The promise of two-person neuroscience for developmental psychiatry: Using interaction-based sociometrics to identify disorders of social interaction

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Summary

Social interactions are fundamental for human development, and disordered social interactions are pervasive in many psychiatric disorders. Recent advances in “two-person neuroscience” have provided new tools for characterising social interactions. Accordingly, interaction-based ‘sociometrics’ hold great promise for developmental psychology and psychiatry, particularly in the early identification of social disorders.

(49/50 words)

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Social group living is a fundamental survival strategy employed from birth. Newborn infants instinctively seek and maintain affiliative bonds with adult caregivers who provide care and protection. These human capacities are subserved by the ‘social brain’ whose function is to navigate the complexities of social interaction. When children fail to become competent social interactors the impact on development and mental health is immense. In fact, disordered social interactions play an early and pervasive role in many, if not all psychiatric disorders. It has been further suggested that these disorders may result as much from an ‘interaction mismatch’ across persons, as the break-down of individual brains (Schilbach 2016; Bolis & Schilbach 2017). Yet, the most promising recent efforts to improve psychiatric diagnoses – through blood tests, neuroimaging, genetics or ‘digital phenotyping’ (Insel, 2017) – have continued to focus on the individual to the neglect of social interactional deficits. Meanwhile, the burgeoning field of social neuroscience has already established the feasibility of investigating the concurrent social behaviour of two (or more) interacting participants (Schilbach et al. 2013, Leong et al, 2017; Neale et al, in press). Here, we contend that the neurobehavioural study of social interactions – or interaction-based ‘sociometrics’ – holds much promise for developmental psychology and psychiatry, particularly as a tool for identifying early disorders in the social domain.

Figure 1. Illustration of interaction-based sociometric data collection and analysis. (Left) Examples of different sociometric indices that may be concurrently collected from the infant (top) and adult (bottom) during social interaction. (Right) Examples of interaction-based sociometric analyses to identify temporal contingencies and statistical dependencies between infant and adult indices, such as joint gaze (top) and neural synchrony (bottom). Written consent has been provided for the use of these images.

Imagine walking into a child developmental clinic of the future. Your infant is brought into a play room where EEG electrodes are placed on her scalp to measure brain activity, and ECG electrodes on her chest measure heart rate and arousal. These electrodes wirelessly transmit her neural and physiological signals to the monitoring station next door. A microphone is buttoned onto her vest and motion capture cameras track her movements and posture. Each toy is equipped with eye-tracking software that dynamically monitor your child's gaze patterns as she switches her attention from one toy to the next. Next, a psychologist walks into the room and manoeuvres the social interaction through different phases, each designed to elicit a different social response. Next, high-performance computers analyse the complex dataset using powerful machine learning algorithms. But rather than focusing on your child's individual data, these algorithms extract sociometrics that quantify how your child *relates* to the psychologist, as illustrated in Figure 1. Some sociometric indices lie within the typical range for children her age, but other indices may be less typical – such as the way she tends to avert her gaze from direct eye contact and sluggish neural synchronisation with (and faster de-coupling from) the psychologist's brain activity patterns.

Accordingly, the promise of interaction-based sociometrics, in our view, is that this approach may lead to earlier, more sensitive identification of abnormalities in social development. Although social observation scales and instruments currently exist to diagnose different conditions (such as the Autism Diagnostic Observation Schedule [ADOS] and Early Social Communication Scales [ESCS]), these rely heavily on the assessor's subjective judgment, experience and training. Further, some key aspects of social behavior are not captured by these tests, such as gaze, postural or neural changes. Meanwhile, findings are emerging from the field of social neuroscience that speak directly to this gap in knowledge. Even very subtle shifts in the social interactional status within dyads produce changes in inter-individual neural synchrony when participants are engaged in reciprocal and freely forming interaction: For example, Leong et al (2017) showed that a brief aversion of the adult's eye gaze was sufficient to produce a significant and reliable drop in neural synchronicity between adult-infant pairs, even when no overt changes in infants' own eye gaze patterns were detected.

A second benefit of the sociometric approach is its potential to advance a mechanistic understanding of social interaction difficulties throughout the life-span. Psychiatric disorders are

ubiquitously characterized by social impairments, and it has been suggested that they can in fact be characterized as disorders of social interaction (Schilbach, 2016). Consequently, the *contingency* of social interaction between partners (rather than the independent behaviour of a patient) may be a novel and quantitative measure that could inform transdiagnostic assessments of social impairment in psychiatry, and may even predict interaction success between patient and therapist. For example, Bilek and colleagues (2017) recently showed that in borderline personality disorder, cross-brain connectivity in control-patient dyads was significantly lower as compared to control-control dyads. However, for remitted patients, cross-brain connectivity was restored. Interaction-based measurements, therefore, deliver state-associated biomarkers that may help to guide diagnostic and therapeutic procedures in the future.

Several major challenges currently limit the use of sociometric indices as envisioned. One significant technical challenge is the quantitative assessment of interpersonal movement kinematics and their impact on other measured biological signals, such as the introduction of movement artifacts into the measured EEG signal. To address this, new automated tracking tools are needed to support more sensitive motion detection and correction. Similarly, benchmarks for more stringent control in two-person experimental setups need to be established (Bolis & Schilbach, 2017). A second major challenge pertains to the statistical analysis of interactional data. Standard approaches used in stimulus-response tasks fail to capture the complex and interdependent nature of social interaction behaviour. Consequently, new conceptual and statistical solutions need to be established: Here, interaction-based sociometrics could make a significant contribution by providing an objective quantification of the on-going behaviour of individual partners, as well as their mutual temporal contingencies - such as joint gaze and neural synchrony. These statistical dependencies, which can be formulated in Bayesian terms, could reveal not only *infants'* level of responsiveness to adult behaviour, but adults' responsiveness to infants as well, which may have relevance for conditions such as maternal post-natal depression.

In summary, an interaction-based sociometric approach in combination with new methods for the analysis of interactional contingencies may provide new insights into the neurobehavioral mechanisms of social interaction (Schilbach et al. 2013), as well as powerful new tools for characterizing disorders of social interaction during early development and across the lifespan.

Declarations

All authors declare no conflict of interests.

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