The unsettled baby: how complexity science helps

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BACKGROUND
Although unsettled behaviour is a common problem in the first months of life, families complain that they receive conflicting advice from health professionals. A simplistic, biomedical approach may cause harm, because only 5% of unsettled babies have organic disturbance. However, an approach that focuses on psychosocial support may fail to diagnose correctable clinical problems, including feeding difficulty, which paradoxically risks entrenching parental anxiety and disrupted mother–child relations long term.

Applied complexity science frames the mother and baby as a complex adaptive system (CAS), made up of multiple known and unknown dynamically interacting and co-evolving factors out of which cry-fuss behaviours emerge, and demands a transdisciplinary integration of evidence.

Applied complexity science makes sense of the puzzling non-linear interrelationships observed between cry-fuss problems and various factors, including aversive feeding behaviours, or perinatal anxiety and depression.

The CAS of the mother and baby self-organises according to inherent patterns determined by a long evolutionary history, emphasising the importance of supporting parents' trust in, and attunement with, their unsettled baby's innate capacity for self-regulation in the first months of life. The CAS of the mother and baby displays sensitivity to initial conditions, so that a small change early on may have unpredictable and disproportionate effects after an unpredictable time lag, emphasising the importance of early intervention once unsettledness emerges. Application of complexity science to the design of a team-delivered primary care approach to the unsettled baby supports the parents' autonomy and resilience, encourages flexibility and experimentation, and embraces the suboptimal.

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A REDUCTIONIST APPROACH MAY HAVE UNINTENDED CONSEQUENCES

Unsettled behaviour is among the most common clinical presentations in the first few months of life,[1] and one in five infants has parent-reported cry-fuss problems.[2] Although these infants are at increased risk of premature breastfeeding cessation,[3] child abuse[4] and long-term psychological disturbances,[5 6] and their mothers are at increased risk of perinatal anxiety and depression,[7 8] families complain that care is difficult to access and piecemeal, and that they receive conflicting advice.[9] Organic disturbance is implicated in only 5% of cases,[10] and unintended harm may result if concerned clinicians apply a simplistic, biomedical approach to this complex problem, since it emerges out of multiple known and unknown dynamically interacting and co-evolving factors.[11 12] For example, an analysis of research into infant gastro-oesophageal reflux disease (GORD) shows that the outcomes were distorted by unexamined theoretical biases,[13] resulting in two decades of widespread, inappropriate diagnosis of GORD in otherwise healthy, full-term, unsettled babies in the first months of life.[14 15] On the other hand, however, an approach that frames infant cry-fuss behaviours as a transient neuro-developmental disturbance with a focus on psychosocial support for maternal coping may fail to identify various correctable clinical problems, including feeding difficulty. Unidentified and unmanaged clinical problems may entrench cry-fuss behaviours, parental anxiety and disrupted mother–child relations long-term.[16–18]

Clinicians may recognise that persistent crying in babies has multiple aetiologies, but conceptualise the incidence of various factors known to contribute to the problem in a 'diagnostic pie'.[19] This remains a reductionist, 'reduce and resolve' methodology, implying that predictable outcomes are achievable if each separate ingredient can be identified, and fails to consider unpredictable or non-linear relationships between dynamically co-evolving constituents. Multi-component interventions framed in the 'reduce and resolve' paradigm are for this reason regularly found to be less than successful on evaluation.[11 20]

As a result of these problems, research into unsettledness in infants is undergoing a paradigm shift, from a reductionist to a systemic or holistic approach.[12] The emerging field of complexity science provides frameworks for conceptualising and evaluating approaches to such complex, evolving, real-world health problems.[21–32] This paper applies the principles of complexity science to the clinical problem of the unsettled infant in the first months of life, as a framework for the design of an integrated, transdisciplinary, primary care intervention. Evaluation draws on sophisticated complexity methodologies and is outside the scope of this paper.

INFANT UNSETTLEDNESS: AN EMERGENT PHENOMENON ARISING OUT OF THE COMPLEX ADAPTIVE SYSTEM OF THE MOTHER AND BABY

In complexity science, a complex adaptive system (CAS) is a dynamic network of components or systems acting in parallel, yet interconnected and interacting. The mother and baby can be understood as a CAS, made up of dynamically interconnected and interacting CASs, including the genetic, neurological, gastrointestinal, immune and endocrine systems of the baby; the psychological and physical well-being of the mother in the antenatal, intrapartum and postpartum periods; the intimately connected neuroendocrine and enteromammary immune systems of the breastfeeding mother–baby pair; the effects of technology on the physiology of the infant with breast milk substitution; the mother's economic, familial and social contexts; and the belief systems and infant-care practices of the culture of which the mother is a part. Since each agent within its CAS is nested within other CASs, all co-evolving and interacting together, none can be understood without reference to the other.

Complexity science frames certain clinical problems as emergent phenomena arising out of CASs. An emergent

phenomenon results from dynamic and often unpredictable interactions within and between multiple CASs (biochemical, cellular, physiological, psychological, environmental, sociocultural), rather than from the failure of a single component, and may be understood as an opportunity for restabilisation of the CAS.

This theoretical framework facilitates the integration of previously disparate evidence across the medical and social sciences concerning unsettled behaviours in infants. Complexity science enables general practitioners, paediatricians, perinatal psychiatrists, child health nurses, midwives, psychologists, social workers, speech pathologists, lactation consultants, physiotherapists and occupational therapists, all of whom currently approach unsettled infants from different paradigms and knowledge bases, to share a coherent, transdisciplinary approach. Complexity science explains why a single intervention or cluster of interventions for unsettled behaviour, for example, carrying or increased maternal responsiveness, fail to yield reproducible results,[33] and makes sense of problematic, non-linear associations, for example, between perinatal anxiety and depression and cry-fuss behaviours,[7 8 34] or aversive feeding behaviour and cry-fuss behaviours.[15 17 18 35–37]

CHARACTERISTICS OF THE COMPLEX ADAPTIVE SYSTEM OF THE MOTHER AND BABY

The relationships between constituent components of a CAS demonstrate certain properties, including self-organisation, inherent patterns and sensitivity to initial conditions (see boxes 1 and 2).

Self-organisation

The property of self-organisation refers to the capacity of the CAS to self-modulate by means of multiple positive and negative feedback loops around shifting points of equilibrium, despite constant and not always predictable changes within and around the system. The mother–baby CAS spontaneously self-organises according to multiple feedback loops – biochemical, neurohormonal and behavioural – within the infant, within the mother, between mother and infant, and within the broader familial and sociocultural systems.[38] Because of self-organisation, CASs show resilience in the face of perturbation, and are characterised by a high degree of flexibility and adaptivity. As a result, the human infant is extremely adaptive to a wide range of infant-care norms across diverse cultures. But unsettled behaviour may emerge if disruption of feedback loops exceeds the capacity of the mother–baby CAS to compensate, or adapt. For example, unidentified breastfeeding difficulty, including problems with attachment, positioning and suck–swallow–breath co-ordination, may interfere with self-organising neurohormonal and autocrine breastfeeding feedback loops, causing cry-fuss behaviours, failure to thrive, or both.[36 39] The neuroplasticity of the infant's brain is another example of complex self-organising feedback loops. Precry cues signal the need for external regulation of state; when this biological expectation is unmet, infants move into the physiological disorganisation of a full-blown cry, which is quickly overwhelming and difficult to soothe. Some infants, depending on temperament, neurodevelopmental maturity, adaptivity or

Box 1 The complex adaptive system of a mother and baby, out of which cry-fuss behaviours emerge, is sensitive to initial conditions with disproportionate outcomes

Jane presents with her first baby, N, aged 10 days. N was born at term by vacuum extraction weighing 3.2 kg, and was discharged at 48 h breastfeeding. He has a 5-day history of cry-fuss behaviour for long periods each day. He weighs 3.15 kg. Jane offers N the breast every 4 h. By feed times he is agitated and has difficulty latching on. Although he appears hungry, he feeds for 5 min then falls asleep, then wakes again after about 30 min and starts crying again. You encourage Jane to start supplementing with infant formula after every feed and to continue feeding N no more than every 3–4 h to develop a routine. Over the next 2 weeks Jane stops breastfeeding, explaining that she doesn't have enough milk. N gains weight, but the crying persists, he vomits frequently each day, and continues to be difficult to feed. By 2 months gastro-oesophageal reflux disease is diagnosed and he is started on a proton pump inhibitor. Jane is anxious because of her 'sick' baby, who continues refusing the bottle and crying at each feed despite treatment. She wants to make sure he finishes every bottle because he usually vomits some up. She starts solids at 4 months to ensure he is getting enough to eat and to assist the reflux. Although the crying settles, N is resistant to changes in texture and the taste of solids and feeding difficulties continue. Jane is diagnosed with postnatal depression. She dreads meal times, as N refuses to eat all but a very narrow range of foods, and in small quantities. When he starts preschool, N's teacher reports that N often has difficulty paying attention and doing as asked. Jane explains that N has always been a difficult child.

Box 2 The complex adaptive system of a mother and baby, out of which cry-fuss behaviours emerge, self-organises according to inherent patterns and re-stabilises

Jane presents with her first baby, N, aged 10 days. N was born at term by vacuum extraction weighing 3.2 kg, and was discharged at 48 h breastfeeding. He has a 5-day history of cry- fuss behaviour for long periods each day. He weighs 3.15 kg. Jane offers N the breast every 4 h. By feed times he is agitated and has difficulty latching on. Although he appears hungry, he feeds for 5 min, then falls asleep, then wakes again after about 30 min and starts crying again. You suggest that Jane feeds her baby frequently (at least 8 and up to 12 times a day) from both breasts. Since crying is a late cue, you encourage her to watch her baby for signs of hunger and the need for comfort, and to respond. With frequent emptying of the breast, endocrine and autocrine feedback mechanisms increase Jane's milk supply. The baby stays awake during feeds, is easier to feed since he is in a more organised state, and receives more milk. Holding and carrying N when she can and sleeping with him beside her bed promotes Jane's milk supply, and assists in settling him. Although N vomits frequently each day, sometimes during feeds, he gains weight nicely. Later, when N starts preschool, he settles in well. Jane tells the teacher that N was a 'high needs' baby, but grew out of it.

other unknown factors, learn to by-pass precry cues if the cues are not effective in securing external regulation, and habituate rapid disorganisation into unsoothable crying in response to minimal triggers.[16 40–43]

Inherent patterns

Interactions of components of CASs often coalesce according to inherent patterns, which are nevertheless dynamic and adaptable. The inherent biological patterns of the human infant in the first weeks and months of life arise out of a long evolutionary history.[44] These patterns include frequent waking during the night in expectation of external co-regulation,[45 46] and unpredictable and frequent feeding at the breast, by which the infant self-regulates the mother's milk supply to match its variable need.[39 47–50] But 'distal' care, which emphasises early independence, became the dominant style of infant care in the west from the time of the Industrial Revolution. Building on this, 'scientific mothering' rose to the fore from the early 1900s, advocating routinised infant-care practices that are in tension with the inherent biological patterns of mothers and infants.[51 52]

Framing the mother and baby as a CAS suggests that cry-fuss behaviours are more likely to arise in the first few months of life in less adaptive, less neurodevelopmentally mature or temperamentally predisposed infants, when inherent, biologically determined patterns fail to align with the realities of contemporary life.[13 53 54] This explains why infants receiving 'proximal' care are more likely to be settled;[53] why routinised, three or four hourly feeds may be associated with failure to thrive, unsettled behaviours and reduced breast milk supply, leading to lactation failure;[38 39 49 53] and why attempts at training infants to sleep through the night in the first months of life do not help cry-fuss problems.[55 56]

Sensitivity to initial conditions

Relationships between various elements in a CAS are often non-linear. When a CAS displays the non-linear property known as sensitivity to initial conditions, early, difficult to detect changes in one variable or element can lead to massive shifts in the system through amplification effects or synergies with other variables, setting the CAS on a new trajectory with dramatically changed performance, although skewed outcomes may not be apparent until after a significant delay. Sensitivity to initial conditions suggests that the timing, rather than the magnitude, of an intervention may be critical.[21 57 58]

For example, early breastfeeding problems exert a number of disproportionate short- and long-term effects on the mother–baby CAS, including unsettled behaviours. Many health professionals remain unaware of their knowledge deficits concerning lactation.[59 60] These same knowledge deficits bias crying baby research,[13] and unsettled babies remain at risk of premature breastfeeding cessation.[3] Due to the highly plastic feedback loops in the infant brain, unidentified and unmanaged feeding difficulties entrench cry-fuss behaviours and aversive feeding behaviours in some infants.[16 61] Aversive feeding behaviours may then result in maternal anxiety, disrupted maternal–infant interactions, and, if entrenched, long-term behavioural problems.[6 17 18 36 62] Breast milk substitution is a technological intervention to which most infants adapt, but which may also generate short- and long-term emergent phenomena.[63–65] For example, formula-feeding predisposes to cow's milk allergy (CMA), which causes unsettled behaviour in infants.[66]

Understanding the sensitivity to initial conditions that operates in the mother–baby CAS makes sense of the complicated inter-relationships between failure to thrive, aversive feeding behaviours and unsettledness – signs which, due to implicit biomedical framing and researcher's knowledge deficits concerning lactation, have been used to inappropriately diagnose GORD, food allergies (other than CMA) and lactose intolerance in unsettled babies in the first months of life.[12]

PRACTICAL IMPLICATIONS FOR FAMILIES

If infant unsettledness is an emergent phenomenon that arises out of a self-organising mother–baby CAS, transdisciplinary integration in the design and delivery of an intervention is fundamental; simplistic, biomedical approaches have a constrained role; and the presenting clinical crisis can be framed as an opportunity to support the family's transformative learning. From the perspective of complexity science, the health outcome of a complex intervention for unsettled infants may be best conceptualised as a 'fitness landscape' instead of various single, discrete endpoints. The mother and baby's position in a fitness landscape evolves and fluctuates over time, as parents embrace the suboptimal, mistakes and misdirections, and variability.[25]

Since the mother–baby CAS is characterised by self-organisation, parents are co-creators of the intervention: health professionals respect the parents' autonomy and understand that the carer's personal experience of the problem is the 'core-driver'.[67] The inherent resilience of both mother and baby is supported by early identification and treatment of both organic problems in infants, for example, urinary tract infection,[10] and maternal health problems, for example, perinatal anxiety and depression;[7 8] also by informing families about normal crying in infancy and strategies to manage feelings that could lead to harming the baby.[68] Experimentation and flexibility are encouraged as healthy and adaptive qualities of self-organising systems.[25]

Mothers are encouraged to attune to their baby's cues and trust the baby's inherent biological patterns, including the unpredictable feed and sleep needs by which infants self-regulate in the first months of life.[16 42 48 62] Because of human evolutionary biology, babies sleep safest in same room as parents,[51 69 70] and are more settled in the first few months of life if they are breastfed on demand and in close physical contact with the care giver.[53] Attunement contrasts with socioculturally-determined behavioural approaches (eg, feed–play–sleep routines, feed spacing, practices designed to teach independent sleep), commonly prescribed for babies from the first weeks of life.[51 52] But the only 'right' approach to balancing an infant's inherent biological patterns and the challenges of contemporary life is the one with which the mother and her family opt to experiment at any given time.

In Australia, existing multi-disciplinary programs are mostly tertiary residential units, servicing families with older babies who have already consulted multiple health professionals, and in whom feeding difficulty and disrupted mother–infant relationships are often entrenched.[71 72] Because the mother–baby CAS is characterised by sensitivity to initial conditions, early community-based intervention for unsettled behaviours is critical. Any baby who continues to cry after initial assessment and management by a primary care practitioner requires rapid referral to health professionals expert in feeding difficulty and the holistic

psychosocial assessment and support of families of newborns. Early screening of this population of mothers for psychosocial risk factors and perinatal anxiety and depression is vital.[7 8]

CONCLUSION

Application of complexity science in the design of an intervention for the unsettled baby and its mother provides a compelling rationale for two key features. Firstly, re-framing the mother and baby as a CAS emphasises the importance of early intervention from the first days and weeks by a co-ordinated team of primary care doctors, midwives and child health nurses, who are upskilled in lactation support, and able to co-ordinate in timely manner with feeding experts and perinatal and infant mental health experts, as required. Secondly, re-framing the mother and baby as a CAS emphasises the importance of supporting parents' trust in and attunement with their baby's innate capacity for self-regulation in the first few months of life. Given the prevalence and significance of cry-fuss behaviours in infants, and the economic burden of late, tertiary intervention, the design and evaluation of such an integrated, multi-disciplinary, primary care program is a priority.

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