**Longitudinal study of extra-stimulated, full-term control, and preterm infants: High-density EEG analyses of cortical activity in response to visual motion**

In my master thesis I investigated the effects of receiving extra motor stimulation and the effects of preterm birth during the first postnatal year on the development of visual motion perception. Understanding the functional development of the brain and whether extra stimulation accelerates the development of visuo-cognitive systems is important to ensure early intervention in both physically healthy infants and at-risk infants such as preterm infants. Using EEG longitudinal data, the thesis investigated the development of visual motion perception by comparing three groups of infants, i.e., extra-stimulated infants, a control group of infants who received a traditional Western upbringing, and preterm infants, at the ages of 4-5 months and 9-12 months. VEP and time-frequency analyses were applied to investigate whether there are any significant differences in brain responses to visual motion between the three infant groups.

When navigating through the dynamic environment, the gathering of perceptual information allows for controlling and guiding future actions so that accidents might be avoided, and goals reached. Visual motion perception is crucial for navigating the environment and provides essential information for self-motion, orientation, control of posture, and locomotion (Agyei, Holth, Van der Weel & Van der Meer, 2015; Vaina & Rushton, 2000). The perception of this information, termed optic flow, is the pattern of visual motion available to the eye when we are moving relative to our environment (J. J. Gibson, 1979). Considering the relevance of these abilities to everyday life, it is important to understand the developmental processes underlying how infants learn to make use of relevant visual information for perception (Agyei, Van der Weel, Van der Meer, 2016).

When infants acquire the first locomotor skill, typically crawling, it dramatically changes the relationship between the infant and the environment. The possibilities for exploration drastically increase as infants' transition from a state of being passively carried around to becoming active explorers of their surrounding world (Gilmore, Baker & Grobman, 2004). Suddenly, the range expands, and the child can even move towards and touch things he or she has previously only looked at. The child is no longer dependent on an adult to move but has been given new and exciting freedom, and their opportunities to learn about objects and events in the world increases. This opens a sea of exploration opportunities for the infants, which provides new perspectives and experiences that can drive changes in a host of different psychological phenomena. However, infants need to have the opportunity to explore and interact with the environment independently to develop the competence of crawling. In contrast to the unidirectional traditional maturational view of brain development, more and more neurologically focused empirical work suggests that locomotion is not merely a maturational antecedent to these changes. Instead, the changes are a function of the specific experiences that accompany moving oneself through the environment (Anderson et al., 2013).

Motor development and psychological development are fundamentally related, even though they are often treated separately (Adolph & Hoch, 2019). Extra stimulation in the form of baby activities plays a central role in Asia and Africa. Infant stimulation includes activities that arouse or stimulate the infant's sense of sight, sound, touch, taste, or smell. In turn, such practices have been demonstrated to affect the timing of acquisition of motor skills (Hopkins & Westra, 1988; Karasik, Tamis-LeMonda, Adolph & Bornstein, 2015; Super, 1976), with enriched stimulation being associated with an earlier onset of motor behaviours, and to have immediate as well as long-lasting developmental effects (Lee & Galloway, 2012; Lobo & Galloway, 2008; Zelazo, Zelazo, Cohen, & Zelazo, 1993). Regarding motor development, Western belief systems often proclaim infants to be fragile and should be handled with care, while some non-Western cultures consider rough handling and deliberate exercise necessary for healthy motor development (Adolph & Hoch, 2019). African and Caribbean people have a culture where caregivers encourage newborn upright stepping movements to train walking, and the result of these belief systems seems to be infants who sit and walk at younger ages than non-exercised infants (Hopkins & Westra 1988, 1990; Super 1976). This is also shown in true experiments with random assignment, where a brief daily exercise of walking and placing reflexes in infants leads to earlier onset of walking alone in Western infants (Zelazo, Zelazo & Kolb, 1972). Lobo and Galloway (2012) also found that a few weeks of daily postural training leads to faster improvements in prone and sitting skills and earlier onset of crawling and walking alone. These findings suggest broad and long-lasting changes can arise via brief periods of change in caregiver-infant interactions. It can thus be suggested that infants born into cultures where extra stimulation is considered important develop earlier than infants from cultures where this is not valued.

The human brain is an organized dynamic network of interconnected neurons and associated synapses that work together such that dysfunctions within the network can have unfortunate effects on behavioural patterns (Agyei et al., 2016). Infants born preterm have been found to be more at risk of neurological deficits and developmental disorders. An infant is defined as preterm when he/she is born before 37 completed weeks of gestation. With increasing numbers of preterm infants surviving, the impact of preterm birth on later cognitive development has been given considerable attention over the years. Magnetic resonance imaging (MRI) studies have demonstrated that being born preterm causes differential brain development, leading to abnormalities in the microstructure of tissues and in cerebral morphology (Counsell & Boardman, 2005). Some of the dysfunctions of preterm birth have been related to cognitive and behavioural impairments (Aarnoudse-Moens et al., 2009; Bhutta et al., 2002; De Jong et al., 2012; Delobel-Ayoub et al., 2009; Johnson, 2007; Salt & Redshaw, 2006). Among the major functions affected by preterm birth, visual cognition is one ([Atkinson & Braddick, 2007](https://www.sciencedirect.com/science/article/pii/S0278262608003205#bib2)).

Given the association between experience and developmental advancements, it was expected for infants receiving extra stimulation to have had greater opportunities for actively engaging with their environment compared to their control and preterm peers, and therefore to show an accelerated development of visual motion perception. Thus, it was hypothesized that extra-stimulated infants would display overall shorter latencies of VEPs in addition to induced activities at higher frequencies than the other two groups. Based on research indicating impaired dorsal stream functioning, the preterm infants in this study were expected to show abnormal development of visual motion processing during the course of the first year of life compared to their peers.

The findings revealed that infants receiving extra stimulation showed an overall greater sensitivity to visual motion than their traditionally-raised peers and preterm infants during the first year as reflected by their shorter latencies in response to visual motion, and oscillatory activities at higher frequencies in the alpha-beta frequency ranges. The greater improvement in extra-stimulated infants than their traditionally-raised peers was attributed to their caregivers' overall handling patterns, including enriched activities. The poorer responses in the preterm infants were associated with impairment of the dorsal visual stream specialized in the processing of visual motion. Consequently, the results may prove beneficial for future attempts to improve infants capabilities at risk for abnormal visuomotor and neurological development. Future studies, as well as follow-up studies of the extra-stimulated enrolled in the present study at school age, may reveal whether the accelerated developmental improvements of visual motion perception in extra-stimulated children are still present and what potential effects this may have on the children's everyday lives, especially as potential interventions to advance development in infants born with risk factors.

Combined, the present study adds to the body of literature demonstrating that visual experience and brain maturation together work to advance the development of visual motion perception in infancy (Agyei et al., 2015; Agyei et al., 2016; Orekhova, Stroganova, Posikera, & Elam 2006; Vilhelmsen Agyei, van der Weel & van der Meer, 2019). The current findings support the relevance of visuomotor experience during the first year of life. Enriched stimulation during the first year of life constituted an important factor in facilitating enhanced visual motion perception in extra-stimulated infants. The present results support previous findings demonstrating enriched stimulation to promote developmental behavioural advancements (Adolph & Hoch, 2019; Karasik et al., 2010, Lobo & Galloway, 2008) by examining this link from a neurodevelopmental perspective. However, the preterm infants did not show a similar progression when it comes to visual motion processing with age as their peers.

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