

## Description of a Screening Instrument Identifying Newborn Infants with Low Level of Self-Regulation

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### Abstract

Low level of self-regulation in newborn infants has an impact on mother - infant interaction and may hinder the child's optimal development. The objective with this study was to describe a hierarchical, conditional, global instrument for assessing the level of self-regulation in newborn infants and apply this instrument on a healthy group of optimally, healthy newborn infants.

On the basis of, clinical experiences, theoretical considerations and statistical analysis, seven subvariables in the Neonatal Behavioral Assessment Scale, (NBAS) were selected to constitute the instrument. The instrument was related to non-nutritive sucking pattern (NNS), and sucking pattern was measured by a method for automatic analysis. The screening instrument was applied to a group of 38 optimally healthy newborn infants, 18 girls and 20 boys.

The study showed that the screening-instrument distinguishes different levels of self-regulation, as well as uncovering gender differences. Ten infants, seven boys (35%) and 3 girls (17%) showed a low level of self-regulation. This distribution is coherent with gender-based differences when scoring the entire NBAS. Furthermore, convergent validity was found between the scale and the NNS.

The study demonstrates a possibility of constructing a screening instrument assessing level of self-regulation in newborn infants. In supporting mother - infant interaction and create optimal conditions for infant development it is of considerable value to assess and attune to the infant's level of self-regulation..

**Keywords:** Screening Instrument; Neonatal Behaviour; Infant Development; Homeostatic Control; Self-Regulation; Ordered Categorical Data

### Background

Many children are born healthy but may later develop a dysfunctional behavior for example, regulatory problems, such as attention-deficit/hyperactivity disorder (ADHD). The prevalence of infants with ADHD estimates worldwide around 5% [1]. The percentage has been claimed to increase [2], but for example, Polansky, *et al.* [1] argue that variability in ADHD prevalence is mostly explained by methodological characteristics of the studies. They point out that in the past three decades there has been no evidence of an increase number of children with ADHD, when standardized diagnostic procedures are followed.

The diagnosis of ADHD has been found to be associated to the parent - child interaction, especially when the parent has a very critical attitude to the child [3]. An improved understanding of the role that comorbidity and environmental factors play in ADHD etiology seems to be critical to future ADHD prevention efforts [4-6]. Many studies confirm the complexity of child's development.

It is a consensus that there are variations in development between children at the same age and that children therefore need to be handled differently and need different support to develop optimally. But we rarely talk about differences when it comes to newborn babies that newborns vary in development and maturity. For example, one mother may leave the maternity ward with a baby, who is tense,

is sleeping or fussing and crying most of the time when awake, is difficult to comfort and is almost impossible to interact with. Another mother comes home with a baby, who is often alert when awake, rarely crying, only needs a little help getting comforted when upset and is easy to interact with. As both the mother and the infant shape the interactional processes [7-10] and the quality of early mother-infant relationship has a crucial impact on infant development [7, 10, 11, 12] means that the first child is at risk of not developing optimally and that the mother needs support.

Despite this there is no screening instrument which includes behavioral assessment in clinical practice for healthy term or late preterm newborn infants (34 -36 weeks gestational age), besides Apgar score [13], general neurological- and a pediatric assessment. However, for the neonates who are born preterm or/and with other diseases or dysfunctions, there are several methods for assessment, e.g. CRIB score [14], a risk assessment of disease and injury [15], assessment of general movements [16].

Brazelton and Cramer [6] emphasized the importance of homeostatic control (control of autonomic responses, motor activity and state of consciousness) as the first task for the infant to achieve, in order to participate in any interactive processes at all. Butterfield, *et al.* [17] found that the newborn baby's ability to see and to signal readiness for interaction promptly after he or she was born was important to the bonding. The bonding provides one part in the development of attachment between the infant and the primary caretaker. The quality of the attachment behaviors is an important predictor of the child's later psychological and social competence [18].

The autonomy of the newborn child is a question of its ability to organize itself in relation to external and internal stimuli. The less energy absorbed by the autonomic nervous system, motor activity in the form of unintentional movement, tension and handling of inadequate stimuli from outside, the more energy the child has to develop interactive behavior that will promote predictable responses [19]. Hence the level of self-regulation does not only interfere with the interactive exchange between mother and child but has also an immediate effect on the predictability in their interaction. Expectable behavior helps and reinforces the mother to nurture the baby appropriately. Furthermore, the child's range of states of consciousness and its ability to change states in order to handle its surroundings have been found to have a crucial impact on cognitive and emotional development. Greenspan [20] suggested that deficiencies in early regulatory patterns can be viewed at either as distinct disorders at an early developmental stage or as intermediary risk patterns for later symptoms and disorders because they are related to specific sensory processing and motor patterns.

At present the Neonatal Behavioral Assessment Scale, NBAS, appears to be the most comprehensive assessment instrument of newborns [19]. It has mainly been used as a research instrument and not so much clinically, probably because it places great demands on the user. Besides using the NBAS as an assessment of infant's maturity, development or neurological status, several studies have also demonstrated the value of NBAS as an intervention and communication tool. It is an assessment instrument, which can be used throughout the neonatal period to the end of the second month [19]. The instrument combines a neurological examination with an assessment of an extended behavioral repertoire of the infant in an interactional process. The developmental aspect is followed from Autonomic Regulation preceding to Motor Organization and further by the task of State Regulation and finally Social Interaction [19]. Nine of the sub variables measure State Regulation, Peak of Excitement, Rapidity of Build Up, Irritability, Lability of States, Cuddliness, Consolability, Self-Quieting and Hand to Mouth.

A previous study with NBAS used to describe the functioning of optimally healthy neonates [21] showed that these sub variables had a wide inter-quartile range compared with the subvariables measuring Autonomic Regulation and Motor Organization. Furthermore, the study showed that the first six of these eight sub variables were associated to each other. These six sub variables and the sub variable Self-Quieting were also associated to the supplementary items Examiner Facilitation and Examiner's Emotional Response. Examiner Facilitation measures the help that the examiner has to invest to get the infant's optimal performance. Neonatal social behaviour with an examiner during the NBAS examination has been found to be related to neonatal social behavior with the mother and to maternal functional stimulation [22].

Besides NBAS, Nugent and his colleagues at the Boston Children Hospital have developed The Newborn Behavioral Observation System (NBO) [23], which is “an infant-focused, family-centered relationship-based tool”. It is not an examination or test as opposed to NBAS but a kind of intervention to support the interaction between the child and parents.

The advantage of the NBAS scale is that it makes it possible to understand the infant’s functioning from many perspectives and understand the process of early development, in contrast to an ordinary pediatric and neurological examination. It shows that the newborn infants need different amounts of help to become soothed, organized and to change state. They themselves use a variety of self-quieting behavior like sucking on a thumb or fist, changing position by turning the body slightly, firmly gazing etc. Some newborn babies use one of these activities, others a combination of them.

For many babies in the western countries the non-nutritive sucking (NNS), sucking on a pacifier, thumb etc. is a predominant tool and seems to be a powerful soother for the infant to regulate itself in negotiation with and adjustment to outside stimuli, the environment. NNS is an innate behavior and develops early, around 14 - 20 weeks of gestational age [24]. Wolff [25] and Goldson [26] have found a correlation between the pattern of NNS, maturity and neurological development.

As the assessment of BNBAS is extensive and time-consuming and requires a fairly extensive and rigorous training to use and score, a kind of screening technique for self-regulation, which provides a more simple method, is desirable for differentiating capable and mature neonates from those who are at risk for future dysfunctions and need special handling and follow-up.

### Aims of the Study

The aims of this project were:

1. To *identify* crucial sub-variables in the NBAS scale and develop a screening-instrument in order to assess the newborn infant’s level of self-regulation,
2. To *apply* this instrument to a group of optimally healthy full-term newborn babies to *describe* the variations in this group in relation to the concept of self-regulation,
3. To *relate* the level of self-regulation to the NBAS and the pattern of NNS.

### Our questions were:

- Are there sub-variables in the NBAS which in an appropriate way could be used to operate the concept of self-regulation in the newborn infant and can be used as a screening instrument in identifying infants at risk for disturbances in mother-infant interaction and in consequence developmental deficiencies?
- Is the level of self-regulation, as measured by the screening instrument, related to the whole assessment NBAS and the NNS pattern?

### Subjects

On prespecified days, the midwives at the maternity ward registered the infants who scored positive according to Kyllerman’s and Hagberg’s optimal health conditions a modification of Prechtl’s optimal concept [27]. Optimal health in this study was defined as scoring positive to all optimal conditions except the age of the mother. Instead of 18 to 30 years, we extended the age to 35 years. The babies were examined the third day of life and not more than three babies were examined per day and if there were more babies who fulfilled the requirements, they were consecutively chosen. The optimal conditions for health were supplemented with the Apgar score [13]. The requirement was a score of least eight points at 5 minutes. The distribution of characteristics of the infants is shown in table 1.

| Items                  | Boys<br>n = 20 | Girls<br>n = 18 |
|------------------------|----------------|-----------------|
|                        | Mean (SD)      |                 |
| Maternal age, years    | 27.3 (4.8)     | 27.4 (4.7)      |
| Birth weight, g        | 3605 (434)     | 3455 (396)      |
| Birth length, cm       | 51.3 (2.0)     | 50.5 (1.5)      |
| Gestational age, weeks | 39.6 (0.9)     | 39.5 (0.9)      |

**Table 1:** Characteristics of infants and mothers.

This study included 20 boys and 18 girls. The gestational age was determined from the date of the last menstrual period and by ultrasound verification at 15 - 16 weeks of gestation. The infants were examined at 48 - 72 hours of age to minimize the influences of the delivery. The aim was to examine the baby at the midpoint between two meals. As breastfed infants are often fed at irregular intervals, this goal was not always achieved.

The parents gave their consent to the assessment. All the babies were examined by one of the authors (CLP). The babies were examined with the whole NBAS in a small quiet room in daylight in the presence of at least one parent.

The examiner had been trained and certified reliable in administering and scoring of the NBAS by the Boston group at Harvard Medical School.

The Ethics Committee of the Faculty of Medicine, Göteborg University, Sweden approved the study.

### NBAS Method

The NBAS is a so-called Composite Measurement Scale, which means that it is a multi-dimensional, multi-item scale [28,29]. The NBAS basic score-sheet includes 28 behavioral items, 18 elicited responses, reflexes and 6 supplementary items [19]. The supplementary items were constructed partly for the fragile and vulnerable infants, partly to capture some of the more personal characteristics of the infant's behavior as well as the response of the examiner to the infant. The behavioral items, including the supplementary items, are scored on nine-point scales and the reflexes are scored on a three-point scale. In some of the behavioral items the end-point score 1 or 9 represents optimal status, in others the central score 5. Thus, the outcome item scores 1 - 9 do not represent a common ordered structure of the response variable.

### The NNS Measurement

The NNS was measured by a previously described method for automatic analysis in infants [30]. An ordinary bottle nipple with a pressure signal transducer inside was used. The signals were detected and analyzed by a specially designed computer program. The pattern of the infant's sucking was analyzed by duration of burst (s), average amplitude (index), sucking frequency (Hz) and interval since last burst (s). The amplitude was calibrated dynamically by a pump generating known sinus-shaped pressure changes with a frequency of 2 Hz. In a previous study using this method, it was, however, discovered that the amplitudes recorded differed depending on the rubber of the nipple [30]. To equate for these differences and avoid bias in the system, the nipples were given randomly to the infants. The amplitude reflects the pressure in the nipple but has no exactly comparable numerical value. This, however, has no implications here since we were simply interested in the differences and not in absolute values.

The recordings of the NNS were carried out with the baby in the parent's lap. The baby was in the beginning in a state of alertness but during the registration some of them became drowsy. If the baby seemed to fall asleep during the recording, it was gently awakened. The recording lasted for 10 minutes.

### Statistical methods

Qualitative judgements provide ordered categorical data. These types of data remain invariant in all order-preserving transformations, which means that one succession of labels can be replaced by another, for example, numerals by letters or by a set of increasing numbers of symbols. Therefore, categorical data do not represent any mathematical value except ordering and this property restricts the application of common mathematical and statistical methods of analysis [28,29,31,32]. For example, a sum score of multi-item scales has no interpretable meaning and is therefore inappropriate as a global score of a multi-item instrument. One approach of creating a global score of multi-item measurements is to use the median categorical level of the item responses [28,29]. Median is defined as the category such that half of the observations, at most, are both less than and more than, the median [33].

The relationship between the pattern of NNS and the level of autonomy is described by a Box Whisker plot [34].

## Results

### Operating the concept of self-regulation on the basis of the NBAS

Based on the items in the NBAS, a screening-instrument for assessment of *the level of self-regulation* was developed.

According to the above theoretical discussion, theories about early interaction and dyadic processes [7,12,19,35] and research results concerning the impact of the dimensions regulation and range of states [35-37] seven sub-variables were identified, operating the main variable, the level of self-regulation (Table 2).

Hence the variable level of self-regulation is a more comprehensive concept compared with homeostatic control. For example, it contains the baby's ability to quiet itself, the way it reacts to different stimulation and how much help it needs to get organized.

As the original response categories of the NBAS do not represent an ordered structure, the categorical labels (numbers 1 - 9) were transformed to new labels (A - I), all representing an increased level of good functioning where A means a high level of self-regulation and I a very low level of self-regulation. A conditional global three-point scale of level of self-regulation was defined. The conditions of the levels of self-regulation are presented in table 2. The levels are very low level of self-regulation (LLS), ordinary level of self-regulation (OLS) and a high level of self-regulation (HLS). The seven subvariables according to the criteria in table 2 and the median self-regulation level of the seven subvariables determine the baby's level of self-regulation.

#### **The variables are measured by the NBAS**

##### **Low level of self-regulation (LLSR)**

##### **Peak of excitement** (level of arousal to stimuli)

I. Infant achieves insulated crying state. Unable to be quieted or soothed.

H. Infant screams (state 6) in response to stimulation more than twice, although some quieting can occur with consoling with difficulty. Usually needs finger or pacifier to console.

G. Low level of arousal to all stimuli. Never above state 2, does not awaken fully.

F. Some arousal to stimulation - must be awakened to reach state 3.

E. Infant reaches state 4 only briefly - is predominantly in state 3 or lower.

States of consciousness, crying = 6, fussy, alert = 5, wide-awake, alert = 4, drowsy = 3, light sleep = 2 and deep sleep = 1.

**Irritability** (measures the number of times the baby gets upset and the kinds of stimuli that make the baby irritable) Stimuli: uncover, undress, pull-to-sit, prone, pinprick, TNR, Moro, defensive reaction)

I. Irritable fussing to 8 of the 8 stimuli.

H. Irritable fussing to 7 of the 8 stimuli.

G. Irritable to 6 of the 8 stimuli.

##### **Rapidity of build-up** (the period of "control" which the infant can maintain)

I. Never quiets enough to score this.

H. Upset at first auditory and light stimuli.

G. Upset at uncovering.

##### **Cuddliness** (the measurement of the infant's response to being held in alert states)

H. Resists being held most but not all of the time.

##### **Consolability** (the number of manoeuvres the examiner uses in order to bring the baby to a quiet state)

I. Not consolable.

H. Pacifier or finger in addition to dressing, holding and rocking.

G. Dressing, holding in arms and rocking.

##### **Lability of states** (the infant's state performance over the examination)

I. 23 or more changes over 30 minutes.

H. 19 - 22 changes over 30 minutes.

G. 16 - 18 changes over 30 minutes.

##### **Self-quieting activity**

I. Cannot quiet itself, makes no attempt, intervention is always necessary.

H. Brief attempt to quiet itself (less than 5 seconds) but with no success.

G. Several attempts to quiet itself, but with no success.

##### **Ordinary level of self-regulation (OLSR)**

##### **Peak of excitement**

D. Infant reaches state 6 in response to stimuli more than twice, but with consoling is easily brought back to lower states.

C. Infant reaches state 6 after stimulation more than twice, but returns to lower states spontaneously, at least twice.

##### **Irritability**

F. Irritable fussing to 5 of the 8 stimuli (uncover, undress, pull-to-sit, prone, pinprick, TNR, Moro, defensive reaction).

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| <p>E. Irritable fussing to 4 of the 8 stimuli.</p> <p>D. Irritable to 3 of the 8 stimuli.</p> <p><b>Rapidity of build-up</b></p> <p>F. Not until pinprick or reflexes of the feet.</p> <p>E. Not until undressed or being handled.</p> <p>D. Not until pulled to sit, standing, walking or placing.</p> <p>C. Not until prone, placement, incurvation, defensive reaction or TNR.</p> <p><b>Cuddliness</b></p> <p>G. Doesn't resist but doesn't participate either. Lies passively in arms and against shoulder (like a sack of flour).</p> <p>F. Eventually moulds into arms, but after a lot of nestling and cuddling by examiner.</p> <p>E. Usually moulds and relaxes when first held.</p> <p>D. Always moulds and relaxes when first held.</p> <p><b>Consolability</b></p> <p>F. Holding and rocking.</p> <p>E. Picking up and holding.</p> <p>D. Hand on belly and restraining one or both arms.</p> <p><b>Lability of states</b></p> <p>F. 14 - 15 changes over 30 minutes.</p> <p>E. 11 - 13 changes over 30 minutes.</p> <p>D. 9 - 10 changes over 30 minutes.</p> <p>C. 6 - 8 changes over 30 minutes.</p> <p><b>Self-quieting activity</b></p> <p>F. One brief success in quieting itself for a period of 5 seconds or more.</p> <p>E. Several brief successes in quieting itself.</p> <p>D. An attempt to quiet itself which results in sustained successful quieting with the infant returning to state 4 or below for at least 15 seconds.</p> <p>C. One sustained (15 seconds) and several brief successes (5 seconds) in quieting itself.</p> <p><b>High level of self-regulation (HLSR)</b></p> <p><b>Peak of excitement</b></p> <p>B. Infant reaches state 6 after stimulation once or twice. Is predominantly in state 5 or lower.</p> <p>A. Infant reaches state 5 but is predominantly in state 4 or lower.</p> <p><b>Irritability</b></p> <p>C. Irritable fussing to 2 of the stimuli.</p> <p>B. Irritable fussing to 1 of the stimuli.</p> <p>A. No irritable fussing to any of the above.</p> <p><b>Rapidity of build-up</b></p> <p>B. Not until the end of examination.</p> <p>A. Never upset.</p> <p><b>Cuddliness</b></p> <p>C. Always moulds, initially nestles head in crook of elbows and neck of examiner.</p> <p>B. In addition to moulding and relaxing, the infant nestles and turns its head, leans forward on shoulder, fits feet into cavity of other arm. All of the body participates. Always moulds initially. Head nestles in crook of elbow and neck. Turns towards body in horizontal and turns forward on shoulder.</p> <p>A. All of the above and baby grasps and clings to examiner.</p> <p><b>Consolability</b></p> <p>C. Hand on belly steadily.</p> <p>B. Examiner's voice and face only.</p> <p>A. Examiner's face only.</p> <p><b>Lability of states</b></p> <p>B. 3 - 5 changes over 30 minutes.</p> <p>A. 1 - 2 changes over 30 minutes.</p> <p><b>Self-quieting activity</b></p> <p>B. At least 2 sustained (15-seconds) successes in quieting itself.</p> <p>A. Consistently quiets itself for sustained periods, never needs consoling.</p> |
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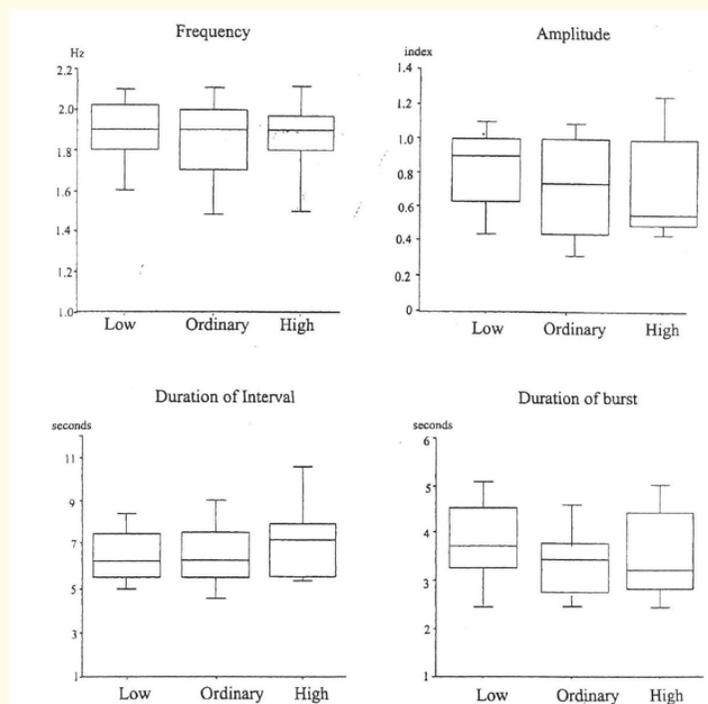
**Table 2:** Criteria for the three levels of self-regulation.

## Application

In the application and description of the screening instrument to optimally healthy newborn infants, special interest has been focused on gender differences. Among the group of healthy infants, the distribution of levels of self-regulation showed that 7 (35%) of the boys whereas 3 (17%) of the girls had a low level of self-regulation at an age of 48-72 hours of age.

The result showed that the screening instrument discriminated between the levels of self-regulation. The result also showed an evidence of gender based differences.

Furthermore, there was a consistency between the level of self-regulation and the pattern of NNS (Figure 1).



**Figure 1:** Non-nutritive sucking in the relation to the level of self-regulation.  
Low = LLSR,  $n = 10$ , Ordinary = OLSR,  $n = 17$ , High = HLSR,  $n = 11$ .

The differences in the NNS-patterns follow the level of self-regulation. The infant with high level of self-regulation tended to suck with lower amplitude, shorter duration than the infant with low level of self-regulation.

## Discussion

This study demonstrated that by using seven of the sub variables in the NBAS, it becomes possible to construct a hierarchical, conditional global assessment scale which discriminates three levels of self-regulation in a group of optimally healthy infants. In the distribution of the scale, gender differences were found. As a group, girls tend to have a higher level of self-regulation than the boys had. The result is in accordance to gender differences when scoring the entire NBAS assessment [21,38].

The consistency in the pattern between NNS and level of self-regulation indicates a convergent validity of the self-regulation scale. The relationship between the level of self-regulation as defined in this study and the pattern of NNS points to the fact that self-regulation

measures a quality that is related to an innate behavior initiated early in the fetus development. The infant with low level of self-regulation tends to suck more intensively than the infant with ordinary or low level of self-regulation, according to the pattern of NNS. Thus, the NNS pattern seems to be related not only to neurological development and general maturity but also to the level self-regulation. Marchini, *et al.* [39] showed in a study of infants that the insulin was secreted during NNS, which in turn may indicate a vagal effect. We can only speculate about the results. But if we accept that the level of insulin and the vagal effect increase the more intensely the baby is sucking the pattern of NNS may partly be a result of the baby's attempt to reduce its disorganization and increase the level of self-regulation.

Clinicians and investigators agree that the baby is an important participant in the early interaction process [8,10,12,19]. Some infants, depending on constitutional differences and maturity, can easily adapt to the external world, are easily consoled or can console themselves. Soon after birth they have a basic rhythm for sleep and hunger and can stay alert and be attentive. They have a clear signaling behavior. On the other hand, there are infants who are mostly shifting between sleep and crying states and who have a low threshold for the intake of stimuli and get hyper-excitabile and irritable and have difficulty consoling themselves. They are at the mercy of physiological requirements and are little engaged in the environment. These infants are very dependent on sensitive and nurturing parents who can reduce this discomfort. We presume that infants who have a low level of self-regulation during their neonatal period are at risk for negative social, emotional and cognitive development. The screening instrument should help to identify these infants.

The screening instrument is suitable to use together with the ordinary physical examination. Keefer has presented a combined model of physical and behavioral examination [40]. She estimated that it did not take much more time than an ordinary physical examination.

The examiner of the screening instrument needs to have the knowledge of the NBAS and to carefully observe the elicited behaviors in the interaction with the baby, but only carefully score the seven sub variables included in the screening instrument. Furthermore, the examiner does not need to elicit all behaviors for example, not all the items in the dimension habituation or all the reflexes. By eliciting and scoring fewer items, time is saved and if there is a need for follow-up to monitor changes over time in the level of self-regulation, the assessment may easily be repeated during the neonatal period. This scale identified 35% of the boys and 17% of the girls among optimal healthy infants as having a low level of self-regulation at an age of 48 - 72 hours and the percentage is probably bigger in an unselected group of newborns and in the group of late preterm. On the other hand, in one week to 10 days the percentage of infants with low level of self-regulation certainly will slightly decrease in the group of term neonates [12]. However, the study showed that one fourth of mothers (in this group ten) who themselves are going through an important change leave the maternity ward with a baby who is hard to interact with.

The screening instrument provides qualitative data which not only give guiding information, e.g. information indicating special needs of care, but also information that may indicate an extended assessment. The screening instrument may also form a good basis to share with parents the experience of their baby's maturity, personal characteristics and individual needs.

There are studies that show that self-regulation has an impact on development and childhood adjustment [41,42]. Allan N. Schore stated in his preface of the book, *Affect regulation and the origin of the self*, that "studies of the infant brain demonstrate that its development occurs in stages over critical periods and that its maturation is influenced by the environment and is experience dependent" [12]. Thompson underlined the cardinal principle that emotion is initially regulated by the primary caretakers but as development proceeds it becomes increasingly self-regulated as a result of neurophysiological maturation [43]. Thus, in supporting mother infant interaction both knowledge of the mother and also of the individual child is required. This screening instrument encompasses personal characteristics of the infant.

### Conclusion

This screening instrument is an examination of the baby focused on identifying the infant's level of self-regulation. The screening should be conducted in the presence of at least one parent. By sharing the result with the parents, it can form the basis for intervention if needed.

It is therefore suggested, in creating optimal conditions for infant development, prevent dysfunctional infant behaviour and, in supporting mother - infant interaction, it is of considerable value to assess and attune to the infant's level of self-regulation.

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