

**Neonatal participation in neonatal imitation:**

**Narrative in newborn dialogues.**

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**Abstract**

Since the publication of Meltzoff and Moore's seminal paper, neonatal imitation has been discussed, debated and scrutinised at considerable length. Despite this, the temporal structure within which the interaction sits, has received limited attention. We hypothesise underlying successful examples of neonatal imitation exists a narrative temporal structure, expressed and perceived not only through vocalisations but also (if not primarily) through movement. We contextualise neonatal imitation through a communicative lens, viewing the phenomenon as an early dialogue between adult and infant, underpinned by the same narrative structure as other 'proto-conversations' in infancy. From this perspective several of the leading and traditional theories that have been proposed to explain neonatal imitation are considered. Ultimately, we argue neonatal imitation is an innately dialogical phenomenon that forms one of the first examples of primary intersubjectivity, exemplifying the importance of the neonatal period in human psychological and social development. On this basis we propose further study is required into the temporal structure underlying neonatal imitation.

## **Neonatal participation in neonatal imitation:**

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#### **1.0 Narrative in the neonatal phase**

Narrative structures underlie multiple aspects of our culture. They can be found throughout many parts of our daily lives - in the music we listen to, the books we read, and in the dance, theatre, television and film we enjoy. They exist in the speeches we hear from our political leaders and the conversations we have with our friends. Bruner (1990) considered narrative to form an organising life principle of human cognition, and to be central in human communication. It is through narratives that we develop our understanding of the properties of objects and how persons of different character are motivated and interact. Narrative gives meaning to our scientific and general understanding of the world. They form a fundamental architecture of intelligence that allows individuals to create meaning within an interaction, and in everyday projects.

These narratives, and the form of meaning-making they constitute, can be traced back to the earliest stages of human development. Even before birth, evidence indicates the actions of the foetus are purposive, and made with awareness of a social other (Castiello et al., 2010; Piontelli, 2010; Delafield-Butt & Gangopadhyay, 2013; Quintero & De Jaegher, 2020). These self-generated actions, which test the world seeking a response from the environment, are what Piaget identified as the earliest sensorimotor intelligence (Piaget 1953, 1954). This basic action-response testing nature of foetal and infant action forms the foundation for the development and learning (Trevvarthen and Delafield-Butt, 2017).

Following birth, the interests of the neonate can become entwined with those of the caregiver in early intersubjective events or proto-conversations during which vocal and movement-based interactions (that are not yet imbued with language) are structured through a

narrative architecture (Gratier & Trevarthen, 2008). Within dyadic infant-parent interaction these early interactions follow a common motif, or template, of expressed interest, arousal, and intention shared on both sides (Brazelton, 1974; Stern, 2000; Trevarthen, 2012). Acoustic analysis of these interactions demonstrated a regular temporal pulse or rhythm, where each expressive act is reciprocated by the other, reflecting and improvising its quality (Malloch, 1999; Trevarthen, 1999). These reciprocated expressions increase the interest and intensity of the interaction, and generate a clear narrative structure common to all the time-based adult human arts of introduction, development, climax, and conclusion (Malloch and Trevarthen, 2009). Stern (1999) described these prelinguistic infant-adult interactions as 'proto-narratives', which as an infant grows and develops become imbued with words to begin new, linguistic competences built from these interactions and their shared meaning (Terrace, Bigelow, Beebe, 2022). Those regularly structured patterns of emotions and intentions develop conversations with ever more complex narrative form (Delafield-Butt & Trevarthen, 2013). Such narrative-based interactions are imperative for successful socio-cognitive and communicative development (Delafield-Butt 2018). Understanding the organisational structure of the earliest interactions in which infants engage their human companions is an important consideration for the field of developmental psychology, and especially important for understanding the context in which neonatal imitation is proposed to unfold. Theoretical re-positioning (aligned with embodied (Di Paolo & De Jaegher, 2015; Varela et al, 1991), enactive (Stewart et al, 2011; De Jaegher & Di Paolo, 2007), and ecological perspectives (Reed, 1996) that take into account infant agency) allow us to approach these interactions from a fresh perspective by placing greater emphasis on social context and the body's function in social cognition and meaning-making (Delafield-Butt & Trevarthen, 2015) whilst still retaining the benefits of clear, quantifiable, and testable experimental findings.

For many years narratives were thought to be dependent on language and an abstract rationale form of intelligence (Hutto, 2007), but recent infant research has shown the capabilities of even newborn infants to engage in proto-conversations. These exchanges contain a prelinguistic meaning-making that utilises vocal and bodily gestures to create non-verbal, co-created narratives within the proto-conversation (Delafield-Butt & Trevarthen, 2015; Malloch, 1999; Malloch & Trevarthen, 2009). Dautenhahn (2002) considered these pre-verbal narratives the basis of a consciousness in a purposeful social existence. For this to be true, narratives do not need to be based in language. Indeed, all narratives are rooted and expressed in movements of the body. The infant's role in the creation of these 'units' of meaning-making generates the foundation of learning patterns that allow the formation of the embodied practices, including music, theatre, dance, storytelling and all forms of co-operative activity (Cobley, 2013; Delafield-Butt & Adie, 2016; Delafield-Butt & Trevarthen, 2015; Gratier & Trevarthen, 2008; Negayama et al., 2015).

It is also possible that a narrative architecture underpins successful examples of neonatal imitation. Neonatal imitation can be argued to represent sensitivity to another human being (Trevarthen, 2001) and may serve as an early example of early reciprocal communication present long before the development of language (Nagy & Molnar, 2004). It has been proposed that such imitative interaction provides an initial means of communication for infants with caregivers, and may aid in the development of conceptual understanding of others as those with whom goals and interests can be shared (Meltzoff & Moore, 1998). Viewing this phenomenon through a dialogical lens allows us to consider it as an early example of primary intersubjectivity, and of being a precursor to other proto-conversations already identified between adults and infants (e.g. Delafield-Butt & Trevarthen, 2015; Gratier, 2003; Jaffe et al, 2001; Stern, 1977, 1999). On this basis, we might expect imitative

interactions to possess the same generative architecture and characteristics as other proto-conversations.

However, in a laboratory setting neonatal imitation is simply defined as movements (usually involving the face, hands or fingers) or vocalisations made by infants in the first month after birth that imitate those made by a human or non-human model. Within this strict experimental paradigm, a model presents a movement that can be a facial or bodily expression, or a sound, and an infant's response is monitored for attempts at responding with the same movement or sound. It is important to note that despite the ongoing debate surrounding neonatal imitation, it is not necessarily the neonate's ability to imitate that is of the greatest importance when considering the phenomenon. Indeed, there has been limited examination of neonatal imitation in natural settings with parents, and in the studies that have been completed it is a behaviour that is displayed rarely during interactions with carers (Simpson et al., 2014). It is perhaps more useful to view neonatal imitation as one of multiple ways neonates can express themselves, and so it forms part of much more nuanced, and complex, natural behavioural repertoire (Trevvarthen, 1979).

### **1.1 Imitation as communicative social learning**

In this paper, we propose that through study of the temporal organisation of neonatal imitation, it will become possible to delve more deeply into the fundamental capacity of neonates to engage with another individual's actions and agency, and therefore to better understand the role of this particular, peculiar element in neonatal social behaviour. The importance of imitative interactions in building attachment and in developing cultural intelligence has been supported in a wealth of psychological research (e.g. Nadel, 2014), and in recent neuroscientific findings (Ammaniti & Gallese, 2014). Indeed, imitation through

infancy allows infants to socially connect with and learn from others. Meltzoff and Marshall (2018) argue that even though other animal species have been found to imitate, in humans there is a unique ability to imitate across modalities (from bodily movements to vocalisations), and that human children are highly motivated to be like their caregivers and other adults. This helps underpin the diverse cultural outcomes found in human societies, as imitation forms a bridge between infants and caregivers, from whom cultural information is gathered, re-embodied, then remembered and understood.

Imitation plays a fundamental role in establishing what Piaget came to term the child's developing 'sensorimotor intelligence' (Piaget, 1953, 1954). From the very beginning of child psychology, Baldwin recognised imitative mechanisms as fundamental for learning the patterns of one's own body, made with self-conscious awareness, "The self-repeating or 'circular' reaction... is seen to be fundamental and to remain the same, as far as structure is concerned, for all motor activity whatever: the only difference between higher and lower function being, that in the higher, certain accumulated adaptations have in time so come to overlie the original reaction, that the conscious state which accompanies it seems to differ *per se* from the crude imitative consciousness in which it had its beginning." (Baldwin, 1895, p. 23, italics our emphasis).

Baldwin's 'circular reaction' is a conscious act that explores repetition and deviation from the model (antecedent) made creatively in subsequent self-generated movement. In this case, he is concerned with intra-personal imitation, *per se*. But we now know how self-generated movement and observation of others' actions harness the same neural systems (Rizzolatti & Sinigaglia, 2007). Indeed, Meltzoff and Marshall (2020) review and describe the neurological basis of infant bodily processing (in regard to the infant's own body and bodies belonging to other individuals) and, stemming from this, propose an early recognition of the correspondence between self and other in terms of bodily representations. This forms

the foundation for the future generation of a shared social intelligence (Bråten, 2009; Rizzolatti & Sinigaglia, 2008).

The notion of neonatal imitation having a social or communicative function has been expressed for some time. Meltzoff & Moore's (1997) active intermodal matching mechanism (AIM), for example, described a mechanism underpinning neonatal imitation that also forms the basis for understanding the intentional acts of others. Meltzoff and Gopnik (1993) believed it is through this mechanism and the act of imitation that a neonate begins to identify a person as 'like me' relative to other inanimate or physical objects. Similarly, Trevarthen (1979, 1980) proposed an innate readiness in infants to know another human being, which allows them to intrinsically appreciate the 'other' as being separate from themselves, and facilitates direct contact between them and their carers (alongside other adults). The phenomenon of neonatal imitation sits comfortably within this ideal of an infant mind being predisposed to social interaction with other human beings, with Bråten (1988), Maratos (1982), and Užgiris (1991) all linking neonatal imitation with the wider concept of social communication. The work of Nagy (Nagy & Molnar, 2004; Nagy 2006) has furthered this idea, describing neonatal imitation as 'the first dialogue', and demonstrating the infant's ability to initiate imitative interactions, as well as simply imitating an adult or experimenter. When we view neonatal imitation in this way, as opposed to an action-response phenomenon, its importance with regard to human (and even non-human primate) social capacities becomes more prominent. Seen as an interaction, neonatal imitation can be considered the first step on the road to wider social cognition. Based on the argument presented by Fuchs and De Jaegher (2009), social understanding and social cognition are rooted in the embodied interactions we engage in from the earliest age. They argue it is the interaction process that gives rise to intersubjectivity: through the reciprocity, musicality, affective attunement, vocal expression and movement of an interaction, social cognition emerges and meaning is created



and transformed in what is described as participatory sensemaking (De Jaegher and Di Paolo 2007, 2008; De Jaegher 2009). Looking at neonatal imitation through an intersubjective lens (where the temporal organisation of the interaction plays a fundamental role in the successful communicative creation of imitative acts of meaning), could allow for a deeper understanding not only of the function of neonatal imitation in human and non-human primates, but also a reappraisal of the current debate and the mixed findings that continue to fuel disagreement within the field.

### **2.0 The structure of narrative**

Narratives form the foundation upon which the development of our understanding and communication with the world is built. But what form do the narratives themselves take? All narrative structures, from the most complex to the simplest, find their foundation in the vitality dynamics of play during infancy (Stern, 2010), and in the musicality of infant-adult intersubjectivity (Malloch & Trevarthen, 2009). Analysis of temporal form of early dyadic interactions demonstrate a common motif, or template, of expressed interest, arousal, and intention. Malloch (1999) and Trevarthen (1999) mapped a regular temporal pulse or rhythm, where each expressive vocalisation was reciprocated by the other, reflecting its quality by matched timbre, intensity, and pitch. Considered alongside the bodily movements of the dyad, these reciprocated, matched expressions generated a narrative structure of increasing intensity of interest and arousal. before receding again (Malloch and Trevarthen, 2009). This narrative structure has four simple phases of arousal and intensity interspaced in a patterned manner which builds and fades (Trevarthen & Delafield-Butt, 2013). Indeed, throughout a child's development this patterning remains remarkably stable, whether it is in the babbling of an infant to its mother, or the classroom interaction between teacher and student (Delafield-Butt & Trevarthen, 2013; Delafield-Butt & Adie, 2016). This format can

more precisely be broken down into four distinct states (see Fig. 1), which exist in a cyclical format. These are the 'introduction' state, the 'development' state, the 'climax' state and the 'resolution' state (Delafield-Butt & Trevarthen, 2015). The stability of the patterning across these different stages of development casts a shadow over Stern's (1999) characterisation of the initial, prelinguistic adult-infant interactions as 'proto-narratives'. Instead of being a precursor to the future development of fully fledged narratives, we follow the rationale that they are complete acts of meaning-making in their own right, despite the lack of linguistic precision. This notion is predicated on the fact that meaning, even in adult-adult interaction, can be non-verbal. It supports the ideas of Bruner (1990) who saw narrative structuring as being present in social interactions even before the onset of language use – “narrative structure is even inherent in the praxis of social interaction before it achieves linguistic expression” (Bruner, 1990, p. 77). Similarly, Read and Miller (1995), social psychologists, consider narratives to be “universally basic to conversation and meaning making” (pp. 143).

Each of the states within the narrative structure have specific qualities and characteristics that allow them to play a key role in the development of narrative and the joint creation of meaning (Delafield-Butt & Trevarthen, 2015). The introduction state brings the onset of the interaction, where a shared attention is established and two individuals begin to form the narrative that will follow. In the development state the narrative begins to build both in terms of arousal and intensity, with reciprocal acts being enacted in an almost musical exchange that share common timing and a reciprocity of the quality and form of a gestural or vocal expression. These may build in intensity, sometimes rising rapidly in a crescendo, until a peak moment of excitement and arousal is reached in the climax of the interaction, after which the arousal, intensity and excitement subside and the energy imbued within the narrative recedes as the memory of the act is consolidated in the resolution phase, and the two agents recover their poise ready for the next project. At this conclusion, the involved parties

may disengage from the narrative. This will often be followed by a period of contemplation where the involved parties may reflect on the interaction that has been shared, and the episode is processed, even if brief. This period of reflection will then allow the participants to renew their joint focus and begin to build a new narrative, if both parties choose. This temporal format has been mapped in the proto-conversations of adults and infants (Delafield-Butt & Trevarthen, 2015; Gratier, 2003; Gratier & Trevarthen, 2008; Malloch, 1999; Malloch and Trevarthen, 2009; McGowan & Delafield-Butt, 2022). When neonatal imitation is viewed as an example of such proto-conversational dialogue, a narrative framework within these reciprocal, rhythmic exchanges becomes a logical extension to the application of narrative theory within human development.

Whilst the structure described here is often considered to be the typical narrative format for an interaction, it is important to bear in mind that the precise presentation of these phases can vary depending on multiple factors. Often an entire narrative structure may not be successfully created in a single attempt, and an interaction will instead be formed of multiple broken narratives which might gradually build until a complete narrative structure is achieved (Delafield-Butt et al., 2018). The exact make-up of the four-part structure can also vary dramatically, with for example, multiple climaxes within a single cycle. Despite this, a full and successful narrative interaction will contain each of these elements (Delafield-Butt & Trevarthen, 2015).

There is also evidence to support the presence of this four-part patterning across multiple languages in the proto-conversations of infants and adults (Gratier, 2003; Gratier & Apter-Danon, 2009; Gratier & Trevarthen, 2008; Malloch, 1999; Trevarthen et al, 2014) and in non-human primates such as chimpanzees. For example, Marler & Tenaza (1977) outlined narrative patterning, but under a different guise and using different terminology - they labelled the respective sections as the introduction, build-up, climax and let down. The

acoustic features of chimpanzee pan hoot patterning as described by Mitani & Gros-Louis (1998) align with the narrative structure outlined above and highlight the presence of this temporal structure across species. Additionally, non-human primates have been shown to manipulate this temporal structure within their calling, modifying the length and timing of their vocalisations (Roy et al., 2011), and even altering the structure so as to facilitate joint pan hoot chorusing between individuals (Fedurek et al., 2013). This, along with previous evidence demonstrating the bonding effect of pan hoot chorusing between male chimpanzees (Mitani and Brandt, 1994) highlights the social nature of the narrative temporal structure in chimpanzees as well as humans.

In humans, these narrative structures can be considered a version of Piagetian schemas, the effective conclusion of which leads to satisfaction in its accomplishment, learning its patterns and effects, and a tendency for its repetition. These narrative schemas serve as a template for future engagement. The affective element of satisfaction created through the narrative's successful completion, is thought to be particularly important. It gives it a special affective tone to the thoughts and memory of its unfolding, and of the participants in which it was shared. Narrative forms a memory of a single, mutual experience, the joint creation of which gives it special social significance.

Delafeld-Butt and Adie (2016) considered the narratives between teachers and children in nurture groups. In one example, the interaction between adult and child as they engaged with the task of descending flights of stairs was analysed and the narrative structuring of the interaction examined. In this case the impact of the successful completion of the task, as well as the narrative structuring of the interaction, was evident and shared between the child and teacher. Delafeld-Butt and Adie (2016) pointed out how it would be easy to imagine the child repeating the same narrative alone at a later date, evoking the same processes and form used in the initial interaction (a point that could be interestingly

considered alongside deferred imitation found in infants, where infants have been found to imitate a modelled action up to 24 hours after the initial modelling (Meltzoff, 1988)). It is through this process that infants and children at various stages of development learn socially accepted patterns.

It is also evident from interactions such as these that for narrative structure to successfully form it is necessary for each of the participants to be aware, mindful and attentive to one another's movements, actions and vocalisations. Such expressions are always intentional (Delafield-Butt & Gangopadhyay, 2013) so it is necessary that the sensorimotor systems of each of the participants are appropriately attuned. This process of the participants becoming attuned to one another is of paramount importance as it is only when this is achieved that individuals are able to gain an understanding of another's expressive acts, and respond appropriately. In the realm of neonatal imitation, Anifeld (1991) found that a key component for successfully finding evidence of imitation is the length of time for which an action is modelled. When an action is modelled for less than 60 seconds, many pre-1990 studies failed to find evidence for neonatal imitation. Such short periods of modelling could prevent the attuning of neonate and experimenter, and hamper the development of a narrative-based interaction, which ultimately leads to a lower probability of finding evidence of neonatal imitation.

Debate surrounding the extent of infant awareness, and self-awareness is informed by neonatal imitation. Evidence for the existence of neonatal imitation lends support to the possibility that there exists in human beings an innate awareness of self and other long prior to the development of language. In contrast to many earlier models of infant development, those informed by evidence of imitation in early infancy tend to support the presence of relatively complex cognitive concepts and mechanisms, including (to at least some degree) an awareness of the self, but also intersubjective abilities and motor control. That is not to say

such theories argue in favour of a fully developed sense of selfhood, nor adult-like reflective and conceptually-backed understanding of the other. Rather, it is proposed there exists in infants the foundations onto which future reflective awareness is built. Meltzoff and Moore (2000) proposed neonates have access to 'initial mental structures' that serve to develop more advanced mechanisms and concepts. For them, neonatal imitation is a 'discovery procedure' possessed by infants that aids in their understanding other persons. Gallagher and Meltzoff (1996) followed a similar line suggesting that neonates are capable of a basic differentiation between self and other, and have a rudimentary understanding that their own body is like that belonging to another human being. More recently, Meltzoff and Marshall (2020) have brought together neuroscientific and behavioural evidence to suggest that even very young infants can represent their own bodily actions with those of others in 'commensurate terms' (Meltzoff & Marshall p. 11). For Meltzoff, the self and other are linked (Meltzoff 2007, 2013), with infants being able to learn about the internal states of others through perceptual representation of the bodily acts of others, and their internal monitoring.

Another key feature that appears to be required for narratives to successfully form is a 'rhythmic temporal pattern'; the common tempo or pulse between participants that structures the organisation of an exchange, with actions, movements and vocalisations occurring on or within a rhythm or beat (Malloch, 1999). This notion stems from the notion of communicative musicality that identifies and maps the reciprocal exchange that shares and reflects imitative acts within a common, shared time. It is important to note that the definition of 'musicality' within communicative musicality differs somewhat from what would be generally understood by the term. It does not refer to the songs or melodies that are the output of musical artists. Rather it refers to a much more basic and foundational human characteristic that underpins the production and appreciation of music (Blacking, 1969), and that forms the basis of affective resonances in communication especially prevalent in infancy,

such as in the intonational emphasis of pitch and timing in infant-directed speech. This musicality is defined by reciprocities of expressive quality and distinct timing that altogether give narrative structures over the course of several seconds, or tens of seconds. The structure of these interactions first identified within adult-infant protoconversational dyads follows the formal definition of music (Malloch, 1999; Trevarthen, 1999). Within these engagements, each partner adds creative flourish to enhance and contribute to the dialogue as two jazz musicians might riff off each other's expressive beat (Malloch & Trevarthen, 2009). In this way, imitation forms a basic building block of the exchange, but it is never a mechanical imitation devoid of affective and personal expression, but rather one that acts in mirror reciprocity with creative reflection in each generative expression (Malloch, 1999; Trevarthen, 1999). Sharing a pulse also means this shared timing can be manipulated to create dramatic effects, for example tension can be raised by withholding an expression on the beat, or excitement increased by coming in early (Gratier & Trevarthen, 2008). Interestingly, Trevarthen (1979) suggests that social interaction and communication can be achieved through the imitation of such rhythm and musicality, and although subtle changes may be more difficult to consciously detect than the traditional mouth opening or tongue protrusion from the neonatal imitation paradigm, their role in creating a successful imitative trial could be paramount.

The importance of movement in the embodied interactions of communicative musicality highlights another important aspect of human communication: it is multi-modal. To fully appreciate the narrative structures that underpin communication in infancy or neonatal imitation, it is therefore necessary to consider not only the role of vocal expression in their creation, but also that of movement (Trevarthen & Delafield-Butt, 2013; Delafield-Butt & Trevarthen, 2015). Through a consideration of this modality within the neonatal imitation paradigm, the role of shared rhythm of body and voice, their expressive qualities

and their reciprocal exchanges between partners, altogether generate a narrative form in which the infant is able to parse and draw meaning from that interaction. This expected narrative form and its intersubjective contact is important for psychologists to appreciate in any assessment of an infant's ability to imitate a 'model' action. It is our proposal that this modelling is intrinsically a part of the infant's attempt to form meaning, or understanding *vis-à-vis* its adult modeller, through participation in the shared narrative.

### **3.0 Movement is communicative and the temporal nature of adult - infant interactions**

Within the history of research into adult-infant interactions the role of bodily movement has played a distant second fiddle to a predominant focus on vocalisations, facial gestures, and eye contact (Adolph et al., 2010; Pérez & Español, 2016). However, the work of researchers such as Beebe, Stern, Condon and Sanders serves to demonstrate the importance of movement as a mode of communication within adult-infant interactions. For example, in a landmark study, Condon and Sander (1974) demonstrated the sensitivity of infants to the motor impulses of adult speech, and described the synchronised fashion in which they found infants moved to their mother's rhythm and speech as being like an interactive dance that preludes the development of language. Stern *et al* (1977) further highlighted the importance of a multimodal analytical approach that considered the temporal nature of an interaction. However, they found that the vocal units and movement units within an interaction did not arise in synchrony but did share similarities in terms of frequency of occurrence, their temporal structural form, and their occurrence in unison and independent of one another. These findings demonstrate the need to consider movement units as independent units of communication, and the necessity of measuring it when considering adult - infant interactions.



It is not just the movements and actions of the infant that are worthy of attention though. Other studies have highlighted the communicative nature of adult movements alongside those of the infant (Beebe & Gerstman, 1980; Stern, 1974). It is in the movement of both participants within the dyadic interaction (as much as within their vocal patterning) that evidence of an underlying narrative structure can be found. In neonatal imitation studies in particular there is (understandably) an overwhelming focus on the behaviours of the infant (particularly upon their facial expressions), but by also including the temporal organisation of the behaviours of the adult in analysis of these paradigms, a more complete understanding of the imitative interaction can be discerned.

The focus on infant ability to imitate facial expressions within the neonatal imitation paradigm stems from the assertions of Piaget that an infant's ability to imitate actions they cannot view themselves arises later in development than observable self-body movements (Piaget, 1951). The analysis of neonatal imitative interactions has also primarily been focused on the infant's facial responses, with minimal attention paid to the infant's body (other than as an indicator of levels of arousal (Nagy et al., 2013)). However, the studies discussed in this section provide a strong rationale for a focus not only on the vocal exchanges and facial expressions that take place during adult-infant interactions, but also the role of movement originating from the bodies of both neonate and adult. Beyond the vocalisations and facial expressions of a parent and child there is rich and purposeful communication, and it is only through a multimodal approach that it is possible to gain a complete picture of this and appreciate the infants full and embodied response during the imitative exchange.

### **4.0 Neonatal imitation as primary intersubjectivity**

The interactions outlined above can be described as intersubjective, with a form of this (primary intersubjectivity) being present in humans from birth (evident in the proto-

conversations of mother and infant (Delafield-Butt & Trevarthen, 2015)). Primary intersubjectivity is created within dyadic interactions in the earliest stages of postpartum life (it is important to keep in mind that the communication between mother and baby is not simply a one-way dialogue originating from the mother, but rather an interaction of joint attention between two individuals that contains joint meaning). It is through a process of turn taking and responsiveness to one another's emotions, bodily gestures, facial expressions as well as vocalisations that intersubjectivity is achieved (Stern, 2000). Tronick (2005) argues that it is through the back-and-forth responses of mother and infant, which build upon the emotions and purpose of the partner, that joint meaning is established, a so-called 'dyadic state of consciousness'. In cases where individuals are unable to establish joint meaning and experience primary intersubjectivity, development can be severely negatively impacted (Trevarthen et al., 2015).

The importance of intersubjectivity stems from the narrative form that underpins its structure and function. Delafield-Butt and Adie (2016) describe how the interactive processes involved in intersubjectivity act as a mechanism for making sense of the world - "Meaning is co-created within the organization of the interaction, structured by the agencies and power of will with its expressions of interest and intention from both sides, constituting something unique: a dyadic (or greater) unit that is more than the sum of its parts" (Delafield-Butt & Adie, 2016, p. 118). Through the coming together of two independent beings with their own agency, feelings and aims, something original and new is created in their narrative-based interaction in a process that forms the foundation for learning. Just as this is true for the proto-conversations of mother and baby or the exchanges of teacher and student, so it could be true of the interaction of experimenter and neonate within the imitation paradigm.

#### **4.1 Structures potentially responsible for the communicative nature of movement in intersubjectivity**

Alternative suggestions have been made regarding the underlying biological structures responsible for intersubjectivity. One such structure believed to be influential is the mirror neuron system. Initially discovered in Macaque monkeys, the system allows for the organisation of actions whilst also producing 'reflective' firing patterns when observing another individual's actions. The term reflective refers to the mirror neuron system's activation in the same manner when a specific action is performed by an individual, and when it is being observed. It can be argued this allows for the development of a rudimentary understanding of the intentions of another individual. This would not require higher level cognitive development nor executive functions, but through synchronicity between the motor intelligence of two individuals and their nervous systems there would be the potential for an understanding of another's motor intentions (Sinigaglia & Rizzolatti, 2011). The mirror neuron system has also been highlighted as a possible candidate in the discussion surrounding the underlying mechanisms of neonatal imitation. The immaturity of the prefrontal cortex in the neonatal brain also raises the possibility of subcortical components of the mirror neuron system, or other subcortical structures being at play in both neonatal imitation and early forms of intersubjectivity. When discussing the role of the mirror neuron system in this regard, it is important to think of it in the context in which it operates. It is within embodied interactions that its true importance comes to the fore, and the link between action and perception is most pronounced in the creation of social understanding (Fuchs and De Jaegher, 2009).

Another possible structure that might underpin the development of intersubjectivity is the polyvagal system. Porges and Daniel (2017) outline this as a structure that allows for the sharing of regulatory control of certain bodily functions (*e.g.* breathing and heart rate).

However, whilst the initial purpose of the system in evolutionarily more primitive organisms was limited to autonomic physiology, it has evolved in mammals to play a much more dynamic function (Porges & Furman, 2011). Through the brainstem, what was once a system limited to autonomic physiology becomes a powerful social engagement system that influences the intonation of actions made by our hands, our facial expressions and even our voices. This link between autonomic physiology and expressive forms of communication allows humans to socially demonstrate elements of our vitality, wellbeing and needs. This in turn develops the basic form of mutual understanding seen in intersubjectivity.

The role of the brainstem in underpinning the development of narratives and intersubjectivity potentially extends far beyond the polyvagal system, as it functions across a variety of areas relevant for the development of sensorimotor activity and autonomic functioning. In the realm of the sensorimotor, it has a role in the up-take of proprioceptive sensory information in addition to hearing taste and touch (all of which play a part in the self-regulation of communication and movement (Dadalko & Travers, 2018; Merker, 2005, 2013; Panksepp and Northoff, 2009; Venkatraman et al 2017)). The autonomic nervous system, which is located in the brainstem, controls eating, alertness, sleep regulation, heart rate and breathing (Ngeles Fernández-Gil et al., 2010). Moreover, principal responsibility for actions that are responsive to rhythm lie with the brainstem (Delafield-Butt & Trevarthen, 2017). In addition to these functions, the brainstem has an important role in some higher order functions such as sensory processing, goal-orientated behaviour, the modulation of emotions (Berntson & Micco, 1976; Venkatraman et al., 2017) and the regulation of social attention (Geva et al., 2017).

Of the varied functions the brainstem is involved in, its impact on higher order functions including sociability and attention is clearly important with regard to intersubjectivity and communication, however, its role in regulating behaviour and emotion is

also hugely relevant in the creation of a basic form of consciousness. The integration of sensory information that takes place in the brainstem is not a passive process, and it has been argued this is what creates basic psychological experiences and ultimately leads to Panksepp's (2005) notion of the primary, or 'core self'. Indeed, Panksepp (2005) argues that the same brainstem functions that are responsible for sensory and motor information integration are responsible for the generation of basic conscious experiences. He calls these 'primary process functions' and they include core feelings as well as the desire and intention to act through movement. This brainstem-based primary consciousness, that is able to anticipate and perceive, represents an adaptable form of mental agency which generates purpose and meaning (Delafield-Butt & Trevarthen, 2015). If human language and thought are considered as deriving from the same neuro-anatomical systems that generate motor actions in response to stimuli in the environment, the basis of this could be the brainstem sensorimotor and affective integrative systems outlined here (Merker, 2007). Following birth this primary self actively seeks to share and create meaning with social others and this desire to build and share narratives is present in the earliest interactions of human life, and can be seen, Kugiumutzakis and Trevarthen (2015) believe, in the infant's power to imitate expressive actions and co-operate in their temporal sequencing. The ability of the infant neonate to imitate could be viewed as an expression of this primary consciousness to create meaning through a narratively structured imitative dialogic interaction.

### **5.0 Neonatal imitation in light of narrative temporal structuring**

The notion of a primary consciousness seeking to share and create meaning with others links well with the idea of neonates being 'adapted' for narrative-based interactions rooted in communicative musicality. New-born infants display sensitivity and awareness of the purposeful movements and vocalisations of adults in relation to their own person (Condon

& Sander, 1974; Nagy, 2011). In the hours after birth human infants have been shown to demonstrate an ability to take part in imitative exchanges with an adult (*e.g.* Kugiumutzakis, 1998; Meltzoff & Moore, 1983a, 1989), a conversation rooted in movement (Kugiumutzakis & Trevarthen, 2015). These imitative exchanges are considered to be a foundation for social-communication (Meltzoff, 2007) and even, as demonstrated by Nagy and Molnar (2004), a communicative act in and of themselves. They can also be considered the first step in the gradual development through infancy on the road to theory of mind (Meltzoff, 2007) and intersubjectivity (Trevarthen, 2011). Indeed, these imitative exchanges represent some of the first examples of cooperation between infant and adult, an initial form of the primary intersubjectivity outlined above. The infant's ability to engage in these exchanges is one of multiple social skills (others include the ability to identify their mother's voice (Decasper & Fifer, 1980) and face (Burnham, 1993) and a preference for humanoid faces (Valenza et al., 1996)) that constitute what some consider an innate disposition for intersubjectivity (Nagy & Molnar, 2004). These interactions help the development of cooperative endeavours involving movement, which become more intricate and prospective in their nature (Nagy, 2011). Each imitative act can be thought of as forming part of a larger, encompassing narrative, which creates meaning over multi-second encounters in "mutually sustained expectation of a rhythmic project of communication, engaging two persons in a nonverbal 'narrative'" (Kugiumutzakis & Trevarthen, 2015, p. 487). The temporal architecture that frames these imitative exchanges remains a topic that has received extremely limited academic attention (where temporality has been considered, it is normally with a focus on the timing and organisation of infant response (*e.g.* Heimann and Tjus, 2019; Meltzoff and Moore, 1983a) and not the framework of the interaction as a whole), whilst the existence of the phenomenon is itself still hotly debated.

### 5.1 Neonatal imitation in human infants

Whilst the study of neonatal imitation goes back over a hundred years it is only in the last sixty that the phenomenon has received particular attention. It was Meltzoff and Moore's (1977) seminal work which propelled neonatal imitation as a major topic, spurring multiple studies clarifying its nature and supporting its existence (e.g. Field et al., 1982; Heiman et al., 1989; Heiman & Schaller, 1985; Heimann & Tjus, 2019; Kugiumutzakis, 1998; Meltzoff & Moore, 1983; Meltzoff & Moore, 1989; Nagy & Molnar, 2004; Reissland, 1988). There have also been many studies that have failed to find evidence of the phenomenon (e.g. Davis et al., 2021; Fontaine, 1984; Hayes & Watson, 1981; Koepke et al., 1983; Lewis and Sullivan, 1985; Oostenbroek, 2016); and these have in turn been critiqued for using procedures that may have lacked sensitive conditions, both social and perceptual-cognitive, for eliciting imitation in very young infants (e.g., Kugimutzakis, 1998; Meltzoff & Moore, 1983b; Meltzoff et al., 2018). Additionally, imitation has not only been studied in human neonates; numerous studies have also been conducted that have reported its presence in non-human primates (e.g. Bard, 2007; Ferrari et al., 2006; Myowa-Yamakoshi et al., 2004).

Nagy and Molnar (2004), however, went further than to simply support the existence of neonatal imitation in humans. Their study also reported an infant's ability to initiate interactions. In this study 45 neonatal infants, aged 2-54 hours, were found to both imitate tongue protrusion, and initiate voluntary exchanges with an adult utilising the tongue protrusion action. The study utilised both behavioural and psychophysiological measures in order to differentiate initiation from imitation. The psychophysiological measure used was heart rate in order to ascertain levels of arousal (increased heart rate was considered reflective of increased levels of arousal) and of orientation, learning and expectance (decreased heart rate was taken to be indicative of these during imitation). Following several cycles of imitation, it was found that the neonates not only imitated the modelled action, but also

initiated an exchange and waited for the adult to respond, therefore demonstrating a motivational desire to take part in the dialogue.

Such evidence suggests social motivation could underlie neonatal imitation. Several examples of extended exchanges between neonate and experimenter, which were initiated by the infant and grew into what the authors describe as reciprocal conversations, were reported during the Nagy and Molnar's study (Nagy, 2006). These exchanges were regarded as experimental examples of "the first dialogue" (Nagy & Molnar, 2004; Nagy, 2006, 2011) and allow us to consider neonatal imitation one of the foundation stones of primary intersubjectivity. Given the presence of narratives in these early proto-conversations, and evidence from Nagy and Molnar (2004) regarding the social and emotional motivations for the infant in engaging with adults in imitative exchanges, the presence of a narrative structure in the interactions of the neonatal imitation paradigm would be a logical extension to the current state of understanding in intersubjectivity.

Indeed, it is within the paradigm utilised by Nagy and Molnar (2004) that narrative structures seem most likely to be found. There are key methodological differences between the work of Nagy and Molnar and other neonatal imitation studies, for example Meltzoff and Moore (1977). In many such earlier studies the modelling by experimenters was very rigid and experimentally controlled, with only limited consideration of the infant's engagement and response. In Nagy and Molnar (2004) the experimental design was more interactive and representative of imitative exchanges that occur naturally between adults and infants. The impact of this can be seen in the differences in response times of infants in such studies. In Nagy and Molnar (2004) imitation occurred at a rate that enabled the infants to participate in communicative exchanges with adults, with infants imitating in a shorter time frame than had previously been demonstrated in other studies. The responsiveness of infants in the study, and the ability they demonstrated to participate in these early forms of turn-taking dialogues and



primary intersubjectivity, make this experimental structure a prime place to search for evidence of narrative structures within the neonatal imitation paradigm.

## **5.2 Non-human primates**

As noted, neonatal imitation has not only been observed in human neonates - there is also a body of evidence demonstrating the phenomenon's presence in chimpanzees (Myowa-Yamakoshi et al., 2004; Bard, 2007) and rhesus macaques (Ferrari et al., 2006; Ferrari et al., 2009; Paukner et al., 2011). Myowa-Yamakoshi et al. (2004) and Bard (2007) both demonstrated the ability of neonatal chimpanzees to imitate mouth opening and tongue protrusion of a human modeller, believing that their results supported the notion of an innate neonatal imitation 'mechanism' in chimpanzees as well as humans. With regard to macaques, Ferrari et al (2006) utilised a sample of 21 of the animals, aged three days, and found evidence of tongue protrusion and lip smacking were regularly imitated when presented by a human model. Ferrari et al (2009) utilised this data and as well as collecting data from an additional 20 neonatal macaques and found further evidence supporting the findings of the 2006 study (although the ability to imitate seemed to dissipate from age seven days). Additionally, it was found that at one month of age macaques who were shown to be better imitators demonstrated more developed motor skills in goal directed movements. This further demonstrates the potential close link between movement, neonatal imitation and intersubjectivity. The authors believed the mechanisms to explain this result lay in the maturation of the motor and parietal cortices, which are close in proximity to parts of the mirror neuron system.

Evidence has also continued to emerge from non-human primate studies linking neonatal imitation with future social development. For example, neonatal macaques who reliably and successfully imitate have been found to pay more attention visually to the eyes of

others later in the first month of life (Paukner et al., 2014). Simpson et al (2016) found evidence that imitative ability in neonatal macaques predicted gaze following at 7 months, therefore demonstrating the role of imitation in modulating a social cognitive skill later in development. Additionally, Kaburu et al (2016) showed neonatal imitative ability to be a predictor of social behaviour and temperament (in the form of greater dominance behaviour and lower levels of anxiety among lip smacking imitators) at 1 year old. These studies are beginning to highlight the importance of neonatal imitation not only as a neonatal phenomenon, but also a predictor of other wider social behaviours, and point towards the underlying links between social/motor development and neonatal imitation (possibly stemming from shared underlying cognitive structures involving, for example, the brainstem).

Such non-human primate results are important as there are strong similarities between the observed imitation in human and macaque neonates (Ferrari, Paukner & Suomi, 2013). For one, imitation is recorded most prominently in the first few weeks of life in both humans and macaques. Additionally, in more naturalistic paradigms the mother is found to imitate their infant more than the infant does the mother. It has also been found that in both species there is a large degree of individual difference with regard to the quality of imitation. This, it has been suggested, could be the result of differing levels of social predisposition between individuals (Paukner *et al.*, 2014), or an infant's sensitivity to social cues within the multi-modal interactional flow between adult and infant (Heimann, 1998). Other factors linked with individual differences have also been proposed such as levels alertness and activity, visual acuity, temperament (Heimann, 2022) and expressiveness (Field, 1982).

As outlined earlier, the presence of narrative structures within chimpanzee pan hoot chorusing already demonstrates the existing influence such temporal structures have on the social interactions of some non-human primates, and how the temporal structure is actively manipulated to enhance social bonding (Fedurek et al., 2013). It is such similarities between

human and non-human primates, and the potential links between imitation and potential downstream social development, that make the investigation of narrative structure in primate development an attractive area that could shed further light onto the development of human social interaction, and neonatal imitation.

## **6.0 Theories behind neonatal imitation**

From the varied findings in the field there continues to be a high level of debate around the existence of neonatal imitation (*e.g.* Meltzoff et al., 2018; Oostenbroek et al., 2016), as well as multiple theories to explain the mechanisms that underlie it. Some of these theories attempt to explain neonatal imitation as a phenomenon that is not imitation *per se*, but that is simply an associative reaction devoid of any social meaning, whilst others consider it an innate ability. For the purposes of this paper a range of key theories will be discussed. However, rather than simply providing a summary of the theories and explanations that exist, we aim to contextualise them in light of intersubjectivity, and consider how they align with the view of neonatal imitation as proto-dialogue between two actively engaged persons with agency.

### **6.1 Imitation as a reflex**

One explanation of the underlying causes of neonatal imitation proposes that there is actually a relatively simplistic mechanism underpinning positive imitative results. This theory argues that the imitative acts recorded in studies of neonatal imitation are in fact non-mental reflexes (Anisfeld, 1996), a triggering of an involuntary motor response or a fixed action pattern that is activated upon witnessing the demonstration of a particular behaviour. Anisfeld (1996) believed that the only act where there was evidence of neonates imitating was tongue protrusion, and claims of imitative abilities in early infancy were too “uncritically accepted”.

He took the view that such claims were actually facilitated by a trend to view infants as more advanced than they were in reality (Anisfeld actually points the finger very clearly at Dan Stern in this regard). It has been demonstrated in some studies that neonates will perform tongue protrusion actions in response to other similar stimulus events (such as a ball or felt tip pen being moved towards the face of the infant (Jacobson, 1979)), and such findings have been interpreted as signifying the potential for multiple protruding objects to release a sucking reflex which creates the illusion of an imitative response.

However, considering neonatal imitation results as reflex reactions does not entirely remove communication from the paradigm. Another interesting adaptive function of such an innate releasing mechanism, outlined by (Bjorklund, 1987), is that it facilitates social interaction between an infant and adult. Bjorklund believed that neonatal imitation was an example of a transient ontogenetic adaptation (Oppenheim, 1981) in that it serves a specific survival purpose for the neonate, which becomes redundant later in development. For Bjorklund, neonatal imitation helps maintain social interaction between adult and infant, but this ability becomes less important when infants develop greater control of head and mouth movements. Were the 'imitation as reflex' hypothesis an accurate explanation of neonatal imitation, the role of narrative temporal structuring in its facilitation may still be compatible, adding temporal detail to description. Despite this, the 'imitation as reflex' theory risks doing the opposite to what Anisfeld accused Dan Stern of, by over-simplifying what is an apparent complex interaction between infant and adult.

### **6.2 Imitation due to arousal**

Another popular explanation of the apparent empirical evidence of neonatal imitation relates to the excitation of arousal of the neonate in the paradigm. An example of this was proposed by Anisfeld (1991), who described how attentional competition (originating from

the modelling adult) inhibits infant tongue protrusion during the modelling period. This results in a build-up of what can be defined as arousal, which is released following the completion of action modelling. A more recent examination of neonatal imitation which employs the arousal hypothesis looks at the phenomenon in the context of aerodigestive development (Keven & Akins, 2017). It is clear the arousal hypothesis remains a popular account of neonatal imitation (e.g. Anisfeld, 2005; Jones, 2009; Keven & Akins, 2017; Vincini et al., 2017), a fact not least due to continuing debate around the imitation of actions beyond tongue protrusion (acceptance of neonatal imitation in actions other than tongue protrusion makes it difficult to ascribe the behaviour of the infant to increased levels of arousal) but also other key factors. These include the aforementioned findings that other stimuli can also illicit tongue protrusion (balls and felt tip pens (Jacobson, 1979), lights and toys (although only until the infant had developed the ability to reach, at which point the rate of tongue protrusion was found to decrease significantly, leading to the suggestion that reaching may have become the infants primary response to arousing stimuli) (Jones, 1996), and music (Jones, 2006)), and neonates looking for longer at displays of tongue protrusion than they do mouth opening (Jones 1996).

This leads to one of the key weaknesses in the arousal hypothesis: much of the evidence given to support the theory stems from tongue protrusion, and it does not take full account of infant's abilities to imitate a variety of adult modelled actions. Additionally, Nagy et al (2012) focused on infants' ability to imitate tongue protrusion and found imitation of this behaviour was not simply the result of arousal during the testing process. Her own findings from Nagy and Molnar (2004) found increasing heart rate when an infant imitates whilst decreasing heart rate was recorded during unprompted actions. As discussed above, this would suggest there to be different mechanisms underlying imitation when compared to infant initiated behaviours.

However, notwithstanding these limitations of the theory, as with ‘imitation as reflex’, the arousal hypothesis is not necessarily a non-communicative theory that is incompatible with the suggestion of underlying narrative patterns underpinning neonatal imitation. If adult facial modelling prompts arousal in an observing infant, and this triggers a response, the observing adult could be drawn into an exchange of facial expressions/movements which take the form of a non-verbal dialogue. Such an arousal-driven dialogue could be underpinned by the same narrative structures found to underlie other examples of early social interactions between adults and infants, and it would not be necessary for adults to be aware of the imitative nature of the interaction (indeed, Heimann (2002) suggested parents could be affected by the imitative responses of their infants without actually being aware imitation was taking place). One of the unanswered questions around the arousal hypothesis is exactly how the stimuli affect levels of arousal, and while multiple factors could affect how social stimuli effect the internal states of infants, one factor worthy of consideration is the temporal structure within which the stimuli are presented. Indeed, narrative temporal structuring could be a modulating factor on levels of infant arousal during these interactions.

### **6.3 Imitation through association by similarity**

A relatively new theory put forward to explain neonatal imitation is the association by similarity theory (AST) proposed by (Vincini & Jhang, 2018). Vincini and Jhang posit a process through which current experiences of cognitive events are connected to past events and experiences of a similar nature; in the words of the Vincini and colleagues “AST hypothesizes that the same resources that represent those action features in action planning and execution represent those features in perception” (Vincini et al., 2017, p9). Within AST, the modelling that infants show an ability to imitate are part of an existing repertoire of habitual and spontaneous actions which are ‘awoken’ when they witness the corresponding

action being modelled (Vincini & Jhang, 2018). AST can sit alongside an arousal account of how infant reactions in the imitation paradigm are provoked, and in itself does not claim that neonates have an in-built ability for imitation, nor that neonatal imitation has a foundational role with regard to social cognition. The theory claims to neatly account for the varied findings across neonatal imitation literature (both in terms of the mixed evidence for the existence of neonatal imitation, and any variations in the weight of evidence for imitation of particular acts), the fact it is more common in controlled laboratory than natural settings, and for evidence of imitation falling away after 2-3 months of age (Vincini et al., 2017).

Whilst AST does not view neonatal imitation as acting as a foundation for social cognition in the same way as some other theories of neonatal imitation, it does not disallow it being a communicative exchange. Vincini and colleagues are of the opinion that the same logic can be applied to AST as is applied to the arousal hypothesis with regard to social interaction. Therefore, whatever role arousal plays in facilitating adult-infant interactions in the arousal hypothesis, can also be true for AST. They also suggest AST supports the Direct Social Perception hypothesis (Gallagher, 2015), and therefore Interaction Theory, as an alternative to more traditional theories of mindreading.

### **6.4 Imitation due to associative learning**

Associative learning provides another popular account for neonatal imitation. This is based on the idea that infants can learn to associate their own actions with the movements of other individuals, which then allows for the development of imitative abilities. A major proponent of a version of this argument is Heyes, who in her Associative Sequence Learning theory (Catmur & Heyes, 2019; Heyes, 2001, 2018) proposes that associations between sensory and motor representations form during an infant's development due to correlated sensorimotor experiences. Heyes believes that as a result of these experiences, bidirectional

associative links are formed so that the action observation can result in action execution. Such sensorimotor associations should be formed in everyday life, for example when an infant is imitated by an adult or when adults and infants engage in synchronous activities (Heyes, 2018).

A key issue with the associative learning account for neonatal imitation is the time taken for sensorimotor associations to form within a child. Imitation has been demonstrated in the first few hours of birth for a variety of actions and expressions, presumably too early in the course of development for associative links to have formed in the manner described by Catmur and Hayes (2019) and other proponents of the associative learning account. This objection is equally valid with regard to macaque neonates, who are able to imitate before they have experienced relevant facial interactions with carers (Ferrari et al., 2006). The rate at which infants receive imitative feedback from carers is also not considered to be great enough to build such learned associations (Watson, 1979). Were this not the case it would not be impossible to imagine the bidirectional associations of ASL forming during the early imitative based dialogues and proto-conversations of the neonatal imitation paradigm. There is evidence of some infant attempts slowly building towards full imitative actions such as tongue protrusion (Kugiumutzakis, 1998; Maratos, 1973; Meltzoff & Moore, 1977) , and the progressive attempts before successful imitation could be indicative of associative learning taking place. This could potentially indicate a social element to ASL, which could be underpinned by a narrative temporal patterning ultimately leading to successful imitative responses. Again, this theory is also compatible with our proposition, and proposes important angles of consideration.

### **6.5 Imitation underpinned by an in-built cognitive mechanism**



As well as the above explanations, there are others which consider neonatal imitation to be a genuine phenomenon underpinned by an inbuilt cognitive mechanism that allows imitative behaviours to be displayed from birth. One such hypothesis involves a direct sensory-motor matching mechanism underpinned by mirror neurons (Ferrari et al 2006; Rizzolatti et al, 1999; Rizzolatti et al, 2002). This theory outlines that within the neonatal imitation paradigm the motor system of the observing infant is triggered by the process of watching the experimenter model target actions. For example, when an infant observes an experimenter opening and closing their mouth, the same mirror neurons are triggered in the infant that would be activated were the action performed. This directly leads the execution of the observed action. This hypothesis has not only been described on a theoretical level, but also at the neuroanatomical level in neonatal macaques (Ferrari et al. 2012; Ferrari et al. 2017). This explanation of the underpinning mechanism for neonatal imitation has several advantages when compared to other cognitive alternatives. For example, it requires relatively few cognitive processes, and does not necessarily require the infant to have an understanding of why they are performing an action as the process is seemingly largely automated (Vincini et al, 2017). However, this does not remove social importance from neonatal imitation, as imitation underpinned by mirror neurons promotes interaction between neonates and adults (Heimann, 2002), which can become the foundation of future proto-conversations (*e.g.* Malloch and Trevarthen, 2009). Despite the attractiveness of this cognitive explanation, others have argued that such a resonance mechanism is insufficient to explain neonatal imitation (Meltzoff & Decety 2003), with an alternative cognitive model being the active intermodal matching mechanism (AIM) (Meltzoff & Moore, 1997).

Meltzoff and Moore's AIM (1997) goes some way towards appreciating how the underlying mechanism for neonatal imitation could link with the future development of children's understanding of the intentional actions of others, joint attention and theory of

mind (Meltzoff, 2007). It proposes that from infants' self-generated movements, proprioceptive feedback is produced which can be compared by the infant to the visual representation perceived during modelling. Meltzoff and Moore proposed this comparison is viable due to a supramodal action space, in which the observation and execution of human movements are coded in a common framework, and that this coding in a common framework forms the basis for the understanding of the intentional actions of others, joint attention and theory of mind later in development (Meltzoff, 2007). Although AIM is one of the leading theories to explain neonatal imitation as innately present in human infants, Kugiumutzakis and Trevarthen (2015) propose that it is not enough to explain the phenomenon on its own. They argue, it also "depends on matching organized intentional motor systems that seek confirmation by different forms of reafference." For Kugiumutzakis and Trevarthen, there is a two-way exchange of complementary affective states which involves the regulation of motor impulses by a 'hierarchy of rhythms' created in the brains of those involved. It is this element of musicality which directly parallels the underlying mechanisms of neonatal imitation with those of other dialogues and exchanges in human beings. Indeed, as mentioned, in naturalistic exchanges it is not only the neonates who imitate, but also their parents, with both parties timing their expressive movements so as to achieve an intersynchrony between intentions and experiences. This, Kugiumutzakis and Trevarthen believe, is necessary for the construction of joint projects, and the creation of narrative structures.

From this perspective, neonatal imitation is more than a stimulus-response exchange, but rather an intersubjective phenomenon which is social in its very nature. Each imitative exchange is not a single, isolated experience, but part of a developing 'story' that creates meaning over the multiple seconds in which the overall interaction is maintained (Kugiumutzakis & Trevarthen, 2015). This interaction takes place within a jointly created

intersubjective space in which the neonate is required to detect the adults intention and motivation for communication, and respond reciprocally (Kugiumutzakis, 1998).

Kugiumutzakis believes the factors that allow an infant to discern an adult's motivation for communication lie within the acoustical and kinematic features of the modelled actions. It is in this space that the temporal structure of the interactions becomes paramount. If the modelled actions or sounds are presented as though they are introducing or developing a narrative structure, this could form a key element of what Kugiumutzakis describes as the critical invariants that signify to the infant a desire within an adult for communication.

By moving neonatal imitation beyond a physical process, it can become a coupling of embodied agents, co-ordinated through bodily movement and vocalisation, facial expression and timing. Recent findings in infant neuroscience have also shown a specific neural pattern can be detected when an infant performs an action and the adult imitates back to the infant. The imitative "dialog," exhibited through the turn-taking of matching of motor actions, causes a change in the infant neural mu rhythm that is significantly different from that observed when the adult does a nonmatching action, indicating there is something particularly noticeable or communicative about the baby being in a mutual imitative interaction with another person (Saby et al., 2012). These early interactions, simplistic though they may seem, become imbued with affective meaning underpinned by the patterns of the interaction. From the implicit experience of this co-created meaning arises the foundation for social understanding and intersubjectivity (Fuchs & De Jaegher, 2009). Reddy (2008) argues this is what makes imitation relevant for the infant, as it allows a bi-directional interplay in which the two engaged parties influence one another in a shared affective resonance within an interactional framework. We extend this argument, proposing the specific underlying framework is narrative in form.

## 7.0 Conclusion

The potential communicative underlying nature of neonatal imitation makes it fertile ground with regard to developing narrative structures. Imitation represents an effective method of engagement for both young infants yet to develop language skills and slightly older toddlers. It is this that suggests imitation has a function that runs deeper than being purely reactionary to external stimuli. It enables infants to engage in meaningful and purposeful interactions with adults long before the onset of language. Within such interactions there is also the potential for an affective component resonating between neonatal and adult participants. Kugiumutzakis (1998) suggests that a feeling of enjoyment may be created as a consequence of the infant's recognition of the adult as another 'other' entering into a shared interactive unit. Indeed, the interactive unit, or intersubjective companion space, acts as a "nest of emotions" (Kugiumutzakis, 1998, p 79) in which adult and infant can potentially share emotions, and create basic acts of meaning. Whilst such an outlook runs a risk of falling foul of the same criticism Anisfeld levelled toward Dan Stern (of imbuing infants with levels of sophistication beyond their years), without considering the potential affective outcomes of such interactions, and the infants innate desire for companionship, the neonatal imitation debate becomes a poorer landscape.

Through considering neonatal imitation as innately dialogical (Kugiumutzakis & Trevarthen, 2015; Nagy & Molnar, 2004) it is possible to further grasp its underlying importance in human development, and why a temporal analysis of it, similar to that already performed on other interactional exchanges (Delafield-Butt & Trevarthen, 2015) could help us understand its underlying organisation and function. Arbib (2005) suggested that from an evolutionary standpoint, imitation can be viewed as a foundation stone onto which language development was laid, and Nagy (2006) proposed that the same could be true with regard to human development from the neonatal period, through infancy and into childhood. The intersubjective exchange becomes the template on which words and language form (Beebe, et

al, 2022). This foundational role is supported by the latest evidence stemming from infant macaques linking neonatal imitation with future social development (Kaburu et al., 2016; Simpson et al., 2016).

Building on the proposition that neonatal imitation is dialogical in nature and function, we propose that successful examples of neonatal imitation are underpinned by a narrative framework, in the same manner other adult-infant proto-conversations are (see also Heimann, 2022, p 184). This narrative architecture would be expressed in a multimodal format (involving movement, vocalisation, and facial expression), and would require a multimodal analysis to identify the peaks of intensity and arousal expressed in the precise kinematics of movement and acoustic intensity. It seems most likely that narratives will be found within imitation paradigms like that utilised by Nagy and Molnar (2004), in which the neonate was allowed the potential for expressive agency and interest through provocation or initiation. It was within such a paradigm that the role of the infant in creating lasting, intimate, imitative exchanges was first established. However, the same narrative structure could also be present in the model-response pattern utilised by other studies (especially when the movements of the neonate are also considered as part of the response), demonstrating the language-ready brain of the neonate.

The one-month period after birth, commonly referred to as the neonatal phase, is hugely important in terms of development. Nagy (2011) argues that it deserved a specific period of its own in development theory. Narrative structures in neonatal imitation could represent the first part in a developmental trajectory that builds towards larger projects of communication, through primary intersubjectivity and secondary intersubjectivity, and from proto-conversations through to the fully developed dialogues of language in later childhood, onwards.

## **Statements**

### **Conflict of interest statement**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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TMcG and JDB conceived and wrote the manuscript.

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### Figures

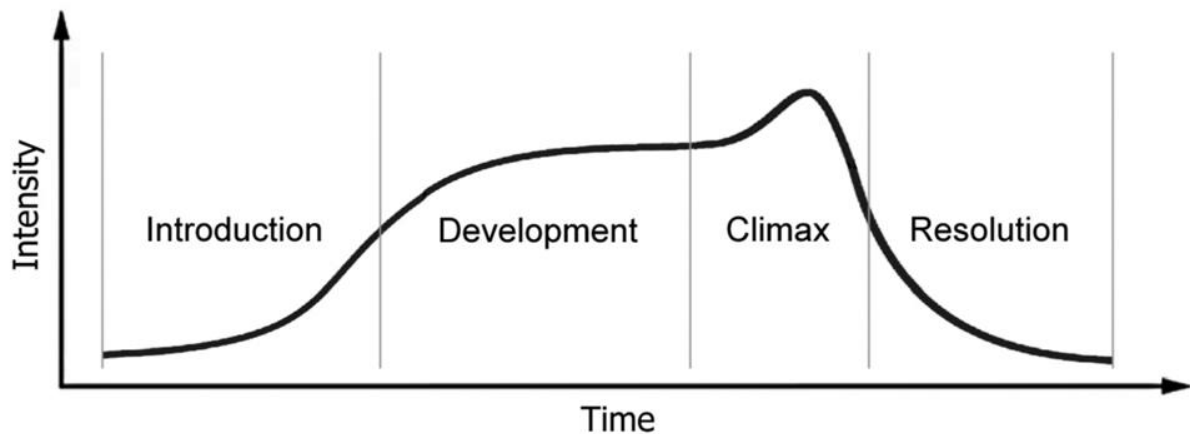


Fig. 1. The intensity contour associated with a narrative structure broken into its four phases:

(i) 'Interest' in the narrative begins at a low-intensity in the introduction, which 'invites' participation in purposefulness; (ii) the coordination of the actions and interests of real and imagined agents intensifies over the development, as the 'plan' or 'project' is developed; (iii) a peak of excitement with achievement of a goal in mutual intention is reached at the climax; after which (iv) the intensity reduces as the purposes of the participants share a resolution, and those who were closely engaged, separate. From (Trevvarthen & Delafield-Butt, 2013)