affected in the infants' sensory profiles, as well as Ocular-Motor Control appears in this study and in the study by Reams¹³ as one of the most developed functions. As for Reactivity to Tactile Deep Pressure, there is no agreement between studies; in the study by Reams,¹³ it appears as an affected function, whereas in the present study it showed the best performance results. The discrepancy between the results in this matter can be explained by cultural differences between countries. The routines observed in Portuguese families, such as holding the babies and physical contact while playing games (e.g., "Where is your nose?"), could explain the superior results regarding tolerance to touch.²³

The affordances at home were evaluated as being only sufficient, i.e., there were affordances, but not enough in terms of number and diversity required to be considered a good supply of stimulation affordances. As for the domains, the most affected was the offer of gross and fine motor toys, and the most appropriate, the structure of the indoor physical space at home. These results show that families

have a concern regarding space organization and the type of toys offered to the baby, but possibly the family budget⁸ or the lack of information prevent the increase of affordances regarding gross and fine motor toys. Another possible reason is the lack of time to take the children to the playground, where there are several large toys/equipment that promote gross motor skills, as parents work on average 8 hours a day, plus the time spent in commuting and household management.

As expected, daycare centers showed good affordances, as a good daycare environment, with good physical and stimulation affordances can promote an excellent opportunity for babies to develop properly, safely, facilitating playing, in addition to providing food, hygiene and contact with other children.²⁴ It can be verified that children that attend daycare have better sensorimotor development, although some authors question whether this is due exclusively to the daycare environment or if the family is also more available during the interaction periods.²⁴

In the daycare rooms up to 12 months of age, the affordances at the level of physical space, the activities and available toys, provided an adequate setting for the promotion of sensorimotor development, contributing to the sensory profile of the babies, even though they had only supervision and not the daily presence of a pre-school teacher.

When we correlated the dependent (sensory profile) and the independent variables (family and daycare context), it was observed that only daycare sociocultural factors influenced the babies' sensory profile. One reason could be that babies spend most part of their active day there, with home being a space with less active time, except for the weekend. The daily hours and the outdoor space of the

Table 2 Pearson's correlation between the sensory profile (TSFI subtests) and biological/sociocultural factors and the significant AHMED-IS domains.

Factors	Daily hours in daycare	Daycare area	TV time at daycare	Outdoor space at daycare
TSFI Test	r=-2.79	r=0.24	r=-0.30	r=0.52
Oculomotor Control	p=0.009	p=0.047	p=0.012	p<0.001

Table 3 Predictors of Oculomotor control performance.

Variables	Oculomotor Control		
	β	t	p-value
Daycare area	0.02	0.18	0.855
Daily hours in daycare	-0.25	-2.16	0.035
TV time at daycare	0.06	0.49	0.627
Outdoor space at daycare	0.45	3.07	0.003

r²=0.28; p<0.001.

B, standardized coefficient; t, statistical.

daycare were the variables that most influenced the sensory profile in relation to the ocular-motor performance, with an explanatory power of 27.5%. The daycare center can offer a larger number and better quality of affordances, in addition to stimulating the use of these affordances. It is possible that, as babies spend more time in daycare than at home, these several opportunities influenced the ocular-motor performance. However, more than 8 hours spent in daycare can discourage development, as these hours are not of stimulation and use of affordances and could be spent at home with the parents, playing games that stimulate the ocular-motor performance. It has been observed in previous studies, that the interaction of parents with their babies during play time encouraging reaching out and grasping and participation in imitation games, allowing the baby to move freely and choose toys to explore, improves sensorimotor development.¹¹ As suggested, regarding the outdoor space in apartments, the stimulation affordances showed weak classifications.^{25,26} The outdoor space at the daycare should have different toys/equipment, such as suspended equipment, rocking chairs, balls, routes with obstacles and different types of surfaces, among others, to provide the infants with stimuli that will be processed, so that they can perform the tasks that are required to explore the space itself and toys.²¹ In Portugal, the outdoor space of the daycare is often disregarded; the quantity and especially the quality of the toys/equipment that are found in the outdoor space do not allow adequate sensory development because they are little versatile and not safe enough. These should potentiate the stimulation of brain areas and sensory components in order to promote greater input of proprioceptive and vestibular stimuli, as well as stimulating all the processing at the cerebellum level. One example of these activities are those requiring balance (cerebellum) or planning/organization activities and motor performance (frontal cortex),^{5,27} which may contribute to a better ocular-motor control. This study highlights the importance of organization and planning of outdoor space, in the context where the baby spends most of the day.

It is worth mentioning the importance of performing similar studies aiming to encourage the establishment of recommendations on the most advisable type of equipment and material to maximize the sensorimotor development of babies by preventing the onset of future problems at school age.⁷ Currently, parents and educators demonstrate a greater concern with the development of capacities that contribute to school success, placing more importance on activities developed in indoor spaces (cognitive and fine motor activities), disregarding the potentials developed in outdoor spaces.

The study limitations include the fact that it did not apply validated tests as complement of the sensory profile assessment to confirm the results obtained, as well as the self-administered evaluation questionnaire by the caregivers in the daycare setting, as it was designed to evaluate the home setting. It is noteworthy that the correlations were weak, as well as the difficulty in generalizing the results at national and international level.

Nevertheless, it can be concluded that the babies' sensory profile was, on average, between normal and at-risk range and consequently, a new evaluation is recommended,

possibly followed by referral to therapeutic supervision to confirm the results. The families had a sufficient supply of stimulating opportunities, whereas the daycare centers showed good opportunities both in terms of physical space or toys and games. Daily hours in daycare and the outdoor space in the daycare center were the sensory profile predictors regarding the babies' oculomotor control performance.

In summary, the results of this study allow us to recognize the importance of the childcare context regarding babies' sensory development, which is of great importance for the formation of multidisciplinary teams responsible for the design and planning of these spaces.

Funding

This study did not receive funding.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

To the babies and their parents for participating in this study, as well as to the daycare centers and their caregivers, for their availability.

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