Effect of the home environment on motor and cognitive behavior of infants

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\begin{abstract}
Although information is sparse, research suggests that affordances in the home provide essential resources that promote motor and cognitive skills in young children. The present study assessed over time, the association between motor affordances in the home and infant motor and cognitive behavior. Thirty-two (32) infants were assessed for characteristics of their home using the Affordances in the Home Environment for Motor Development – Infant Scale and motor and cognitive behavior with the Bayley Scales of Infant and Toddler Development – III. Infant’s home and motor behavior were assessed at age 9 months and 6 months later with the inclusion of cognitive ability. Results for motor ability indicated that there was an overall improvement in performance from the 1st to the 2nd assessment. We found significant positive correlations between the dimensions of the home (daily activities and play materials) and global motor performance (1st assessment) and fine-motor performance on the 2nd assessment. In regard to cognitive performance (2nd assessment), results indicated a positive association with fine-motor performance. Our results suggest that motor affordances can have a positive impact on future motor ability and speculatively, later cognitive behavior in infants.
\end{abstract}

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1. Introduction

A child’s development is founded upon various related domains, all of which are influenced by biological, social, and environmental factors that are vulnerable to favorable or adverse situations. Bradley, Burchinal, and Casey (2001) extend that general idea stating that those situations seem to have greater impact during the first few years of postnatal life. Those first years mark intense biological maturation and behavioral change, especially in motor behavior (Adolph & Berger, 2006; Piek, 2006). Attraction to this area of research is due in large part to acknowledgement that level of motor development is a critical factor in child behavior (Adolph & Berger, 2006; Schoner & Thelen, 2006; Spencer et al., 2009). For example, research indicates that aspects of motor ability are associated with cognitive ability (Murray et al., 2006; Piek, Dawson, Leigh, & Smith, 2008). To illustrate, Murray et al. (2006) found a significant linear relationship between age of learning to stand and adult categorization; the earlier the attainment of the milestone, the better was the categorization. The authors argue that there was a link between early gross motor development and adult executive function. Piek et al. (2008) studied whether
information obtained from measures of motor performance taken over a 4-year period in infancy and early childhood predicted motor and cognitive performance of children once they reached school age. The researchers found a strong positive relationship between early gross motor ability and later school aged cognitive development, especially processing speed and working memory. Complementing those findings, it has been suggested that early motor development may act as a ‘control parameter’ for further development, in that some motor abilities may be a prerequisite for the acquisition or practice of other developmental functions such as perceptual or cognitive ability (Bushnell & Boudreau, 1993).

Motor behavior of the developing infant is shaped by a combination of environmental, organismic, physiological, and genetic factors. Of the various factors comprising the environment, few would disagree that the home is a primary agent for learning and developing the foundation for positive lifelong behaviors, especially during the early years (see review by Son & Morrison, 2010 and UNESCO report by Itus, 2006). Interestingly, major studies designed to assess the general characteristics of the home and the relationship to later behavior have reported that one of the most striking and consistent findings has been “availability of stimulating play materials” as a predictor of future mental behavior (Bradley et al., 1989; Mundfroim, Bradley, & Whiteside, 1993). Abbott, Bartlett, Fanning, and Kramer (2000) concluded that the home environment is surely within the host of subsystems that contribute to infant motor development.

With the present work, we investigated the influence of home (motor) affordances on motor and cognitive ability in infants during their first 18 months of life. Our interest in this question derives from earlier work in which we examined the relationship between affordances in the home and motor performance of infants (Caçola, Gabbard, Santos, & Batistela, 2011). With that study we found a significant association between home affordances and infant motor development; more specific, availability of gross- and fine-motor toys predicted motor development scores. Here, we extend that investigation to include, along with motor assessment, influence of affordances on future cognitive ability. Infants were tested for home, motor and cognitive traits at age 9 months and 6 months later. The primary questions were – Do affordances in the home environment for motor development predict motor and cognitive behavior after 6 months? And, if so, what characteristics in the home account for the strongest relationship? The application of this work relates to the need to identify factors that may contribute or constrain motor and cognitive ability in infancy. Such information could be helpful in providing opportunities for developmental change earlier in life, especially with infants that are at risk for developmental delays.

2. Materials and methods

2.1. Participants

Recruitment letters were sent to parents of infants through community health agencies and public/private daycare centers in a metropolitan area of the state of São Paulo, Brazil. Thirty-two (32) parents returned the consent forms and all were eligible to participate in the study, based on the criteria of having no congenital malformations or neurological impairments. The study was approved through institutional ethics procedures.

2.2. Measures

For assessment of the home environment, we used the Affordances in the Home Environment for Motor Development – Infant Scale (AHEMD-IS) (Caçola et al., 2011), a validated and reliable parental self-report that addresses the quality and quantity of factors (opportunities) in the home that are conducive to enhancing motor development in children of 3–18 months of age (also see Haydari, Askari, & Nezhad, 2009; Hsieh et al., 2011; Rodrigues, Saraiva, & Gabbard, 2005; Temple, Naylor, Rhodes, & Wharf-Higgins, 2009). The instrument is strongly founded in selected propositions of ecological (affordance) theory (e.g., Adolph & Robinson, 2008; Gibson, 2001). Namely, the home environment can provide affordances that can be conducive to stimulating motor development. Affordances are opportunities that offer the individual potential for action, and consequently to learn and develop a skill or a part of the biological system (Stoffregen, 2000). One of the major categories of affordances is play material – toys and play items that have a high likelihood of promoting optimal physical and motor development, if made available.

The AHEMD-IS consists of five dimensions (Outside Space, Inside Space, Daily Activities, Fine-Motor Toys, Gross-Motor Toys) and a section on Child and Family Characteristics. For simplicity of presentation, we combined Outside Space and Inside Space into one dimension of Physical Space, as well as a combination for Fine-Motor and Gross-Motor Toys, which result in the larger dimension of Play Materials. Three types of questions are used: simple dichotomic choice, 4-point Likert-type scale, and description-based queries. Scoring for each dimension is calculated by summing up all points obtained for each question within each dimension (Physical Space [0–16], Variety of stimulation [0–25], and Play Materials [0–126]). Total score is the sum of scores of the three dimensions [0–167].

The instrument used for motor and cognitive evaluation was the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III; Bayley, 2006). The Bayley-III is a widely documented instrument that assesses developmental functioning of children between 1 month and 42 months of age in relation to five developmental domains: cognitive, language, motor, social–emotional, and adaptive behavior. For the purposes of this study, we used the cognitive and motor scales. The motor scale assesses fine-motor (66 items) and gross-motor skills (72 items) separately. Global motor ability and cognitive performance are expressed through a standardized score ranging from 40 to 160 points, with an average reference
of 100 ± 15. With the present study, the cut-off point for being suspect of delay in motor performance was a score below 90, or classification as low average, borderline, or extremely low.

2.3. Procedures

Parent volunteers were mailed a packet including the AHEMD-IS and contacted by phone to schedule an appointment for the 1st assessment of motor skills within 2 weeks. After 6 months, researchers once again sent the AHEMD-IS to be completed and returned, and contacted to schedule the 2nd assessment. Included with that assessment was the cognitive scale of the Bayley-III test; infants were tested first with the cognitive scale, followed by the motor scale. Both scales were administered at the infant’s daycare center in the order of chronological age or age corrected for prematurity when appropriate. All assessments were performed by the same physical therapist with the assistance of two trained physical therapy students. Testing procedures were administered as instructed in the test manual. If testing was interrupted because the child was not alert or adequately active, the evaluation was re-scheduled for completion within one week. Each assessment lasted about 40 min.

2.4. Treatment of the data

Data analyses included use of Shapiro–Wilk normality tests, Paired Student’s t-tests or Wilcoxon Signed Ranks Test to compare the 1st and 2nd assessments, and the Spearman correlation test to correlate all continuous data. We also tested possible changes in the home environment and motor abilities over the 6-month period utilizing Cohen’s d estimated effect size analysis (for paired data) (Son & Morrison, 2010). Group characteristics were analyzed via descriptive statistics. An alpha level of 0.05 (two-tailed) was set for statistical significance.

3. Results

3.1. Descriptive characteristics

As noted earlier, 32 infants (homes) participated in the study. In both the 1st and 2nd assessments, those completing the inventory answered that they were either married or living together as domestic partners. Six (6) percent lived in apartments and 94% in single family houses. In Brazil, SES typically does not determine differences in housing type; that is, the upper class lives in both apartments and houses. Eighty-four (84) percent of families lived on less than R$2000 a month (about US$1000), while 16% lived on more than R$2000 a month.

Regarding education, 16% of mothers completed middle school or less, 66% completed high school, 19% graduated from college, and none had post-graduate degrees. In reference to fathers, 22% completed middle school or less, 75% completed high school, none graduated from college, and 3% had post-graduate degrees.

Of the total sample of infants, 50% were females; 18% of females and 18% of males were preterm infants. The majority of participants were an only child (72%), 25% lived with one sibling and 3% had more than one sibling. In addition, all infants attended daycare regularly; 84% had attended for less than 3 months, 9% between 3 and 6 months and 6% had attended for 7–12 months. Time spent in daycare ranged from 4 to 8 h a day per child. Sixty-five (65%) percent were enrolled in public daycare centers, while 35% were enrolled in private daycare centers. Implications of daycare participation are discussed in the latter section of the paper.

The gestational age and birth weight with the 1st assessment averaged 38 ± 2.2 weeks and 3172 ± 415 g, respectively. The mean age at the 1st assessment was 9 ± 2.1 months and 15.2 ± 2 months on the 2nd assessment; age corrected for the 6 preterm births.

3.2. AHEMD-IS

AHEMD-IS values for total score and dimensions showed large variability in opportunities provided in the home environment with the 1st and 2nd assessments (Table 1). Total scores on the 1st assessment were significantly related to total scores on the 2nd assessment, t(30) = 0.81, p < 0.01. Correlations between the two longitudinal assessments within AHEMD-IS dimensions demonstrated strong correlations (above 0.60) with the exception of Daily Activities, revealing a moderately positive correlation, r(30) = 0.44, p < 0.01.

Regarding changes in home affordances over time, overall scores revealed significant change (d = 0.65). We found that Outside Space changed very little (d = 0.28), Play Materials changed some (d = 0.45) and Daily Activities had considerable change (d = 1.25). Paired t-tests revealed that scores on the 2nd assessment were significantly larger than on the 1st assessment, for total AHEMD-IS score, t(31) = −6.02, p < 0.01, and the dimensions Daily Activities, t(31) = −6.58, p < 0.05, and Play Materials, t(31) = −4.23, p < 0.01.
Table 1
AHEMD-IS scores over time.

<table>
<thead>
<tr>
<th></th>
<th>1st assessment</th>
<th>2nd assessment</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average/median</td>
<td>SD</td>
<td>Average/median</td>
<td>SD</td>
<td>r</td>
<td>t</td>
<td>Cohen’s d</td>
</tr>
<tr>
<td>Total AHEMD-IS</td>
<td>48.44/44.50</td>
<td>18.11</td>
<td>59.78/55.50</td>
<td>16.68</td>
<td>0.81</td>
<td>-6.02</td>
<td>0.65</td>
</tr>
<tr>
<td>Inside Space</td>
<td>6.38/6</td>
<td>1.58</td>
<td>6.13/6</td>
<td>1.64</td>
<td>0.62</td>
<td>1.01</td>
<td>0.16</td>
</tr>
<tr>
<td>Outside Space</td>
<td>2.84/4</td>
<td>2.14</td>
<td>3.47/4</td>
<td>2.39</td>
<td>0.70a</td>
<td>-</td>
<td>0.28</td>
</tr>
<tr>
<td>Physical Space</td>
<td>9.22/10.50</td>
<td>3.09</td>
<td>9.59/10.50</td>
<td>3.17</td>
<td>0.74a</td>
<td>-</td>
<td>0.12</td>
</tr>
<tr>
<td>Daily Activities</td>
<td>15.31/15</td>
<td>3.53</td>
<td>19.22/20</td>
<td>2.72</td>
<td>0.44</td>
<td>-6.58</td>
<td>1.25</td>
</tr>
<tr>
<td>Fine-Motor Toys</td>
<td>14.19/11.50</td>
<td>10.77</td>
<td>19.56/16.50</td>
<td>10.91</td>
<td>0.80</td>
<td>-4.50</td>
<td>0.50</td>
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<tr>
<td>Gross–Motor Toys</td>
<td>9.72/8</td>
<td>6.37</td>
<td>11.41/10</td>
<td>5.38</td>
<td>0.71</td>
<td>-2.09</td>
<td>0.29</td>
</tr>
<tr>
<td>Play Materials</td>
<td>23.91/20.50</td>
<td>16.29</td>
<td>30.97/28.50</td>
<td>15.35</td>
<td>0.82</td>
<td>-4.23</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Cohen’s d = estimated effect sizes lower than 0.5 are considered small, 0.5–0.8 are considered moderate, those greater than 0.8 are considered large.

a Correlation coefficient of Spearman.

b Wilcoxon signed ranks test.

c Paired t test.

Table 2
Correlations between AHEMD-IS and the motor and cognitive scores.

<table>
<thead>
<tr>
<th></th>
<th>AHEMD-IS – 1st assessment</th>
<th>AHEMD-IS – 2nd assessment</th>
<th>Cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PS</td>
<td>DA</td>
<td>T</td>
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<tr>
<td>Motor performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine</td>
<td>-0.15</td>
<td>-0.09</td>
<td>-0.13</td>
</tr>
<tr>
<td>Gross</td>
<td>-0.10</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Global</td>
<td>-0.15</td>
<td>0.02</td>
<td>-0.04</td>
</tr>
<tr>
<td>2nd assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine</td>
<td>0.14</td>
<td>-0.01</td>
<td>0.35c</td>
</tr>
<tr>
<td>Gross</td>
<td>0.16</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>Global</td>
<td>0.15</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Cognitive</td>
<td>-0.07</td>
<td>0.15</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

Significant correlation with p < 0.05.

PS, Physical Space; DA, Daily Activities; T, Toys.

3.3 Bayley-III

3.3.1 Motor scales (1st/2nd assessment)

On the 1st assessment, the majority of infants (68%) scored in the category average or above, as expected. However, 25% scored below the low average category, and 6% were categorized as borderline. On the 2nd assessment, 94% scored in the average category or above, while the two remaining children scored in the categories low average (3%) and extremely low (3%). Overall, there was an improvement in motor performance from the 1st to the 2nd assessment, especially in the high average category (from 16% to 38%).

Regarding changes in motor development over time, we found that fine-motor ability changed some, effect sizes were moderate ($d = 0.40$); gross motor ($d = 0.76$) and global motor ability ($0.71$) had moderate to large changes.

3.3.2 Cognitive scales (2nd assessment)

The vast majority of infants (97%) scored above average or average for their age range, while a single infant (3%) performed at the low average category.

3.3.3 Relationship

Table 2 shows the relationship between the 1st and 2nd AHEMD-IS assessments and infant motor and cognitive performance. Results indicated a moderately positive correlation between global motor performance on the 1st assessment and Daily Activities (AHEMD-IS) on the 2nd assessment, $r(30) = 0.351$, $p < 0.05$. A similar correlation was indicated between Play Materials with the 1st assessment and fine-motor performance on the 2nd motor assessment, $r(30) = 0.352$, $p < 0.05$. In addition, AHEMD-IS total score on the 1st assessment was significantly related to fine-motor performance on the 2nd assessment, $r(30) = 0.395$, $p < 0.05$. None of the AHEMD-IS dimensions were related to cognitive development, however, there was a moderately positive relationship between fine-motor performance on the 1st assessment and later cognitive development, $r(30) = 0.428$, $p < 0.05$.

4. Discussion

In the present study, we assessed the association between motor affordances in the home (including family characteristics) and infant motor and cognitive ability. We used the AHEMD-IS to assess opportunities in the home environment and the
Bayley-III to determine motor and cognitive ability. We assessed the home and motor behavior at 9 months and re-assessed after 6 months with the inclusion of cognitive ability.

One of the major findings of this study was that the home environment provided a significant influence on future infant motor behavior (fine-motor). Our results revealed a positive correlation between Play Materials on the 1st assessment and higher fine-motor development on the 2nd assessment. In addition, total score on the 2nd assessment was also related to fine-motor development. This finding complements the study of Caçola et al. (2011), who investigated the relationship between home scores and motor development using the Alberta Infant Motor Scales. The researchers found Gross- and Fine-Motor Toys predicted motor development scores of infants between ages 3 and 18 months. We do wish to note that the study was conducted at a relatively single point in time (over a 2-week period).

Another key finding is that fine-motor ability correlated positively with cognitive ability. This finding supports several studies indicating that there is a strong relationship between fine-motor skill and cognitive ability (Ayhan, Aki, Aral, & Kayihan, 2007; Bumin & Kavak, 2008; Piek et al., 2008; Wuang, Wang, Huang, & Su, 2008). For instance, Wuang et al. (2008) reported that children with higher cognitive deficiency (difficulties in verbal comprehension and processing speed) also scored lower on motor ability, especially in fine-motor skills.

With our study, children who had higher AHEMD-IS scores also displayed better fine-motor and cognitive ability on the 2nd assessment. It is our contention that this result is the most interesting and unique contribution of the study. Whereas we acknowledge that more work is needed, we feel that there is a case for arguing that affordances provided in the home, as measured by the AHEMD-IS, could have provided some of the foundation for the level of cognitive ability shown at the follow-up assessment. With that said, we cannot ignore the likelihood that other factors associated with affordances may have influenced outcome. For example, perhaps parents with children who demonstrate advanced motor abilities provide more toys and other affordances. Furthermore, it could also be the case that homes that provide an abundance of affordances also encourage more motor activity and help their children.

It seems important to mention that there were changes in the home environment over the 6-month testing period, associated with Daily Activities and Play Materials. As expected, there was minimal change in Physical Space due in large part to families not moving to or dramatically changing residences. We believe that the change in the home environment, especially in Play Materials was associated with the cultural factor of infant’s first birthday. In Brazil, like many countries, it is traditional to celebrate with a party where the infant receives many toys as gifts. In our sample, all infants had their first birthday sometime between the 1st and 2nd home assessments. We can also infer that parents, after responding to the AHEMD-IS questionnaire in the 1st assessment, were more concerned about providing affordances for their child, thereby (for example) increasing interaction, play space and purchasing play materials.

In addition to the ‘motor’ affordance characteristics described, other factors measured by the AHEMD-IS very likely contributed to outcome as well. For example, parent education: 85% of all parents finished high school. A body of research confirms that parental education, especially maternal education, could play a significant role in child development (e.g., Bradley & Corwyn, 2002; Lung, Shu, Chiang, & Lin, 2011). Another factor is daycare – as noted earlier, all infants in the present study attended daycare regularly from 4 to 8 h a day. Whereas in our study general educational and facility daycare characteristics were similar, we acknowledge that differences could have affected outcome. Future investigation with children receiving minimal or no daycare, which is rare in Brazil, is being considered. Another point worthy of note in regard to parental characteristics, with our sample prenatal and neonatal conditions (gathered by interview and medical records) suggested a general aptitude of parents for providing adequate childcare.

In summary, these findings provide evidence that there is an interrelation between affordances in the home environment, motor (especially fine-motor ability), and cognitive development. And finally, it appears that early motor affordances in the home environment maybe an essential agent for developmental change. We also believe that the association found between the home and future motor/cognitive ability can tell us significant information about the complex nature of early motor development. Exploring the quality of the home environment and its impact on infant development is a relatively small, but fundamental clue for understanding the complex nature of human development.

Conflict of interest

Neither of the authors have any conflicting interests with regard to this work.

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