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Prematurity and Infants' Neuromotor Development: Some Considerations

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Abstract: The present paper is concerned with the theoretical matter of understanding whether the prematurity condition, per se, is a predictor factor of infants' later performance, particularly from the neuromotor point of view. A review of studies on this issue is presented when some controversy are highlighted and considerations are made to external factors which may account for children's neuromotor improvement. Among the important external factors discussed are the children's gestational age and their familial environment. Some consideration is also made on early systematic tactile stimulation on babies born preterm since it is also believed to be one of the possible reasons for infants' later better neuromotor development. Another aspect also discussed in this paper is the assumption that temperament is correlated with the preterm condition. Considerations are made regarding the fact that the correlation between prematurity and temperament is established by the subjectiveness of infants' ratings of temperament, as assigned by their parents.

Zusammenfassung: *Frühgeburtlichkeit und die Entwicklung der Motorik und Steuerungsfähigkeit des Kindes: Einige Überlegungen.* Der vorliegende Beitrag beschäftigt sich mit der Frage, ob Frühgeburtlichkeit an sich das spätere Verhalten des Kindes bestimmen kann, insbesondere im Hinblick auf die motorische Steuerungsfähigkeit. Eine Übersicht über die hierher gehörigen Untersuchungen wird gegeben, wobei auf einige kontroverse Befunde eingegangen wird. Der Einfluß von äußeren Faktoren, die für eine günstige motorische Entwicklung des Kindes wichtig sind, wird reflektiert. Dabei sind besonders das Schwangerschaftsalter und die familiäre Umgebung von Bedeutung. Besonders betrachtet wird auch die systematische taktile Stimulation bei frühgeborenen Babys, da die Annahme besteht, daß sie ein möglicher Grund für eine bessere Entwicklung der Motorik und Steuerungsfähigkeit des kleinen Kindes ist. Ein anderer Aspekt der Diskussion in diesem Beitrag ist die Annahme, daß mit der Frühgeburtlichkeit bestimmte Züge im Temperament verbunden sind. Dabei wird im einzelnen die Subjektivität der Bewertungen des Temperaments durch die Eltern diskutiert.

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Although on the one hand there is a large number of studies supporting the notion that preterm infants catch up with full-term infants by school age, there is, on the other hand, a lot of controversy about this issue. The different views about preterm infants and their outcomes have supported, and encouraged, a great number of follow-up studies with low- and high-risk infants, born preterm. Concerning the infant's neuromotor development, different findings have been reported when studies are carried out comparing full-term and preterm infants. The results lead us to go for further investigations in terms of looking at the findings from different perspectives: is preterm infant's neuromotor development more delayed than the full-term infant's neuromotor development? Is there any external factor which may account for differences in the neuromotor development between different groups of infants, depending on their conditions of birth? Furthermore, is there any link between prematurity and children's ratings of temperament?

The emotional and cognitive development of these infants, born preterm, are, also important fields of investigation. Among other important aspects, they embrace the infant's own capacity to establish relationships with the caregiver and with the world, as well as the importance of the parents' and the nursing's care and their link with the infants' attachment to their secure figure and cognitive development. Although these aspects (emotional and cognitive) are very important in an infant's life, they are not, at the moment, the focus of attention of our communication. The aim of the present paper which concerns some theoretical consideration is, therefore, to highlight some studies reported on preterm infants and it focuses on two specific points: 1) prematurity and neuromotor development: the consequences of early systematic tactile stimulation on infants' later neuromotor development and, 2) prematurity and temperament: are infants born prematurely more likely to be rated as being more difficult infants?

Prematurity and Neuromotor Development: Some Investigations

There is a large number of follow-up studies which are primarily concerned with the possible outcomes of the neuromotor development of infants born preterm. Forslund and Bjerre (1989), in line with the notion that prematurity leads to delay in development, studied 46 preterm infants (<35 weeks of gestational age) in order to compare their development to the development of infants born full-term. The authors reassessed the sample in a four-year period after birth. At the stage of the follow-up 44 preterm and 25 full-term infants from the initial sample were still available for the study. The investigation concluded that the preterm group, more than the full-term group, had a neurological maturational delay and minor dysfunction since the preterm group showed poorer muscle tone, more difficulty in coordination tests and gross motor functions.

Recent studies have corroborated this finding and Case-Smith (1993), for example, reported an investigation carried out with 65 full-term and 25 preterm infants. The full-term group was aged from 2- to 6-months while the preterm group was aged from 4- to 9-months. The results in that study indicated that the preterm group, compared to the full-term group, showed less fine motor control. This finding is supported by Herrgard, Luoma, Tuppurainen and Karjalainen's

study (1993) with a larger sample: these authors assessed 60 infants born preterm and 60 full-term infants. These two groups were matched by sex and parents' socio-economic and educational status and the assessment occurred when the sample was at the age of five years. The preterm group comprised children with both major disabilities and without disability and, in these two sub-groups of the preterm group the results indicated an overall deficit of motor development, i.e., despite the major disability, the preterm group, more than the full-term group showed problems in the development of the motor area.

Specific investigation between preterm and full-term infants was carried out by Brake and Fifer (1988) concerning the milk consumption, length of the feeding session and rate and amplitude of sucking. The authors evaluated a sample of 80 infants, 47 preterm and 33 full-term and they concluded that the preterm group, as compared to the full-term group, had much more difficulty in sucking the bottle properly and, furthermore, that the preterm group was not capable of being bottle fed successfully until they reached the age of 35 gestational weeks. Also in line with the view of prematurity as associated with delay in motor development, others studies were reported, such as Greenber and Crnic's (1988). These authors report that preterm infants do have poorer motor skills. This assumption is supported by their empirical investigation of 30 preterm and 40 full-term infants in a follow-up study from the infants' birth up to the age of two. The sample was assessed at four, 12 and 24 months, investigating the infants' development (motor, cognitive and language). It is interesting that there was evidence that the preterm group caught up in cognitive and language development and at the age of two the only difference between groups concerned the significantly lower scores on motor development in the preterm group.

Yet concerning differences in motor development Gorga, Stern, Ross, and Nagler (1988) evaluated a 38-infant sample consisting of full-term and preterm infants; the last group being sub-divided into sick preterm and healthy preterm infants. The assessment consisted of a neuromotor behavioural inventory and the sample was tested at 40 weeks of postconceptional age and at three, six, nine and 12 months. The results indicated that full-term and healthy preterm infants had very similar scores and both groups scored higher than the sick preterm group in muscle tone and head control. When the analyses considered the scores of trunk rotation and reaction to movement, however, the full-term group scored higher than both sub-groups of preterm infants. The difference between full-term and preterm groups with regard to the motor ability of trunk rotation remained during the first year.

The consequences of children's early motor impairment is also investigated beyond infancy, when the children are at school age. Marlow, Roberts, and Cooke (1993), for example, conclude that low motor impairment is associated with children's later satisfactory school performance and, therefore, learning difficulties at school could be predicted at an early age by motor assessment. This assumption is based on a follow-up study (in England) when 51 children born preterm (birth weights $\leq$1250 g) were re-assessed at the age of 8 years regarding their school performance, behaviour and maturing motor skills. All these children were assessed at the same time as an age and sex matching control. The findings showed that the VLBW children who, at the age of six years, had had a high impairment from

the motor point of view, showed a decrease in the impairment scores at the age of eight years. This result on the one hand corroborates the notion that VLBW have poor motor skills (as reported at the age of six) but, on the other hand, it also reinforces the notion that premature babies tend to catch up some of their difficulties as they grow older (as seen at the age of eight years).

But the notion that prematurity, per se, leads to delay in neuromotor development is not accepted as a consensus. Furthermore, Kalmar and Boronkai (1991) assures us that the preterm infants' capacity to catch up with full-term infants may be associated with the a favorable familial atmosphere and intellectual stimulation. These authors' conclusion is a result of a 7-year longitudinal follow-up study when 58 preterm low-risk infants and 100 full-term infants were evaluated. The results yielded an interesting pattern when it was concluded that, on the whole, there were no differences between the preterm and the full-term groups, i.e., there was no delay in the neuromotor development in the preterm group. Conversely, the authors concluded that there were particularities between preterm and full-term groups, e.g., in the third and the seventh year of life of children born preterm these children are more likely to present a decrease of ratings of motor development which does not happen (at this stage) in the full-term group. Again, according to this study, the family infra-structure would enable the infant to catch up with his/her limitations along his/her development, i.e., the familiar factors mediate the catching up phenomenon.

So, if the infants born preterm are able to use the resources within the familiar apparatus this may suggest that it is not the prematurity condition, per se, which indicates the children's later development but the preterm's inborn capacities along with the environment and the therapeutic approach available. Before moving on to the effect of early systematic tactile stimulation we would like to consider some differences in the preterm infants' motor behaviour depending on whether the babies were low- or high-risk babies and also, depending on the correct postgestational age.

Back in 1987, Matilainen was already calling the attention of researchers to take into consideration the preterm's correct ages. The author claimed that there was no difference between preterm and full-term infants' psychomotor development when the infants' ages were adjusted and, furthermore, the study states that the differences between groups is accounted for by uncorrected chronological age. That finding supported a previous study in the same line: Palisano (1986) assessed a sample at 12-, 15- and 18-months and found significant differences between preterm ($N = 21$) and full-term ($N = 23$) infants' gross and fine motor development, when the full-term group scored much higher. However, when the quotients of the preterm group were based on adjusted age there was no longer any significant difference between groups. So, motor development is not just a matter of prematurity, it is also related to the maturational process.

Due to maturation one can observe qualitative differences between the performance of preterm infants depending on whether they are low- or high-birth weight babies. Barrera and Cunningham (1986) studied 59 preterm infants, evaluating those children's motor development. The sample was assigned to two different groups: in the first group the birth weight had been less than 1500 g and, in the second group, the birth weight had been from 1500 to 2000 g. Using the Bayley

Scales of Infant Development the authors concluded that the lower birth weight group had lower motor scores than the higher birth weight group. It means that the premature condition, per se, would not answer this question of differences between groups. It seems important to take into consideration the conditions within groups, i.e., within the preterm group particulars should be observed and different results should be understood in relation to specific conditions of each sample.

So far, on the one hand, we have seen that the low performance in the neuromotor tests is much more evinced in preterm infants than in full-term infants. On the other hand, however, some studies have suggested that familiar factors could mediate such disadvantage in the preterm group in terms of facilitating its catching up with full-term infants. Furthermore, it has been pointed out that there are differences between not only preterm and full-term infants but also between low- and high-birth weight infants. Another important factor to be taken into consideration concerns some findings which do not acknowledge the uncorrected and adjusted chronological age of the infants born preterm, which may be an important cause of difference found between groups (preterm and full-term). And what would be the differences within preterm groups, in terms of motor development, when some babies receive early systematic care especially concerning tactile stimulation? Could this early tactile stimulation be a factor which would account for infants' better motor performance? Some considerations on this issue follow.

Tactile Stimulation and Its Outcome on Babies Born Preterm

The necessary care with a preterm infant involves many different approaches, such as specific techniques applied from the staff to the newborn, the approach offered by the parents and even the environmental organization to cope with the fragile babies. Researchers have focused on the investigation of the benefits of the physical environment on the premature's responses and in order to do so comparative studies have been carried out in different intensive units. Wolke (1987) found that a stable environment more contingent in the infant's state, as opposed to an unstructured environment, would help those infants with longer duration of sleep. The benefits of good care available in an intensive care unit are acknowledged by both the medical team and by the babies' families (Swanson 1990). This view is corroborated by a recent study when it has been shown that in intensive care the babies show more flexed posture and more alert-wakefulness when the environment is provided with lower stress and more stable relaxed routines (Becker, Grunwald, Moorman-Jane, and Stuhr 1993). There is evidence, therefore, that the preterm infant reacts very early to external stimuli and, furthermore, that the immature baby can, from the very beginning, discriminate different kinds of stimuli.

However, the assumption that newborns can discriminate stimuli and choose how to react to them takes us back to the discussion of whether the preterm is an individual on its own and, subsequently, how much one knows about its conditions, feelings and needs. More and more there is less support to the view that handling, touching or stroking a premature baby would bring no therapeutic benefit to the newborn. Gradually this view of isolating the preterm has been changing and more and more intensive care units have open their doors, and the parents

seem to be more involved with their preterm babies' care and treatment. In the literature on therapy for premature babies one can see that different approaches have been proposed and different positive findings have been reported on the various therapeutic methods applied to preterm (Rice 1977; Adamson-Macedo, Dattani, Wilson, and de Carvalho (1993); Macedo 1984; de Roiste and Bushnell 1993; Adamson-Macedo and Alves Attree 1994).

Concerning systematic programs applied to the preterm in the intensive care units, there is evidence of the positive effect of the tactile stimulation in terms of the infant's better development. De Roiste and Bushnell (1993), for example, assure us that when the preterm infants are early and regularly stimulated they do learn and are able of having higher sucking pressures. That means that the inborn capacity to suck which is inherent in the human being can and should be, as much as necessary, improved by the use of external help. Needless to say, the more the baby is able to suck the more one would expect this baby to gain weight and, therefore, the more likely the infant is to catch up with full-term infants. Recently, more and more it is thought that a systematic program applied to the babies, in terms of tactile stimulation could facilitate the infant's better development in different areas. The touching effects of tactile stimulation may also be a necessary procedure which should enable normal physical growth. Touching and tactile stimulation could be responsible for the liberation of biochemical mechanisms and of growth hormones.

The notion that tactile stimulation favours the infant's growth is presented by Gottlieb (1983) when the author suggests that stimulation of the infant's sensory system should be done. Even before, though, in 1977, Rice was already concerned with special techniques to be applied to preterm infants once they were discharged from hospital. But it was in 1981 that a systematic program was first presented to be applied to preterm infants. The TAC-TIC method involves a series of coordinated and sequential stroking covering all parts of the baby. The method highlights four principles: gentleness, rhythm, equilibrium and continuity (Macedo 1981, 1984; Adamson-Macedo 1984, 1985, 1991). The author suggests that the TAC-TIC method reduces the secretion of stress hormones and increases the production of endorphin. These phenomena (increase/decrease of specific hormones) could be responsible for facilitating the infant's self-regulation and strengthen the immune system. Furthermore, it has also been shown that no significant fall in transcutaneous oxygen tension or TcPO2 occurs either during or affter application of TAC-TIC therapy, which supports the hypothesis that no oxygenation deterioration of high-risk ventilated infants is observed (Adamson-Macedo et al. 1994).

More recently, the positive effects of the TAC-TIC method have been discussed (Adamson-Macedo and Alves Attree 1994). The authors point not only to the benefits of systematic stroking in terms of the baby's physical and neurological development. Furthermore, it is stated that the improvement in the baby's development, as a result of the TAC-TIC method, plays an important role with their parents and caregivers, i.e., there are also psychological positive effects in applying TAC-TIC therapy to preterm infants. The way the newborn infant reacts to systematic tactile stimulation may have an impact on the parents and caregivers: the infants show evident signals of relaxation and show no evidence at all of being

distressed by being stroked. On the contrary, the physical touch is well accepted by the infant and the infant's overall reaction during the sessions of the TAC-TIC method has been reported to be an important factor to encourage parents to handle, stroke and stimulate their babies.

The view that early systematic stimulation is beneficial to the premature baby is in line with the notion that the environment (physical, familial and emotional) plays an important role in terms of facilitating the infant to catch up with his/her limitations (Kalmar and Boronkai 1991). Early systematic therapy, especially tactile stimulation, as shown in the above review, may account for the preterm's better adjustment in his/her new environment and, furthermore, it may be positively associated with the infant's better neuromotor development.

Prematurity and Infants' Temperament

Not only does the prematurity condition influence an infant's development, as it is also possible that the temperament of the premature newborn may account for the infant's later behaviour. Would preterm babies be more likely to show difficulties throughout life? There is a tendency in the literature concerning this issue to ascertain that premature infants, more than full-term infants, tend to be scored by their parents and caregivers as being difficult infants. There are, though, some particulars in the way some studies are presented in terms of concluding when and for how long temperament seems to account for more difficulties in the preterm group.

Washington, Minde and Golberg (1987), for example, concluded that the differences of ratings of temperament between preterm and full-term infants do exist and, furthermore, the authors assure us that those differences are consistent along different assessments. They evaluated preterms and full-terms parents' reports when the babies were at the age of three, six and 12 months and the results pointed to the fact that the preterm group was systematically scored as being more difficult. Although there are studies corroborating these findings it is important to highlight some peculiarities: Riese (1988), in a two-year longitudinal investigation, assessed 109 full-term babies and 81 preterms. The assessments were done when the sample was at the age of six, nine, 12, 18 and 24 months. The study corroborates the fact that full-term babies are more likely to be scored as being easy and that there is stability in the scoring across the investigation just for the full-term group, i.e., conversely to the previous study, the preterm group did not show consistency of scoring in terms of temperament until towards the end of the second year.

That leads us to think that initial scores of temperament in the preterm group are not a reliable variable to predict infants' later scoring as assigned by their parents. Furthermore, in another study Riese (1987) had already called attention to the fact that the prematurity condition could be disguising a proper evaluation of the infants' temperament in the sense that preterm infants would not fully express emotionality. This finding may alert one to carry on investigating this particular matter since more recent studies do not give any evidence that the preterm infant is impaired in his/her ability to show its emotions. On the contrary, studies have shown that there are no differences between preterm and full-term infants in terms

of their scores of temperament as assigned by their parents, i.e., there is no clear evidence that birth condition (preterm or full-term) accounts for infants' difficult or easy temperament since preterm and full-term infants did not have different temperament ratings from their parents (Ross 1987; Goldstein and Bracey 1988). The notion that there are no significant differences between preterm and full-term infants in terms of ratings of temperament is corroborated by Watt (1987) who assessed these two conditions on a longitudinal basis. Both at six and at 20 months of age there was no difference found in the ratings of temperament between the preterm and full-term groups.

Another interesting aspect to be taken into account concerns the time when the parents show a specific view of their children as being more difficult or easier. Gennarro, Tulman, and Fawcett (1990), ascertain that there are differences between preterm and full-term infants' temperament ratings: both at three and six months of age the preterm group was scored as being more difficult than the full-term group. The authors, however, also concluded that despite the initial assessment, both groups tended to be rated as less difficult when they were reassessed three months later. This finding could lead to question of what happens so that despite the infant's birth condition parents, in general, tend to score their children as being less difficult as these children grow older? Would the preterm infants' parents overcome the biggest difficulties in coping with their babies in the first three months of life? Or do preterm infants really settle and become easier to cope with as they grow older?

Based on the above controversy one can easily question the reliability of the infants' ratings of temperament since such scores derive from the subjective evaluation of their parents. How much of the view that the children are easy or difficult reflect the parent's own feelings and perceptions which, in some cases, may not even be related to the children's behaviour? Especially concerning the prematurity condition, one would expect that the parents' expectation toward their newborn and, therefore, their evaluation of their baby, may be mixed with the experience of having their babies in an intensive care and, eventually, with fantasies of loosing their babies.

Plunkett, Gross, and Meisels (1989) assessed preterm and full-term infants' parents twice: when the infants were 12 and 18 months of age. To corroborate the idea of subjectiveness of ratings, these authors concluded that mothers of preterm and full-term babies did not differ in their ratings concerning their infants' temperament. However, there was difference within groups, in the way each parent would rate the (same) infant: preterm infant's mother, more than preterm infant's father rates the infant as more active and soothable. These differences were not found between couples who had full-term infants. Another point to be considered for further investigation concerns not only the impact of the prematurity on the parents' view of the infant but, furthermore, the distinct impact that the prematurity condition may have on each parent separately.

The matter of different impact that prematurity may cause in each parent should lead us to different points: what is the specific role each parent plays in the newborn life? Are these roles biologically or socially determined? Would these questions, somehow, justify why father and mother, separately, do have different

evaluations of their babies and why they rate them differently according to each one's way of experiencing the fatherhood/motherhood?

Concerning the matter of whether the newborn's temperament is associated with the preterm condition the above controversy suggest that firstly, it would be interesting to get more reliable assessment of temperament as an independent variable, not subject to each parent's own feelingsw and experiences which certainly account for their judgement of their infant's way of being (easy or difficult infant). Secondly, the literature does not give any precise evidence that the premature condition, per se, is associated with a specific rating of temperament. These initial considerations suggest that further investigation should be carried out on this issue.

Summary

The premature condition still has a long way to go in terms of clarifying the extent to which it affects a child's later development. From the neuromotor point of view of the infant's development it has been shown, on the one hand, that children born prematurely seem to show much more impairment when compared to those children born full-term. On the other hand, however, studies have suggested that there is an inherent tendency in the premature infants to catch up with full-term infants provided that some circumstances are respected, such as: 1) familial and external environment organization and support; 2) infant's health condition at birth, despite prematurity and 3) correct and adjusted postconceptional age. These circumstances have given support to particular therapeutic approaches which are believed to be beneficial to the development of the preterm infant and, especially, systematic tactile stimulation as proposed in the TAC-TIC method has been applied and reported to be successfully approved in terms of attending to the infant's (family's) needs.

Considering that the above external factors may account for differences between preterm and full-term groups one would be expected to take into account a series of other variables which may influence the overall development of children born under different circumstances. The aspect of the infant's temperament does not answer this matter but it certainly contributes for further considerations. It has been shown that there is an overall tendency of preterm infants' parents to rate their children as being more difficult. At the same time the studies suggest that, concerning the same infant, there is a significant difference between father's and mother's assignment. The matter of temperament, therefore, should be looked at within the subjectiveness of the parents' judgement which should encourage researchers to go for further investigations and development of more reliable measures.

To conclude, we would like to highlight the preterm capacity to catch-up with full-term infants, while at the same time we agree with the view that familial and external environment, as a whole, do play an essential role in the differences yielded in different studies. Once we show the controversies about the issue of prematurity and impairment we ought to suggest that systematic therapeutic approaches, from the very beginning of the infant's life, should be offered both to the preterm and to his/her family. Therefore, one would expect that the preterm infant's de-

velopment would be a consequence of his/her physical health which would lead him to better/worse development, much more that a simple consequence of the fact of having been born prematurely.

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