Neurodevelopment and the effects of a neurobehavioral intervention in very preterm-born children
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Chapter 2

Reliability, sensitivity and responsiveness of the Infant Behavioral Assessment in very preterm infants


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Abstract

**Aim.** The aim of this study is to investigate the reliability, sensitivity and responsiveness of the Infant Behavioral Assessment (IBA) to evaluate neurobehavioral organization in very preterm-born infants.

**Methods.** Videotaped assessments of very preterm-born infants participating in a recent trial, served to evaluate a standardized IBA observation. Inter-rater reliability was based on 40 videos scored by two independent observers, using percentage agreement and weighted Kappa’s. Sensitivity was evaluated by comparing the IBA results of 169 infants at 35-38 weeks postmenstrual age, dichotomized according to two developmental risk factors. For responsiveness, the effect size (ES) was calculated between 0 and 6 months corrected age in all intervention and control infants and in subgroups of high-risk intervention and control infants with oxygen-dependency ≥28 days.

**Results.** Inter-rater agreement was 93% in the total assessment; Kappa agreement was moderate to good in the behavioral categories. Significant differences were found between groups with or without risk factors. Larger differences between ESs in the randomized groups with oxygen-dependency ≥28 days than in the total randomized groups reflect the responsiveness of the IBA.

**Conclusion.** In this study, we found satisfactory to good clinimetric characteristics of the IBA in very preterm-born infants.
Introduction

The Infant Behavioral Assessment© (IBA)¹ is an assessment designed to evaluate the infant’s neurobehavioral organization to support positive interactions of the infant with the environment. The IBA was derived from the NIDCAP Observation Sheet², the ‘Naturalistic Observation of Newborn Behavior’ by Als³, but intended for infants from 0–8 months of corrected age (CA). Hedlund and Tatarka further articulated Al’s’s⁴ theoretical construct of the ‘Synactive Model of Newborn Behavioral Organization and Development’ for older infants at developmental risk, as well as infants who are typically developing.

The IBA is primarily intended to be used in a qualitative manner, in conjunction with the corresponding intervention program: the Infant Behavioral Assessment and Intervention Program© (IBAIP).⁵ The interventionist continuously observes and interprets the infant’s behavior and the setting during the interaction with the IBA. This behavioral analysis results in strengths-based recommendations to support the infant’s sensory approach of information and neurobehavioral competence, and/or in environmental adaptations to diminish the infant’s stress or discomfort.

The effectiveness of the IBAIP was evaluated in a randomized controlled trial (RCT), enrolling infants born <32 weeks gestation and/or 1500 g. We already published that IBA-guided interventions in this RCT lead to more positive and sensitive mother–infant interactions at 6 months,⁷ more improvement of self-regulatory competence and improved mental, motor and behavioral development in the infants at 6 months,⁸ improved motor outcome at 24 months,⁹ and to more independency of the infants at preschool age.¹⁰

For an accurate role in early intervention, the clinimetric characteristics of the IBA need to be explored. In two pilot studies,¹¹,¹² we described the theoretical background, scoring and interpretation of the IBA. These studies showed that short quantified IBA observations were able to detect considerable differences between low-risk preterm and term infants,¹¹ and between infants that received intervention and control infants at term, 3 and 6 months CA.¹² In addition, the IBA showed differences between term, preterm and preterm intervention infants’ neurobehavioral development over time.¹¹,¹² The purpose of this study is to further investigate the clinimetric characteristics of the IBA, by determining its reliability, sensitivity and responsiveness to evaluate neurobehavioral organization in very preterm-born infants.

Patients and Methods

Data of a recent multicenter RCT, which evaluated the effect of the IBAIP in very preterm infants after discharge from hospital, were used.⁸ Primary outcomes were the Bayley
The trial included 176 infants of <32 weeks gestational age (GA) and/or <1500 g, born in one of the seven Amsterdam hospitals, and with parents living in Amsterdam. GA was determined by maternal history and ultrasound examination in early pregnancy, or postnatal with the Dubowitz-score if ante-partum information was inconclusive. The infants’ mean (SD) GA was 29.6 (2.2) weeks in the intervention group and 30 (2.2) weeks in the control group; the mean (SD) birth weight was 1242 (332) g in the intervention group and 1306 (318) g in the control group.

The interventions consisted of one session shortly before discharge from hospital and six to eight sessions at home, until 6 months CA. The interventionists used continuous naturalistic IBA observations to systematically analyse the child’s behavior during interactions, resulting in immediate strengths based recommendations to support the infant and the parent. In addition, shortly before discharge, at 3 and 6 months CA, standardized IBA observations were registered to evaluate the infants’ neurobehavioral performance for research purposes. In this study, these observations are used to determine the reliability and validity of the IBA. IBA observations of 169 infants were available at baseline (35–38 weeks postmenstrual age, PMA), and 162 infants at 6 months CA; data of 157 infants were available at both baseline and 6 months CA. Data loss was because of technical problems with the video administration or a nonoptimal state of the infant. A detailed description of perinatal and socio-demographic characteristics and infant outcomes can be found in Koldewijn et al.

The Infant Behavioral Assessment

The IBA is based on naturalistic observations, discriminating 113 behaviors in four systems: 26 items in the autonomic system, 44 items in the motor system, 9 items in the state system and 34 items in the attention / interaction system (Appendix 1). The infant’s behaviors are scored as present (=1) if they are observed at least once during the observational interval, or as absent (=0). Within each of the four systems, the behaviors are interpreted as approach (stable / engagement), self-regulatory (utilized by the infant to concentrate, cope and/or console himself), or stress (unstable / disengagement) behaviors. For example, on the IBA score sheet (Appendix 1), the items in the motor system, subsystem hands, are interpreted as follows: grasp and resting are considered to communicate approach / stabile behavior; holding on, hand to midline, hand to mouth, groping, hand on stomach, self-clasp and hand on head are considered self-regulatory behavior; finger extension, finger splay and fisting are considered to express stress. The categories approach and self-regulation demonstrate the infant’s unique behavioral strengths to interact; stress behaviors show the infants’ vulnerabilities and needs.
The IBA is intended for use by health professionals who have experience with young infants. Formal training and certification in the IBA is required; an inter-rater agreement of at least 85% must be established.1 The IBA does not have normative data for either term or preterm infants, as the test aims to assess the individual infant’s behavioral strengths and needs in response to sensory information, to provide the quality and amount of information or support that is appropriate for that particular infant, at that particular time.

**Data collection**

Research use of the IBA requires careful standardization and grading of the challenge for each specific infant group and/or age. The infant needs to be able to join in an age appropriate interaction but should also be challenged enough to use self-regulatory behaviors or show short moments of stress.

At baseline (35–38 PMA), the infant was recorded on video in hospital, during the changing of a diaper by the mother. The infant was in supine in the bed, and a 2-minute ‘observation window’ was used to score the IBA, starting when the diaper was opened. At 3 months CA, the infant was recorded at home. The infant was in an unsupported supine position. A 2-minute ‘observation window’ was used to score the IBA, starting at the moment the mother presented a bell and rattle as used in the BSID-II. At 6 months CA, the BSID-II assessment at the follow-up clinic was recorded on video; a 2-minute ‘observation window’ during the ‘exploration of the bell’ was used to score the IBA, again with the infant in an unsupported supine position. An awake state of the infant was required;¹ a full description of the standardizations is available by the author of this paper.

All IBA fragments were scored from video by an IBAIP certified observer (JvH), who was blinded for group assignment. The IBA was quantified by counting the occurrence of ‘approach’ and ‘stress’ behaviors in the autonomic, motor, state and attention / interaction system, and for the IBA total scores of approach and stress; means were calculated for each of the four systems and the IBA total score. Self-regulation is not used as an outcome measure for the infant’s neurobehavioral organization, as self-regulation has a mediating function that results either in the enhancement of approach (by concentration) or the prevention/reduction of stress (by coping or consoling).

To evaluate the inter-observer reliability of the IBA, video fragments of 40 infants were scored at the CA of 3 months by two independent certified and experienced observers (KK and JvH). The age of 3 months was chosen as the IBA incorporates items for the age of 0–8 months. Three-month old infants are expected to express behaviors throughout the four systems. At term age, infants may express only few approach behaviors in the attention / interaction system and at 6 months only few stress behaviors in the autonomic system.
To investigate the sensitivity of the IBA, we evaluated its ability to discriminate between neurobehavioral outcomes of subgroups of infants with or without the perinatal risk factors of GA ≤28 weeks and oxygen dependency >28 days at the age of 35–38 weeks PMA. The IBA responsiveness to change was investigated over the period from 0 to 6 months. As young infants are expected to make more adaptations and changes in this period than at any time later in life, we expected large changes. We therefore focused primarily on the responsiveness of the IBA to show differences in change after intervention, in the total intervention and control group, and a subgroup of intervention and control infants with oxygen dependency >28 days. This high-risk group was chosen because oxygen dependency was found to be significantly associated with the primary outcomes at 6 months in our RCT. Moreover, at 24 and 44 months, it became clear that the intervention (IBAIP) benefited the development of infants with long-term oxygen dependency most.9,10

Statistical analysis
Data were analyzed using the SPSS 15.0 program (SPSS, Chicago, IL, USA). Percentage agreement for each item was calculated. Item-by-item percentage agreement was calculated for the total and the three categories of approach, self-regulation and stress. In addition, agreement between observers was calculated using weighted Kappa statistics with quadratic weights for these three categories. According to Landis and Koch,15 a Kappa of >0.80 is very good, 0.61–0.80 good, 0.40–0.60 moderate and <0.40 is poor. According to the instructions in the IBA Training Manual,1 the five items for skin colour were removed, because colour cannot be scored from video. The sensitivity of the IBA to discriminate between infants dichotomized according to two developmental risk factors was analyzed with t-tests. An alpha level of 0.05 was considered significant. For the responsiveness of the IBA, Cohen’s16 effect size (ES) was used as a measure of change. ES was obtained by dividing the absolute change between the outcomes at baseline and the outcomes at 6 months by the standard deviation of the baseline measurement. An ES of ≥0.80 is considered large, an ES of 0.50 is medium and an ES of 0.20 is considered small.

Results

Inter-observer reliability
Table 1 summarizes the inter-observer agreement on the IBA categories of approach, self-regulation and stress, and the total item-by-item percentage agreement of the IBA in 40 infants. Inter-observer agreement was moderate in the category of approach (Kw = 0.58) and good in the categories self-regulation (Kw = 0.72) and stress (Kw = 0.75).
Observers achieved an average of 93% (range 85–97%) item-by-item agreement for the total assessment. Of a total of 108 items, 97 had good to excellent agreement (>80%) and 11 had moderate agreement (60–80%). Of the 11 items with moderate agreement, seven were in the motor system, three in the attention/interaction system and one was in the state system.

Table 1. Infant Behavioral Assessment. Inter-observer agreement (n = 40)

<table>
<thead>
<tr>
<th>Categories</th>
<th>No of items</th>
<th>Weighted Kappa</th>
<th>Percentage agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>22</td>
<td>0.581</td>
<td>92</td>
</tr>
<tr>
<td>Regulation</td>
<td>42</td>
<td>0.722</td>
<td>90</td>
</tr>
<tr>
<td>Stress</td>
<td>44</td>
<td>0.754</td>
<td>95</td>
</tr>
<tr>
<td>Total IBA</td>
<td>108</td>
<td>n.a.</td>
<td>93</td>
</tr>
</tbody>
</table>

n.a.: not applicable

Sensitivity of the IBA at term age

The differences on the IBA subsystem scores and total scores in the two high-risk groups are shown in Table 2. All outcomes pointed in the expected direction, indicating less approach and/or more stress in infants at biological risk. Significantly less autonomic approach, more autonomic stress and less total approach were found in infants with a GA ≤28 weeks. Infants with oxygen dependency >28 days showed less autonomic and motor approach, more autonomic and state stress, less total approach and more total stress.

Responsiveness of the IBA to change over time

Table 3 shows the responsiveness of the IBA subscores and total scores between 35–38 weeks PMA and 6 months CA. Approach in the state system could not be calculated because of the preterm infants’ limited use of approach behaviors in the state system at 35–38 weeks PMA. As expected, the ESs were large, both in the randomized total groups and in the oxygen-dependent high-risk groups, except for stress in the state system in the randomized total groups. Again all outcomes pointed in the expected direction: ESs for approach showed positive values (more approach over time) and ESs for stress showed negative values (less stress over time). The ESs in the total intervention group were larger for approach and stress than in the total control group. Largest changes were found in intervention infants with oxygen dependency >28 days. In the control infants of this high-risk subgroup, approach behavior increased to a higher extent (+5.72) than in the total control group, but to a lesser extent than in the total intervention group. In this high-risk control group, stress behavior, however, decreased to a lesser extent (-2.73) than in all other groups.
### Table 2. Infant Behavioral Assessment (IBA). Differences between infant groups with or without high-risk at 35-38 weeks postmenstrual age

<table>
<thead>
<tr>
<th>IBA subscores</th>
<th>Gestational age &lt; 28 weeks</th>
<th>Oxygen ≥ 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (n=30)  Mean (SD)</td>
<td>No (n=139)  Mean (SD)</td>
</tr>
<tr>
<td>Autonomic approach</td>
<td>0.56 (0.76)</td>
<td>1.02 (0.77)**</td>
</tr>
<tr>
<td>stress</td>
<td>2.73 (0.74)</td>
<td>2.33 (0.94)**</td>
</tr>
<tr>
<td>Motor approach</td>
<td>1.93 (1.29)</td>
<td>2.40 (1.29)</td>
</tr>
<tr>
<td>stress</td>
<td>6.43 (1.55)</td>
<td>6.38 (1.62)</td>
</tr>
<tr>
<td>State approach</td>
<td>0.00 (0.00)</td>
<td>0.01 (0.09)</td>
</tr>
<tr>
<td>stress</td>
<td>0.67 (0.61)</td>
<td>0.47 (0.00)</td>
</tr>
<tr>
<td>Attention-interaction approach stress</td>
<td>0.27 (0.52)</td>
<td>0.32 (0.59)</td>
</tr>
<tr>
<td>IBA total scores approach</td>
<td>2.90 (1.90)</td>
<td>2.68 (1.38)</td>
</tr>
<tr>
<td>stress</td>
<td>12.73 (3.07)</td>
<td>11.87 (2.87)</td>
</tr>
</tbody>
</table>

T-test, *P<0.05, **P<0.01

### Table 3. Infant Behavioral Assessment (IBA): Effect Size (ES) of change in all VLBW infants and in infants with oxygen dependency ≥28 days, between 0 and 6 months corrected age

<table>
<thead>
<tr>
<th>IBA scores</th>
<th>ES all intervention Infants (n=83)</th>
<th>ES all control Infants (n=74)</th>
<th>ES intervention Infants with O2 ≥28 days (n=33)</th>
<th>ES control Infants with O2 ≥28 days (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomic approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stress</td>
<td>- 2.71</td>
<td>- 3.26</td>
<td>+ 2.85</td>
<td>+ 1.40</td>
</tr>
<tr>
<td>Motor approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stress</td>
<td>- 3.37</td>
<td>- 3.06</td>
<td>+ 2.54</td>
<td>+ 2.92</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approach</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>stress</td>
<td>- 0.80</td>
<td>- 0.67</td>
<td>- 1.00</td>
<td>- 1.03</td>
</tr>
<tr>
<td>Attention-interaction approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stress</td>
<td>+ 6.16</td>
<td>+ 5.48</td>
<td>+ 6.49</td>
<td></td>
</tr>
<tr>
<td>IBA total scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approach</td>
<td>+ 6.81</td>
<td>+ 5.51</td>
<td>+ 7.71</td>
<td>+ 5.72</td>
</tr>
<tr>
<td>stress</td>
<td>- 3.62</td>
<td>- 3.54</td>
<td>- 4.32</td>
<td>- 2.73</td>
</tr>
</tbody>
</table>

n.a. = not applicable.
Discussion

This study aimed to determine the reliability, sensitivity and responsiveness of the IBA to evaluate neurobehavioral organization in very preterm-born infants. Our data show that the reliability of the IBA in the three categories of communication (approach, self-regulation and stress) is moderate to good, and the item-by-item percentage agreement of the IBA was good to excellent. Disagreement occurred most often in motor items such as ‘stilling’, ‘hands resting’, ‘toe grasp’ and ‘squirm’. ‘Stilling’ is defined as the cessation of movement of the trunk and extremities in anticipation, while the infant expresses invested attention in an object, person or sound in the environment. ‘Squirm’ is defined as writhing or wriggling, agitated movements of the trunk and/or extremities. Differences in scoring may occur when the infant displays the behavior for a very short moment, or as part of another movement. Adding a time component to the definitions of some of these items may further enhance inter-observer agreement. Although some refinement of the IBA definitions may be needed, the scores indicate an acceptable consistency with which different observers can create the same analyses of infant behavior with the IBA.

The sensitivity of the IBA is demonstrated by clear differentiations in neurobehavioral organization between very preterm infants with or without perinatal risk factors. In particular, infants with oxygen dependency >28 days showed less organization, illustrated by less approach and more stress. Apart from a more fragile autonomic system, these infants demonstrated less motor control and displayed more negative emotions or hyperalertness. Infants born with a GA ≤28 weeks were discriminated by their more fragile autonomic system (i.e. less respiratory or visceral stability and more tremor or startle) and overall less approach behavior, indicating a declined ability to process information or to engage in interactions. It appears that the outcomes of IBA observations regarding infants with oxygen dependency and young GA reflect those found in studies using hands-on neonatal neurobehavioral assessments, confirming that engaging a preterm infant in a normal caregiving interaction (in this case the changing of a diaper) may risk instability in the autonomic and motor system.17–19

Large responsiveness was found on all scores of the IBA, in both the total groups and in the subgroups of oxygen dependent infants over a 6-month period, except for state stress in the total group, which was moderate responsive. This last finding is probably due to the standardization of the test, which required an awake state at the start of the observation. The subsystems show that, in all infant groups, the largest changes take place in the attention/interaction system, which is in line with the infant’s early development, during which the infant gradually interacts with and explores his environment more.

Consistent with the improved developmental outcomes of the intervention infants in our trial,8 the IBA measured a larger change in the intervention infants’ neurobehavioral
competence (as the balance between approach and stress). In our trial, the risk factor oxygen dependency ≥28 days was found to have a significant influence on the outcomes.8–10 In line with these findings, the IBA also measured the largest change in neurobehavioral competence in these high-risk intervention infants compared with the total randomized groups and the high-risk control group. High-risk control infants showed more change in approach over time than the total control group. This may point at neurobehavioral recovery, which is normally particularly the case in infants with most severe illnesses. However, the high-risk control infants’ resilience was not accompanied with less stress, which may be at the cost of the infants’ information processing, and/or their energy and health.

The results from this study support the validity of the IBA to monitor and guide very preterm infants’ neurobehavioral organization and to evaluate intervention to provide a more holistic picture of the infant.20–22 The ability of the IBA to support the infant’s neurobehavioral organization during interactions from minute to minute distinguishes the instrument from other neurobehavioral assessments at infant age that provide us with a score but are not directly related to the actual situation in which the caregiver or interventionist can do something for the child. Supporting the infant’s self-regulatory competence to approach and respond to environmental information and to diminish stress is currently seen as an important element in early intervention for infants at biological and/or social risk.23–25 A behavioral analysis of the child’s individual expectations, like the IBA, might be basic for effective neurobehavioral intervention. Moreover, the IBA may have been crucial for the positive results we found in our RCT in very preterm infants.7–10 It gives the interventionist a better insight in the infant’s proximal developmental goals or underlying problem areas and may contribute to the professionals’ understanding and valuation of the self-regulatory and adaptive processes that precede skills or needs.5,6 This strengthens the confidence that the interventionist can timely target areas that need specific support, but also what the infant does well and needs less support and/or more challenge. The ability of the IBA to incorporate the infants’ behaviors to approach information and to regulate themselves has the potential to focus the intervention more positively on ways parents can support and foster their child’s strengths, which may contribute to a satisfying parent-infant relationship.26,27

Also some limitations of this study should be noted. Research use of the IBA requires a careful creation of the sample interaction for each specific infant group and/or age, and our results may not be representative for other groups, ages or circumstances. We found in preparatory studies that a 2-min interaction shows enough variability in behavior if the challenge is well chosen. If the interaction takes 5 minutes, the child often shows a continuation of the same behaviors or the infant may give up. However, the standardized IBA ‘observation windows’ we used for this study provide a relatively short impression of
the infant’s neurobehavioral organization, which may not be representative of the total interaction. Therefore, IBA observations should not be used as a level of performance, in isolation from other measures.

We conclude that the IBA is a reliable and valid tool to evaluate and support neurobehavioral organization in very preterm infants. Additional validation of the IBA in different infant populations at different ages is warranted.

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