Understanding infants' mental skills

New AI and sensor tools to measure development

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Details of this research can be found in Sensors *(2023), DOI: 10.3390/s23052709;* Policy Insights from the Behavioral and Brain Sciences *(2022), DOI: 10.1177/23727322211068020;* Sensors *(2020), DOI: 10.3390/s20205781; and* The British Journal of Psychiatry *(2019), DOI: 10.1192/bjp.2019.73.*

From the first months of life, the social environment – particularly interactions between parent and child – plays a fundamental role in shaping the developing brain and mental faculties. Social behaviours, such as hugs, eye contact, smiling and engaging in conversations, help children cultivate their executive functions as they grow.

These cognitive control skills – including memory, self-regulation and mental flexibility – are crucial for the child to develop focus and the ability to plan actions, and lay the foundation for future academic achievement along with enduring health and well-being.

However, the development of these executive functions may be affected in certain neurodevelopmental conditions, such as autism spectrum disorder and attention-deficit/hyperactivity disorder. These conditions often influence social behaviours in the child and can both impact and be impacted by the quality of early social interactions. Recognising and addressing these challenges at an early stage can significantly mitigate their lifelong impact.

Presently, clinical screening tools are generally only applicable for children aged two and older, which overlooks a critical window for early intervention during infancy. We are pioneers in developing advanced sensor technologies and computational tools for clinical use in the early identification of neurodevelopmental risks.

TRANSFORMING CHILD DEVELOPMENT ASSESSMENTS

A methodological breakthrough is "artificial intelligence (AI) neural sociometrics", a computational technique predicting infant cognition based on multimodal profiles of parent-child social interaction.

By leveraging cutting-edge sensor technologies, we capture and analyse patterns and dynamics of parent-infant interaction: synchrony in pose and movement, shared gaze, emotional expression, vocal turn-taking – when individuals take turns to speak – and neurophysiological measurements of the parent and child's brainwaves and heart rate.

Our approach to these measurements is minimally intrusive, occurring during natural play interactions between children and their parents. With ongoing advancements in signal processing, it may soon be feasible to collect rich biobehavioural data in more familiar settings, such as homes or pre-schools.

To facilitate this, we are developing "smart toys" that are embedded with motion sensors similar to those in smartphones, including an inertial measurement unit

A mother and her child share a moment of eye contact and joint attention while sensors capture their brain and behavioural patterns (image used with specific parental consent). Credit: Baby-LINC Lab.

and a barometer. Designed to elicit natural play, these toys simultaneously measure the child's interactions with them, quantifying the direction and speed of toy movement and the applied pressure. The collected data provides a detailed sequence of toy interactions, revealing patterns from which we can infer aspects of infant cognition and learning through specialised AI algorithms.

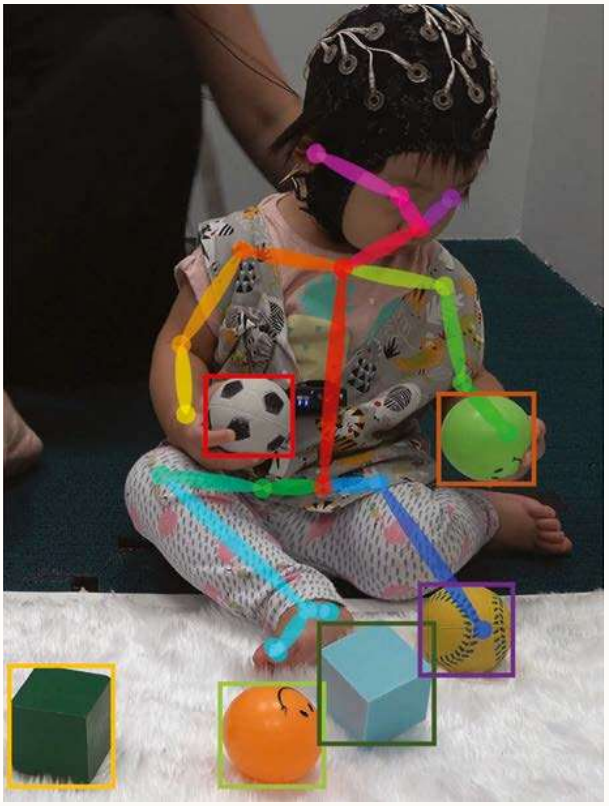
These smart toys, coupled with AI sociometrics technologies, could represent a significant leap forward in early childhood assessment – offering an objective, reliable and scalable method to gather data about a child's developing mental skills, even during infancy.

A NEW PARADIGM FOR CHILD DEVELOPMENTAL SCREENING

Imagine a future where routine 10-minute visits to a child development clinic evolve into interactive play sessions. Families enter a sensor-equipped playroom, where small, unobtrusive sensors and cameras capture brain activity, heart rates, gestures, facial expressions and speech. Toys fitted with eye-tracking and touch sensors provide real-time data on the child's attention and interaction patterns.

A psychologist observes and guides these interactions, extracting meaningful social responses for analysis. High-performance computers equipped with AI algorithms then scrutinise this data, offering real-time feedback on the child's cognitive development.

The time and resources required for such sociometric screening could eventually become comparable to that of a standard newborn hearing test, a nearly universal practice. If achieved, this would facilitate the routine use of sociometric screening as part of a child's developmental journey, informing the timely allocation of healthcare resources and intervention. Early and timely action could fundamentally alter the developmental trajectory of children, setting them on a course towards lifelong cognitive health and mental well-being.



Trained AI algorithms predict the child's pose and interactions with toys in near real-time (image used with specific parental consent). Credit: Baby-LINC Lab.