



FROM MEASUREMENT TO INTERPRETATION: BIOBEHAVIOURAL SYNCHRONY IN EARLY INTERACTIONS OF PARENTS WITH PRETERM BABIES

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Advancing Understanding of Bio-Behavioural Synchrony: FromTheory to Practice with SYNCC-IN Workshops, Warsaw, 5 – 7 May, 2025 Globally, 15 millions of babies are born before 37th postconceptional week each year (WHO, 2020; Chawanpaiboon et al., 2019)

Out of this number, 1.1 million of neonates die due to perinatal complications (WHO, 2020; Chawanpaiboon et al., 2019)

Survival rates for the most vulnerable, very and extremely premature babies, have increased (Wolke, Johnson, Mendonca, 2019; Konzett et al. 2024)

Prematurity as one of the main causes of neonatal death (Perin et al., 2022) and a major risk factor for health and developmental problems in childhood and beyond (March of Dimes, ... & WHO, 2012; Alderdice & Redshaw, 2015)

Particularly challenging to parents in the context of the formation of their relationship with the baby and their mental health (Kmita, 2013, 2018; Goutaudier et al., 2011; Genova et al., 2022).



Complications of prematurity

- Neurological ischaemic (e.g. PVL) and haemorrhagic (e.g. IVH grade III & IV; bleeding to <u>cerebellum</u>) insults to CNS, altered/ disturbed CNS development
- Pulmonary (BPD/ CLD, prolonged mechanical ventilation)

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Original Article

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- Infection, inflammation
- <u>Necrotizing enteroclitis (NEC)</u> ...

Risk of neurodevelopmental impairment in Swedish preterm children treated for necrotizing enterocolitis: retrospective cohort study

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Association between medically and surgically treated necrotizing enterocolitis and abdominal surgery compared with all other preterm babies, expressed as hazard ratios (HR) and 95% confidence intervals (c.i.)

UNIQUE CONSTELLATION OF RISK AND PROTECTIVE FACTORS



Source: Montagna & Nosarti, 2016, based on Healy et al., 2013



Prematurity and autism spectrum



In screening tests the risk as high as 20%, in clinical assessment 6%;

The risk significantly higher as compared to general population (Laverty et al., 2021), (Mir et al., 2021); ~~~~

In EPT children 7- 8% (Johnson i in., 2010; Joseph et al., 2017; Agrawal et al. 2018);

<u>Specific clinical picture</u> <u>and phenotype (</u>Johnson & Marlow, 2011; Hofheimer, Sheinkopf, Eyler, 2015) 11

The ratio of boys to girls 2:1 (Joseph et al., 2017); in girls a stronger relationship with GW, in boys higher risk independently of GW (Allen et al., 2021)



Diagnostic challenges due to the complexity and interrelations of developmental risk factors, specific features of PT children functioning and the dynamics of their developmental trajectories

Prematurity and autism spectrum

www.nature.com/	ip

Journal of Perinatology

Check for updates

BRIEF COMMUNICATION OPEN

Neonatal autonomic regulation as a predictor of autism

symptoms in very preterm infants

Jessica Bradshaw^{1,283}, Christian O'Reilly 😳^{2,3,4}, Kayla C. Everhart 💽⁵, Elizabeth Dixon^{1,2}, Amy Vinyard¹, Abbas Tavakoli⁵ and Robin B. Dail 💿^{2,5}

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INTRODUCTION

Infants born preterm are at a significantly higher likelihood of having autism spectrum disorder (ASD), with reports of a 10-fold increase in the rate of ASD for very preterm infants (VPT, born <32 weeks gestation) [1] and a 20-fold increase for extremely preterm infants (born <28 weeks gestation) [2]. Yet, the etiological link between preterm birth and ASD remains unknown. Preterm birth and ASD are both associated with neurological differences, notably

completed with the mother prior to any study procedures, which were approved by hospital and university institutional review boards. Univariate, multivariate, and robust regression models were used to evaluate neonatal predictors of ASD outcomes.

RESULTS Descriptive statistics for all measures are presented in Table 1 and

- Same or different?
- Possible risk factors/ mechanisms?
 - Links to placental pathology (Mir et al., 2021)
 - Impaired brain connectivity (due to the damage/ abnormalities of the white matter (e.g. Skranes et al., 2007)
 - Impaired cerebellar growth & development (Limperopoulos, et al., 2009, 2014; Brossard-Racine et al., 2015; Spoto et al., 2021) due to:
 - Early insult to the CNS, especially injury to the vermis;
 - Loss of maternal-placental growth factors
 - Detrimental environmental influences
 - Interconnections of the above risk factors





From a "fragile baby" to be cured, protected and monitored

> to a baby with a "social sense" who is an active participant in precious moments of meetings in intersubjective space





Neugebauer, Ch., Oh, W., McCarty, M., Mastergeorge, A. (2022). Mother–Infant Dyadic Synchrony in the NICU Context. *Advances in Neonatal Care* 22(2):p 170-179; DOI: 10.1097/ANC.00000000000855

Core processes in social interaction: A variety of terms



Biobehavioural synchrony

Biobehavioural synchrony can be defined after Feldman (2012, 2017) as "the coordination of biological processes and speciestypical behaviours expressed during or immediately after social contact..." (Long et al., 2020, p. 309).

It involves ongoing matching of biological/ physiological rhythms, affective states, and behaviour of participants, organised in identifiable patterns.



Furthermore, it can be studied at different levels of functioning: from autonomic and endocrine processes, brain activity to behavioural responses, and across various modalities, e.g. heart rate, hormone secretion, neural activation patterns, touch, gaze, vocalisation, etc. (Feldman, 2017). Source: Feldman, R. (2020). What is resilience: an affiliative neuroscience approach. World Psychiatry, 19 (2): 132-150, DOI: (10.1002/wps.20729)

Tenets of resilience

Plasticity

ALL LIVING MATTER

Resilience implicates flexible adaptation to changing conditions, the emergence of new forms from sub-components, and the ability to re-calibrate.

Sociality

ACROSS ANIMAL EVOLUTION

Coordinated action among organisms enhances survival of the group. In mammals, bonding confers resilience by supporting maturation of stress-management systems, providing protection, and ushering social collaboration.

Meaning

HUMAN SPECIFIC

Meaning-making systems sustain resilience by giving significance to human suffering, inspiring strength in the face of trauma, and transcending death through acts of kindness.





BIOBEHAVIORAL SYNCHRONY

Flexible interplay of order and variability, continuous oscillations of mismatch and reparation, and bottom-up coordination of biology and behavior.

Marks the infant's first encounter with the social world and expands across development. Individually stable across

Provides the foundation for empathy,



AFFILIATIVE BRAIN

Parental brain coheres during the period of greatest plasticity in the adult brain and shapes the infant's social brain during sensitive periods of plasticity.

Sustains the capacity to form parental, pair, and filial bonds across mammalian species.

Extends to love beyond concrete attachments to humankind, biosphere, and abstract commitments that transcend the individual's life.

Development and Psychopathology (2025), 1-17 doi:10.1017/S0954579424001950

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Regular Article

Dyadic resilience after postpartum depression: The protective role of mother-infant respiratory sinus arrhythmia synchrony during play for maternal and child mental health across early childhood

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Abstract

Coordination in mothers' and their infants' parasympathetic nervous system functioning (i.e., respiratory sinus arrhythmia [RSA] synchrony) specifically during playful interactions may promote resilience against exposure to postpartum depressive symptoms (PPD), for both members of the dyad. To test biobehavioral synchrony theory-derived hypotheses, we evaluated whether positive mother-infant RSA synchrony during Comparing interactions of preterm and fullterm dyads

Hartzell, G., Shaw, R. J., & Givrad, S. (2023). Preterm infant mental health in the neonatal intensive care unit: a review of research on NICU parent-infant interactions and maternal sensitivity. *Infant Mental Health Journal*, 44(6), 837-856. https://doi.org/10.1002/imhj.22086 Systematic review - 52 studies from the years 1980 – 2022 included (out of 190 identified)

- <u>18/ 40 studies on maternal behaviour</u> decreased sensitivity and more intrusiveness in mothers of preterm infants, 7 studies the opposite, 4 studies mixed results, 11 studies no differences.
- <u>17/ 25 studies on infant behaviour</u> less responsiveness in preterm infants, 2 studies the opposite, and the remainder no difference.
- <u>8/14 studies on dyad-specific behavior</u> less synchrony in preterm dyads and the remainder found no differences.
- <u>Heterogeneity</u> in the study populations, degree of prematurity, timepoints of assessments, sample sizes, and outcome measures
- "....approximately one-fifth of the studies, which mostly consisted of those with larger sample sizes, showed no differences between preterm and full-term infants with respect to maternal sensitivity and parent-infant interaction behavior, perhaps because larger sample sizes contain a wider variety of maternal behavior and sensitivity in both populations....,



A.,12 months corrected age; 28 GW, 1200g, 63 days of NICU stay

"Meeting a new person": A visualisation of affect in two infant-father-mother triads (F. –above, and A. – below). The analysis was made with the Observer XT 9.0.

Examples of studies on biobehavioural synchrony in preterm dyads

Vagal Tone Development

• Kangaroo Care (KC) effects:

– More rapid maturation of vagal tone in preterm infants (Feldman & Eidelman, 2003)

– Improved Respiratory Sinus Arrhythmia (RSA), linked to enhanced mother-child reciprocity (Feldman et al., 2014)

• Associations with synchrony:

– Higher neonatal vagal tone associated with greater prevalence of synchrony (Feldman, 2006)

Oxytocin Responses

• Parental oxytocin levels:

– Higher levels associated with more synchrony and responsiveness in parent-infant interactions (Vittner et al., 2018)

Sleep-Wake Cycles

• Relationship to synchrony:

– Organized sleep-wake cyclicity associated with higher synchrony (Feldman, 2006)

Elicit; Elicit: The AI Research Assistant; <u>https://elicit.com</u> accessed March 27' 2025

Anna Grochowska's study: *autonomic synchrony in mother – infant interactions and affective touch*

15 mother-infant dyads ; 29-35 GW; 18-66 days after birth 1) free mother – baby interaction preceding routine medical procedure (20 minutes,

2) during kangaroo care after the procedure (vaccination/ blood sampling)(5 minutes)

PNS activity – heart rate variability (HRV) measurement with the use of:

1) the newborn infant parasympathetic evaluation (NIPE) index (for infants),
2) the analgesia nociceptive index (ANI; for mothers)

Range from 0 to 100

Six indicators computed with CRQA R package 4.3.2 : max lag, max recurrence, recurrence rate, percentage determinism, maximal length, entropy, e.g.:

<u>recurrence rate (%REC)</u> - the number of shared location relative to the number of possible shared locations - <u>(the time spent in synchrony</u>)

<u>percentage "determinism" (%DET)</u> - the ratio of the number of shared locations that are part of a sequence of shared locations relative to the total number of shared locations - (<u>how often</u> <u>two series are connected in a predictable way</u>)

<u>Maximal length (MAXL)</u> - the length of the longest trajectory of consecutive parallel recurrent points - (<u>the length of the longest period of synchronization</u>),





Infant Behavior and Development 77 (2024) 10200



Registered report stage II

Maternal affective touch and adaptive synchrony in mother-preterm infant interactions: Implications for early bonding processes

Anna Grochowska^{a,b,*}, Grażyna Kmita^{b,c}, Szymon Szumiał^d, Magdalena Rutkowska^c Anna Grochowska's study: *autonomic synchrony in mother – infant interactions and affective touch*



The effects of maternal voice

"At the physiological level, inconsistency in the effects of maternal voice exposure on heart rate regulation, oxygen saturation and the number of cardiac and respiratory events emerged (Bozzette, 2008; Filippa et al., 2013; Johnston et al., 2007; Picciolini et al., 2014; Randand

Lahav, 2014b; Saito et al., 2009)." p.48

Study Protocol



Neuroscience and Biobebayioral Reviews 88 (2018) 42-50 Contents lists available at ScienceDirect



Eliza Kiepura – Nawrocka, PhD





Figure 1. An exemplary illustration of the annotation of parental IDS, infant's vocalizations, and pauses; p. 7.

Journal of Child Language (2021), 1–18 doi:10.1017/S030500092100012X

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ARTICLE

Silence matters: The role of pauses during dyadic maternal and paternal vocal interactions with preterm and full-term infants

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Frequency of paternal utterances significantly and positively correlated with the frequency and duration of infant vocalizations.

Frequent conversational pauses of a relatively short total duration related to more active infants' vocal participation, regardless of prematurity and parent gender.



The biggest challenge: how to make sense of the different levels of interpersonal dynamics?



Conclusions & future directions ...

- From child-focused to truly systemic, transactional understanding of how premature infants & their parents, as active agents with specific characteristics and interaction patterns, shape development
- Acknowledging situational context and timing
- A crucial role of a researcher's reflexive stance
- This implies not only a relationship-based science but also a relationship-based practice



The parent-child connection is the most powerful mental health intervention known to mankind.

Bessel van der Kolk



I'D LIKE TO EXPRESS MY GRATITUDE TO PARENTS AND INFANTS, AND TO MY COLLEAGUES AND STUDENTS WITHOUT WHOM THIS LECTURE WOULD NOT HAVE BEEN POSSIBLE.

Thank you for your attention!



...I believe that even the most rigorous physical scientist must assume that there exists a harmony of forces in the universe he studies. It could not have evolved into the myriad processes and structures with every level of natural complexity if it did not keep a balance of organization, conserving energy in various forms. Nature grows on the edge of creation, between order and chaos, and must conserve a rhythm of being, however fragile, in all its evolving processes and substances. ...

> Colwyn Trevarthen, chapter 33: Universal Harmony, p. 599

Intersubjective Minds

ерітер ву Jonathan Delafield-Butt & Vasudevi Reddy