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Building the physical and psychological self: from a bodily to a spoken interpersonal dialogue

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“Through others we become ourselves”

Vygotsky (1896–1936)

Abstract

In this review, we propose that interpersonal bodily interactions represent a fertile ground in which the bodily and psychological self is developed, gradually allowing for forms of more abstract and disembodied interactions. We start by focusing on how early infant-caregiver bodily interactions, mediated by the sense of touch, play a crucial role in shaping the boundaries of the self but also in learning to predict others' behavior. We then explore the social function of the sense of touch in the entire life span, highlighting its role in promoting physical and psychological wellbeing by supporting positive interpersonal exchanges. We go on by introducing the concept of implicit theory of mind, as the very early ability to interpret others' intentions, possibly grounded in infant-caregiver bodily exchanges (embodied practices). In the second section, we embrace a more collective perspective about the role of sociality in human development, by describing the hypothesis of “dialectical attunement”, reconsidering the self beyond the individual, where it really emerges, unfolds, and manifests itself — in social relationships. We finally consider the most evolved forms of social relationship: intellectual

exchanges among individuals. In this regard, we defend the view that, beside the apparent private dimension of “thinking abstractly”, using abstract concepts is an intrinsically social process, as it entails the re-enactment of the internalized dialogue through which we acquired the concepts in the first place.

Keywords (max 6)

social touch; interpersonal interactions; implicit theory of mind; intersubjectivity; abstract concepts; bodily self

1. Introduction

Self-awareness emerges from bodily exchanges

Bodily interactions among humans represent the necessary background allowing the progressive growth of the awareness of *who we are*. Through the interiorization of the *epidermal dialogue* with the mother, the child creates an implicit representation of her body and through the progressive knowledge of her internal states in conjunction with the social events, she becomes able to predict her own and other’s intentions, emotions, and feelings. The epidermal dialogue will then leave the place to spoken dialogue, where physical proximity is not necessary anymore to be in relation with someone and to understand her internal state. Thanks to the *abstraction/symbolization of interpersonal relations*, two interacting bodies will thus be supplanted by two interacting minds. In this path of self-development, *the other will contribute to the definition of the self* especially through one sense among the five: the touch.

Touch more than other senses participates in defining the *self-in-the-world* (see Gallace and Spence 2010; Farmer and Tsakiris 2012), a concept to which theorists and scientists refer with different terms: individuals’ sensorimotor embodiment, (Kyselo, 2020), minimal self, (Blanke & Metzinger, 2009), or bodily self (Apps & Tsakiris, 2014). Traditionally, the bodily self has been considered as composed of a motor component which is the sense of agency (the sense of being the one who generates an action) and of a perceptual component which is the sense of ownership (the feeling of owning our body, that is the source of our sensory experiences). Bodily self and peripersonal space representations (Fanghella et al., 2021) are shaped by sensorimotor interactions with objects (tool use, Magosso et al., 2010) or other individuals (Soliman et al., 2015; Bolt et al., 2016; 2017). The link between sensorimotor interactions and the bodily self clearly appears since the earliest moments of life. During the first sensorimotor interactions with the environment, children get acquainted with the perceptual co-occurrence of multisensory signals and, by integrating and responding to them, they optimize the natural exchanges between the body and the environment. In order to maintain constant such homeostasis, anticipatory bodily signals are generated: on-line exteroceptive and/or interoceptive sensations are matched with patterns of learned or innate predisposition and, from this repeated matching, the organism strives to reduce the distance between what is experienced *hic et nunc* and its generative models of the world and of the body. Crucially, through such constant optimization of the bodily state, the child might develop bodily self-consciousness (see Ciaunica & Crucianelli, 2019; Fotopoulou & Tsakiris 2017). Since the optimization of the child’s bodily state depends on the caregiver, who is in charge of externally regulating the necessary exchanges between the child’s body and the environment, the bodily self-consciousness appears as being clearly *socially mediated* (see Ciaunica & Fotopoulou 2017). From the perceptual integration and the sensorimotor routines (i.e., breastfeeding, washing, rubbing-cleaning, skin-to-skin sleeping, body-to-body temperature regulation, and skin hydration) to which they are exposed (see Ciaunica & Fotopoulou, 2017), children learn to interpret social contexts formed by chains of events (their action and its consequences

on the caregiver 's behavior and the caregiver's action and its consequences on their bodies). The caregiver, on the one hand, informs the child about the social impact this latter is exerting on the caregiver, while on the other, she informs the child about the social impact the caregiver herself is exerting on the child. By receiving such bidirectional perceptual and sensorimotor feedback, the child learns to predict and interpret the other's behavior. In other words, through the *tactile exchanges* with the caregiver's body, children acquire the awareness of their own bodies. Skin-to-skin contact or social touch has a crucial function not only during individuals' development but in the whole life span. Interpersonal touch can, in fact, be a powerful tool to convey prosocial and emotional communication by means of stroking, patting, holding, or hugging other individuals (Hertenstein & Weiss 2011). While social touch has a crucial role in shaping the bodily self and helping predict others' behaviour during the early stages of life, later it also assumes a communicative role and its saliency is dependent on the social identity of the interactor.

From bodily to mental intersubjectivity

Tactile behavior is also related to the development of Theory of Mind (the ability to impute mental states, such as beliefs, desires, or intentions, to oneself and to others (ToM; Happe & Frith, 2014; Wellman, et al., 2000; for a review, see Wellman, 2018)). Although most children under four years old fail standard ToM tasks, their behaviour suggests that they understand the connection between others' mental states and their actions (see Gallagher et al., 2001; Teglassi et al., 2022). Accordingly with the embodied practice of intersubjectivity (Gallagher et al., 2001), infants plan their actions on the basis of the perceptual inputs received from the caregiver, and such intersubjective sensorimotor mapping might be the precursor of intersubjective mental mapping (see Gopnik and Meltzoff, 1997), on which the implicit ToM might lay down. In this regard, it has been proposed that *implicit* ToM might emerge in the first year of life, while *explicit* ToM would develop later (between the fourth and sixth year of life) (Sodian, 2011, 2016). Moreover, while explicit ToM is dependent on executive functions (Devine & Hughes, 2014; Ruffman et al., 2012; Setoh et al., 2021), implicit ToM is already grounded in embodied practices, emotional, sensorimotor, perceptual, nonconceptual (see Gallagher, 2001) and it refers to infants' behaviour which clearly responds to others' goals, beliefs, intentions, knowledge, or feelings (Baillargeon et al., 2010; Buttelmann et al., 2014; Osterhaus, et al., 2016; Perner & Roessler, 2012). In Teglassi et al. (2022), it has been shown that implicit ToM is correlated with social competence (the ability to process social information), but this is not the case for explicit ToM, after having controlled for the explicit language abilities and vocabulary. This result suggests that infants are early equipped with the ability to correctly interpret others' mental states and this predisposition does not require growth in cognitive abilities and language.

The early-emerging capability to spontaneously interpret others' intention aligns with the idea that our mind might be built on an *implicit embodied dialogue* with other human beings. In keeping with the Vygotskian perspective, the self would emerge within social relations as a space of intersubjectivity necessary to structure and cultivate it. Consistent with this view, neural evidence has shown that during introspection and social cognition there is a recruitment of similar brain circuits, including the dorso-medial prefrontal cortex and the precuneus (Schilbach et al. 2012; Bolis & Schilbach, 2020). As Bolis & Schilbach (2020) proposed, such similarities in neural activations might indicate that social and individual thoughts are not separated by sharp boundaries. In this regard, the authors introduce the concept of "dialectical attunement" (composed of tightly interconnected internalization and externalization processes) to account for the intimate connection between the social and the individual dimensions. In more detail, humans co-construct bodily as well as interbodily anticipatory structures to predict the consequences of sensorimotor interactions (cf. internalization), while co-transforming their ecosocial niche (cf. externalization), continuously receiving and providing social feedback. This

dynamic loop has been thought of as being realized across both collective (i.e., cultural practices and human evolution) and individual time scales (individual development and everyday sensorimotor functioning), enabling self-construction. Thus, within this theoretical framework, human mind development is inherently realized under a constant collective/interpersonal regulation. The role of interpersonal regulation is clearly manifested in the most sophisticated human ability: abstract thinking. The roots of abstract conceptualization are based in the dialogue underpinned among minds: through conversational practice the single individual finds the social validation of complex meanings, while the human community updates and filters the knowledge accumulated along the course of time.

Interbodily interactions anticipate symbolic/abstract communication

Bodily interactions among the infant and the mother begin before the birth and represent the main form of communication between them. These primary experiences of being in relation through the body with another individual will lay the ground for the development of more symbolic modalities of interaction. The leap to symbolic interactions (i.e., conversation, writing, chatting) allows being connected with the other without the bodily contact, which for the infant has represented the main channel at disposal to be in relation with the other. The progressive detachment from the spatio-temporal and bodily dimensions during social interactions entails moving towards highly abstract and at times “disembodied” modalities of being-with. The increased symbolic and abstract mode of social interactions (less physical, more linguistic) is flanked by an increased symbolic and abstract semantic content of the same (less bodily experienced topics i.e., “glass”, “chair”, “table”, more complex sensorimotor detached topics i.e., “freedom”, “peace”, “justice”). In other words, *how* we socially interact and *about what* we interact as well, both conflate into a more *abstract dimension*. Humans, indeed, think abstractly. They form, update and negotiate abstract meanings across individual and collective scales in and through (linguistic) interactions. When processing abstract concepts, the linguistic experience through which they have been acquired is manifested in the inner speech (WAT theory, Borghi et al., 2017, 2018, 2019, 2020, 2021). Inner speech represents the internalized dialogue through which the symbolic meaning has been learned during the linguistic exchanges and will serve the function of co-construing new meanings susceptible to be transformed under the contextual and historical dynamics. In other words, the individual masters abstract meanings by re-enacting the internalized intellectual interactions on which the concepts are grounded. Thus, mastering symbolic knowledge is a process with profoundly social roots.

Here, we offer a broad theoretical perspective on the relevance of social interactions to allow the maturation of all the human dimensions (bodily, psychological, cultural) across many scales (individual, collective). We put together studies suggesting how social interactions, especially in infancy, entail body-to-body experiences which represent the natural scaffolding of self-development. In this regard, the adult mind is shaped by the presence of others who are the necessary actors allowing the self to exist; indeed, firstly, through physical and then through psychological interactions, the human mind might be construed as “intrinsically relational”. This perspective review is structured in two main sections: in the first one we review studies highlighting the impact of social interactions on the individual development; specifically we deal with the role of the sense of touch in the construction of the bodily self and in the prediction of other’s behaviour early in life; we explore the social function of the sense of touch in the entire life span, highlighting its role in promoting wellbeing and positive as well as pleasurable interactions with close others during adulthood. We introduce the concept of implicit theory of mind and its fundamental role in supporting individuals’ understanding of others’ mental state since the very early stages of life. In the second section by stretching the role of social interactions to a collective perspective, we propose a theoretical framework structured around the concept of “dialectical attunement” in which the sense of self

is considered as emerging within social interactions, finally, the last section proposes abstract thinking as an emblematic example of “dialectical attunement”.

2. Sociality and human development across an individual scale: from the epidermal contact to mind reading

2.1 Interpersonal touch, prediction and bodily self

The bodily interactions with the caregiver is the *relational terrain* from which the infant starts to differentiate herself from the other and to build up the minimal self. Through the interpersonal affective touch expressed in many life routines, infants learn the concomitance of multimodal signals that act as external regulators of the infant’s internal homeostasis. The statistical regularities associated with the occurrence of interoceptive, tactile, visual, and auditory stimuli shared with the caregiver’s body promote the development of the *private experience of themselves*, which has a necessary *social origin*. According to the Free Energy perspective (Friston 2005), humans need to interpret many signals from noisy information produced by the organism and by the external world. They, indeed, necessitate to maintain specific homeostatic parameters (i.e., temperature, heartbeat frequency, oxygen and glucose intake, hydration) within certain ranges that are compatible with life, and thus they strive to functionally capture the association between the external and internal/biological events, which are the cause of their balance. Their aim is to predict future changes relevant for their body, and thus anticipate aversive or appetitive contexts. The Free Energy proposal (Friston 2005) suggests that the human brain advances prediction about the association between noisy information and bodily events following a probabilistic approach, specifically by applying generative models. Such generative models are continuously updated to reduce the prediction error and to improve their fit with reality. The *prediction* represents infants’ *active disposition to identify abstract principles* that undergo the noisy signals and thus, to order the reality. Such effort produces two consequences: i) the *immediate* satisfaction of the biological needs in order to maximise the probability of surviving; ii) the *progressive integration* of the multimodal signals to construe the bodily self. When the infant cries because she feels cold, and the caregiver approaches her to bring the infant to the chest, the latter learns the association between her sense of cold, the act of crying, the bodily contact with the mother and the re-establishment of the optimal temperature inside her body. During the unfolding of the events, the infant not only has satisfied primary needs through the bodily interaction with the caregiver, but she has also learned a chain of probabilistic occurrences of the same multisensorial, external, internal events. Every time that the predictions will fit the reality, the infant will be more and more aware of her body, and she will identify herself as a separate individual from the mother. Crucially, the bodily contact between the infant and the mother is the interactive background where the infant can start to predict the statistical regularities that will be the basis of the “mentalization” (see Fotopoulou, 2015) of the bodily self. As it has been already outlined by Ciaunica & Fotopoulou (2017): “*the physical contact and interpersonal touch have a unique, primary role in the minimal self*” and we do agree with the authors’ position for the following reasons. Bodily contact not only serves the satisfaction of the primary needs (i.e. nourishment, temperature regulation, hygiene), but it is also the modality through which we create an implicit mental representation of our bodily self and through which our identity or narrative self is gradually shaped. Thus, the sense of touch, as the perimeter of our body, defines the beginning and the end of the self-construction processes.

2.2. Social and affective touch promotes wellbeing and positive interpersonal exchanges

The sense of touch defines our bodily-self by connecting ourselves with others and with the external world. Next to the function of tracing the perimeter of ourselves, it also represents the channel through which we express and regulate

affective and social interpersonal relations. Around 8 weeks, fetuses already perform movements to touch parts of their environment, such as the womb, their own body, or the body of a twin if present (Bradley & Mistretta, 1975). Later in their development, during the third trimester, they start to actively respond to the tactile stimulation of the abdomen by the mother and they perform less self-touch (Marx et al., 2017). When the baby is born, touch keeps being a fundamental modality for the first interactions and for the general development of the brain (Björnsdotter et al., 2014). Most of the communication between the caregiver and the infant, in particular the one implicated in responding to basic needs, such as nursing and taking care of the baby's hygiene, is supported by touch. These tactile exchanges are critical not only to survival but are also involved in the relief of behavioural and physiological responses to baby's stress (Feldman et al., 2010). It has been demonstrated, for instance, that neonates show decreased heart rate (which is an index of reduced stress) and increased engagement with the caregiver when caressed at a CT-velocity (Fairhurst et al., 2014). These effects are also relevant when the baby must undergo medical procedures: touch can have an analgesic effect (Bellieni et al., 2007) and can facilitate growth and reduce hospitalization (Field et al., 1986). The skin-to-skin contact with the newborn child, i.e., the kangaroo care, is considered in many countries a fundamental practice in the maternal care unit that promotes successful breastfeeding and improvement in the development of preterm babies (Moore et al., 2016). Moreover, these first dyadic interactions (not only their quantity but importantly their quality) are crucial for promoting the development of a positive attachment, the ability to recognize emotions and to self-regulate (Crucianelli et al., 2019; Crucianelli and Filippetti, 2020). Throughout childhood, touch becomes an important factor in family dynamics; a study by Bai and colleagues in 2016 show how touch between children, parents and siblings is a strong predictor of the expression of positive emotions. Besides tactile interactions with the caregivers, few studies have investigated interpersonal touch between children and friends or non-familial adults (Cascio et al., 2019). For instance, it has been demonstrated that friendly touches from a stranger (Leonard et al., 2014) or from a teacher (Wheldall et al., 1986) can enhance children's self-control and attention and decrease disruptive behavior. Psychophysical, behavioral (Fairhurst et al., 2014) and neuroimaging studies (Jönsson et al., 2018) have shown that children's responses to touch are similar to adults' responses, demonstrating the ability to differentiate CT touch from non-CT touch (Croy et al., 2019). The intensity of the perceived touch seems to increase with age, suggesting that the maturation of circuits involved in tactile perception continues throughout the lifespan (Björnsdotter et al., 2014). A recent study by Haggarty and colleagues in 2021 demonstrated that children, differently from adults, rate CT-touches equally pleasant, regardless of the area being touched. This result might reflect the predominant sensory information that children use to evaluate touches, while in adults other top-down influences are at stake. Indeed, the transition to adulthood is characterized by increasing complexity of adaptive functions associated with touch, including the establishment of cooperative social bonds and romantic relationships (Hertenstein et al., 2006), which seem to be embodied into different spatial touching patterns. The strength of the emotional bond with the toucher is directly associated with the number of bodily regions allowed to be touched and the judgment of touch pleasantness (Suvilehto et al., 2015). This evidence is present across cultures (Suvilehto et al., 2019), suggesting that the spatial-related allowance to be touched might be a biologically rooted, adaptive mechanism to regulate social relationships. While on the one hand, intimate forms of touch are the primary way to develop romantic relationships (Andersen et al., 2006), and they are highly associated with well-being (Von Mohr et al., 2021) and relationship satisfaction (Nelson & Geher, 2007), on the other hand, unwanted forms of intimate touch can be an expression of inappropriateness and sexual harassment (Lee & Guerrero, 2001). Brain imaging studies show that the information about the toucher is encoded at the early stages of sensory processing, in the primary somatosensory cortices (Gazzola et al., 2012) and the insular cortex (Suvilehto et al., 2021). Technological advances may allow detailed investigations on how toucher's social characteristics (such as relationship status and group membership) are integrated with the topographical

features of touch to evaluate the touch (in)appropriateness, trigger positive or negative emotional states and behavioral outcomes of approach or avoidance (Lisi et al., 2021a, b). Recent studies show indeed that it is possible to induce vicarious sensations of intimate touch by observing an embodied virtual avatar being caressed on taboo zones (such as the genitalia; Fusaro et al., 2021). Vicarious touches delivered by a male and a female avatar elicited different behavioral and physiological reactions according not only to the participants' sexual preference but also to their own virtual body appearance: when embodying an opposite-sex virtual body, participants responded as if they were in the shoes of their embodied avatar (Mello et al., 2021). This result suggests that it is possible to enhance perspective-taking in people who may lack it and promote intervention on violence and sexual harassment.

2.3. Implicit theory of mind to spontaneously interpret others' behavior

Tactile behavior participates in defining our bodily self, in regulating emotional distress and interpersonal relationships, but there is something more: the very first reciprocal knowledge happens between two interacting bodies. Indeed, at the very beginning the main form of communication is embodied and later it will evolve in more abstract forms. In this regard, Gallagher (2001) introduces the concept of the embodied practice of mind, to point out the importance of primary and secondary intersubjectivity for social understanding. The primary intersubjectivity allows infants to grasp the intentions and emotions of other persons by detecting and tracking eye movements, by interpreting movements, gestures, postures, facial expressions and contextualized behaviors. The secondary intersubjectivity occurs in the first year of age and marks the acquisition of the capability to communicate with others about an object or an event. The infant's attention becomes shared, indeed by following gazes, pointing and communicating with others about objects, she attributes social meanings to events, routines and interactions (see Spaulding, 2010). These embodied practices allow infants to grasp others' intentions without the need to cognitively infer others' desires or beliefs; in fact, the behaviour itself can be naturally decoded. Gopnik and Meltzoff (1997) have proposed that from the intersubjective mapping we might end up promoting abstract inferential processes on the other's mental state. Being already equipped with the abilities to interpret the coupled mapping of the caregiver's sensorimotor inputs onto our own sensorimotor system, means also being able to have access to others' intentions.

Theory of Mind (ToM, but also mentalizing or mind-reading) (Premack & Woodruff, 1978; Wimmer & Perner, 1983) has been the focus of intensive research in the last decades in both developmental psychology and neuroscience.

The dominant method to assess ToM abilities is the false-beliefs test. In this task, participants are asked to read stories about a person holding a false belief and then make predictions about his/her behavior. For example, in the Sally-Anne paradigm, Sally places a marble in a box (location 1) and then leaves the room. Anne then hides the marble in a different box (location 2). When Sally returns to the room, participants are required to identify the box where Sally will look for her marble. To pass the test, participants need to understand that Sally's behavior will be guided by her false belief that the marble is in location 1 and to inhibit the response related to the marble's actual location (the marble is now in location 2). Based on this kind of research, ToM has been initially defined as a complex process of inference about others' minds, which is acquired relatively slowly during development (children can pass the test around 3-4 years of age) and requires executive control and language abilities (Baron-Cohen et al., 1985; Wellman, Cross, & Watson, 2001).

Although this approach has been very fruitful in defining critical aspects of humans' social cognition, it doesn't tell us the full story. In our daily interaction with others, we are not always concerned with explicit reasoning about others'

intentions and beliefs. In fact, rather than on deliberate reasoning, efficient social interaction is largely based on rapid and spontaneous/implicit interpretation of others' actions, facial expressions, gaze direction and touch (e.g., Kirsch, et al., 2018; Becchio, et al., 2012).

In the last years, studies adopting non-verbal implicit measures, such as the analysis of eye movements and reaction times during simple detection tasks in a social context, suggested that both adults and infants before 3 years of age spontaneously or implicitly represent information from another person's perspective (e.g. Clements and Perner, 1994; Onishi and Baillargeon, 2005; Southgate et al., 2007; Kovács et al., 2010; Samson et al., 2010; Schneider et al., 2011; Nijhof et al., 2016; Surian, et al., 2007; Senju et al., 2011). For example, in the study of Kovács et al. (2010), participants observed some movie clips depicting an agent acquiring a true or false belief about the location of an object. At the end of the movie, participants had to press a key to the appearance of the object (expected or unexpected). Reaction times were fast not only when the participant expected the object to be present but also when the agent only (false belief condition) believed the object would be present. Critically, participants were never asked to consider the agent's belief (and remain unaware of the task manipulation as shown with variants of the same task, Bardi et al., 2017a). These results showed that adults track others' beliefs even when they are not required to do so and even in situations where the other's mental state is completely irrelevant to the current goals.

In developmental studies, anticipatory looking and looking time, as a measure of violation of expectation, have been used to test whether young children as early as 7 to 15 months of age show signs of false beliefs representation. In the same study by Kovács et al. (2010) for example, 7-month-old infants display surprise, as indexed by increased looking time, when they are presented with a scenario that is incongruent with an agent's previously acquired belief (Kovács et al., 2010). Evidence in support of the idea that implicit forms of mentalizing emerge early in life has been accumulated in the course of numerous studies (e.g., Southgate et al., 2007; Surian, et al., 2007; Senju et al., 2011). However, possible limitations of some infant ToM tasks are currently a matter of intense debate (see non-replication studies, e.g., Grosse Wiesmann, et al., 2017; Kulke et al., 2018).

Another open question concerns whether implicit and explicit ToM rely on the same mechanisms in the adult brain. Some authors have questioned whether implicit ToM tasks reflects mentalizing of any kind (Heyes, 2014), while others (Apperly and Butterfill, 2009) have proposed the existence of two mentalizing systems: (i) an implicit system that emerges early in life, is fast and efficient and operates unconsciously and (ii) an explicit form of mentalizing that develops later, is more deliberate and flexible. Finally, Carruthers (2016) postulates just a single mind reading system, which operates automatically or in a more controlled way depending on the environmental requirements. Interestingly, a direct comparison between adults' performance in the same task under implicit and explicit instructions showed that participants' performance always reflects the representation of the other's perspective or belief and is not affected by task requirements (Schneider et al., 2014a; Nijhof et al., 2016; Bardi et al., 2017).

Neuroimaging studies have mostly focused on the neural correlates of explicit belief processing. For explicit ToM tasks, a pattern of brain regions has been identified when participants are asked to reason about somebody else's false belief. What is referred to as the 'ToM network' includes most consistently the temporo-parietal junction (TPJ) and the medial prefrontal cortex (mPFC), but also the temporal cortex and the precuneus (e.g. Van Overwalle, 2009; Schurz et al., 2014; Schurz et al., 2021).

Only a few studies have investigated so far, the neural bases of implicit ToM with inconsistent results (e.g., Kovács et al., 2014; Schneider et al., 2014b; Hyde et al., 2015; Bardi et al., 2017a; Bardi et al., 2017b, Naughtin et al., 2017; Boccadoro

et al., 2019; Grosse Wiesmann et al., 2020). Studies comparing implicit and explicit ToM, with the use of the same stimulus material and experimental procedure, found substantial overlap in brain activation within the right TPJ between the two forms of mentalizing (Bardi et al., 2017a; Nijhof et al., 2018). A recent multi-study analysis on the same task found a number of distinct brain regions for implicit ToM but confirmed the existence of overlap with explicit ToM in the right TPJ (Boccadoro et al., 2019).

While neuroimaging studies point towards an (at least partial) overlap between implicit and explicit ToM in the adult brain, a recent study reports that maturation between distinct networks is responsible for different forms of mentalizing in the developing brain (Grosse Wiesmann et al., 2020). More studies will be needed to better characterize belief representation in young children and the developmental trajectories and neural substrates of implicit and explicit ToM.

To sum-up, infants appear to be able to spontaneously interpret others' mental state (implicit ToM) since early in life, and this ability may be grounded in embodied practices (see Gallanger, 2001), not requiring the development of cognitive and linguistic abilities. Indeed, during the very first tactile interactions with the caregiver, infants functionally coordinate with her, by mapping their own sensorimotor signals onto the caregiver's ones (Gallagher, 2001), they also start to interpret others' behavior and intentions. In this sense, the human mind might be built on an *implicit embodied dialogue* with other human beings.

3. Sociality and human development across a collective scale: bodily and intellectual interpersonal regulation

The ability to predict the dynamics of the world on the basis of "internalized experience", while modifying them or the world in case of a misattunement of the two, is largely developed within social interactions. Thus, these mechanisms are not exempt from being affected by socio-cultural factors. For example, a child of this century can be afforded by a mobile phone as opposed to a child of the nineteenth century could not have been. The mobile phone itself represents a technological development, which has largely revolutionised gestures, behaviours and the modalities of being in relation altogether. The dialectic between what we have learned, inherited and what we actively transform by allowing cultural evolution, is oftentimes reflected in abstract thinking. This human skill is based on assimilation/accommodation processes of the interpretative models and the new contextual information. This dialectic itself is the basis of new interpretations of reality, in other words of new meanings, and it is pursued by means of an intense internalized dialogue to structure our thoughts.

3.1. The sociogenesis of the human mind

Sociality permeates each single step of human development. The bodily (Apps & Tsakiris, 2014) and the narrative self (Gallagher, 2000) are the results of continuous interpersonal interactions unfolding over time. Having said that, human becoming is not only an inherently social product across an *individual scale*, but also across a *collective/cultural and evolutionary scale* (cf. Bolis, 2020; Bolis & Schilbach, 2020; De Jaegher & Di Paolo, 2007; Fotopoulou & Tsakiris, 2017; Vygotsky, 1930–1935/1978). People tend to 'fall in synchrony' in social interactions, e.g., through spontaneously aligning rhythmic behaviors, such as gait and clapping or adopting others' mannerisms, from shaking a foot or rubbing the nose, to lexical choices, accents, pauses, speech rates and tone of voice, all the way to actual emotions and moods (cf. Cappella & Planalp, 1981; Chartrand & Bargh, 1999; Garrod & Anderson, 1987; Giles & Powesland, 1975; Hatfield et al., 2011; Koban et al., 2019; Louwerse et al., 2012; Neumann & Strack, 2000). Interestingly, people synchronize with each other

in real-time even against their actual intention (Yun et al., 2012), tending to spontaneously attune to others' behavior (Kilner et al., 2003; Forbes and Hamilton, 2017; Fini et al., 2021b; Boukarras et al., 2021). In fact, such unconscious real-time mirroring, but also interpersonal similarity in longer scales, might facilitate human communication and social relationships by decreasing complexity in interpersonal predictive processing. For instance, it has been shown that the interpersonal similarity of autistic traits is related to friendship quality in the general population (Bolis et al., 2020). In fact, an increasing number of studies has been recently illustrating interpersonal synchrony in social interactions even at the level of brain function, across various time scales and contexts, ranging from motor synchrony (Dumas et al., 2010; Era et al., 2018) and shared psychological perspectives (Lahnakoski et al., 2014), to music experience (Abrams et al., 2013), educational processes (Dikker et al., 2017) and real-life social relationships (Pan et al., 2017; Parkinson et al., 2018).

In this light, the self has been reviewed as the dynamic interplay between internalization and externalization in and through social interaction (cf. Bolis, 2020; Bolis & Schilbach, 2020; Vygotsky, 1930-1935/1978). On one hand, internalization has been thought of as the co-construction of bodily hierarchical structures of the (social) world and the organism, while externalization as the collective transformation of the world. Such a notion of internalization is largely based on the Vygotskian take, defined as the internal reconstruction of an external operation (Vygotsky, 1930-1935/1978), recently reviewed through predictive processing conceptualizations (cf. Bolis & Schilbach, 2020). Predictive processing has been defined as a hierarchical bidirectional process through which an organism adjusts itself in order to 'optimally' predict environmental and bodily regularities, such as seasonal temperature fluctuations and one's own psychophysiological responses. Yet, organisms such as humans are not passive observers who internalize reality, trying merely to adapt to it (cf. Bolis, 2020). On the contrary, humans continuously interact with their world (including their own body), adjusting it according to their prior expectations through processes of externalization. For instance, the body temperature tends to decrease beyond the expected value of ~ 37 °C after persistent exposure to the cold. Shivering, putting on a fire when outdoors or turning on the central heating of a building when indoors, are all typical strategies for reversing this tendency and by doing so increasing survival chances.

Importantly, the abovementioned hierarchical structures of predictive processing and active inference should be considered as inherently collective. First, we dynamically embody others in and through social interaction, shaping each other's bodily structure (cf. De Jaegher & Di Paolo, 2007, Bolis, 2020; Bolis & Schilbach, 2020), and, second, such structures might even be thought of unfolding within nested time and space scales, from biology and cognition all the way up to society (cf. Ramstead et al., 2018). In these lines, architecture and technology can be viewed as a collective strategy to optimize overall uncertainty via transforming the environment according to bodily and interpersonal expectations (Bolis, 2020). In a nutshell, humans actively co-regulate each other, as well as their ecosocial niches, facilitating survival (cf. Fogel, 1993).

Here, let us reconsider an illustrative example inspired by Lev Vygotsky (1930–1935/1978; cf. Bolis & Schilbach, 2020): A baby, trying to regulate her hunger, tries to reach for food. However, she is unable to do so, even after overextending her body and specifically the index finger, as her action repertoire is still not sufficiently developed. A caregiver, predicting the baby's goal, easily completes the action by providing the food closer. After multiple repetitions, the extended index finger can potentially assume the symbolic function of pointing. In fact, the primary purpose of such early social interactions, which help build what we call the self (cf. Bolis & Schilbach, 2020), might be nothing more or less than homeostatic regulation (cf. Fotopoulou & Tsakiris, 2017). This is not surprising when one thinks of early social interactions as an extension of the interbodily interaction in the mother's womb (cf. Ciaunica et al., 2020).

Stretching the above mentioned example to an intergenerational scale, we can envisage the social origins of cultural conventions and norms. Furthermore, considering possible interactions of these processes at the scale of phylogeny might allow us to review human anatomy itself as a social product. To give but an example, the human eye morphology has been thought of evolving in tandem with the enhanced gaze-based interaction in humans (cf. Bolis & Schilbach, 2020; Dobson, 2012; Kobayashi & Kohshima, 2001; Powell et al., 2010). These sorts of multiscale and inextricably linked processes of human becoming while attuning to one another and the environment, is what has been described as dialectical attunement (Bolis, 2020; Bolis & Schilbach, 2020). In fact, Vygotsky had already suggested at the beginning of the previous century that all mental processes within an individual result from an internalization of prior social interactions between people; in a nutshell, “through others we become ourselves” (Vygotsky, 1987).

3.2. Abstract concepts and their dialogical nature as a product of “dialectical attunement”

One emblematic example of dialectical attunement (see Bolis & Schilbach, 2020) and perhaps one of the most stimulating challenges for embodied psychology is the humans’ highest level species-specific skill: talking and thinking abstractly. Abstract concepts (i.e., “justice”, “friendship”, “democracy”) typically lack an objectual referent: they are more detached from the sensorimotor experiences. They vehicle complex information that, through socio-cultural evolution, has become handy and efficiently shared among individuals along the time. As the content of abstract concepts cannot be experienced directly through the individual’s senses, their acquisition is grounded in social interactions. Humans enrich their semantic knowledge of the world not only through interbodily social interaction serving immediate survival needs as we mentioned above, but also thanks to intellectual exchanges with other individuals: the dialogue becomes a source of negotiation and meaning validation. During the dialogical practice among humans, processes of assimilation/adaptation of complex meanings are generated. Two different levels can be distinguished behind the assimilation/adaptation processes: an internal/individual dimension of *meaning-construction*, and an external/social dimension of *meaning-acquisition*. These two processes are never definitive, but by virtue of a continuous intense intellectual activity realized in social contexts, abstract concepts are constantly objects of re-thinking.

The incessant update of human knowledge is possible through a mental function, which corresponds to the inner speech, which is defined as an initial outer speech, internalized during cognitive development (Vygotsky, 2012). Following the WAT theory (Borghi et al., 2017, 2018, 2019, 2020), inner speech, might be more involved during the acquisition and processing of abstract as compared with concrete concepts (i.e., “cup”, “table”, “chair”) (Fini et al., 2021; Borghi et al., 2021). Let’s think, indeed, of the word “cup”. When creating in our mind the physical features of the object, immediately the pre-reflective simulation of the sensorial consequences associated with the afforded action (i.e., grasping) is triggered. The sensorimotor anticipation of the action’s outcome permits regulating the interactive behavior with objects and individuals by guaranteeing the prompt unfolding of coherent/appropriate motor chains. However, when processing an abstract word, e.g., “justice”, instead of the predicted sensorimotor expectations on the objectual referent, the re-actualization of the linguistic experience through which we have learned the abstract concept will lead to the validation of a new fresh contextualised meaning. Put simply, we would internally “talk to ourselves” about a specific meaning to better master it. Thus, while for concrete concepts we anticipate/simulate the individual bodily experience with the objectual referent, with abstract concepts we anticipate/simulate the *dialogical experience* of the intangible knowledge. In this regard, the social metacognition proposal (Borghi et al., 2017, 2018, 2019, 2020) explains the role of inner speech during the processing of abstract concepts by invoking three different mechanisms: we might i) prepare ourselves to ask another individual information to fill the gap of the knowledge or to negotiate the word meaning with others (social metacognition), ii) to re-explain to ourselves the abstract concepts’ meaning by collecting sparse informations, iii)

simulate the dialogical experience through which we have learned in a first place the abstract concept. All these - not mutually exclusive- mechanisms clearly express how a dialogical practice can be interiorized (internalization process) and then re-enacted to flexibly provide a space of *negotiation, re-calibration and social validation* of a mental product, i.e. a meaning evoked by a concept, in order to better represent the reality (externalization process). The social validation of abstract concepts can be either vertical/asymmetric, such as in the case of a child who asks the teacher the meaning of a word; or horizontal/symmetric, as in the case of two peers discussing a concept (Mazzuca et al., 2021; Mazzuca & Santarelli, 2021). Both forms are important: in the first case the child is provided with the opportunity of efficiently acquiring cultural knowledge produced in larger time scales, while the second case can be seen as a prototypical exercise of exploring, negotiating, cooperating but also competing, co-constructing and communicating meaning between parties of equal knowledge and power. Our interpretative models of the world are thus, object of a constant update by means of the so called “internalization” and “externalisation” processes: within and through social interactions is constantly realized the categorization of new meanings based on the already owned knowledge (internalization) and these latter are re-negotiated to fuel/ transform our representation of the reality (externalization). The “gnoseological dialogue” between the person and the world, however, is only apparently “individual”, as the interpretative models we used to understand the reality arise from intellectual exchanges within communities. Hence, the human dimension of knowledge and cultural evolution stems from such dialectic of internalization and externalization at high levels of abstraction in and through social interactions (cf. Bolis, 2020). While people interact, they mutually co-construct and co-regulate their bodily predictive hierarchies, by virtue of perceiving and acting upon each other. This means that humans are not only co-constructed in the ‘here and now’, but also beyond, via collectively generating abstract behavioural patterns and concepts, available in future interactions (cf. interpersonal dialogue), but also privately (cf. inner speech). Here, the dialectical attunement hypothesis (Bolis & Schilbach, 2020) has suggested that a line of evolution, which has enabled such abstracting beyond the concreteness of face-to-face real-time social interactions, should have been toward the direction of deepened bodily and brain hierarchies, as higher levels of a hierarchy in this context corresponds to increased levels of abstraction (cf. Mathys et al. 2011). Crucially, such a structural deepening might have enabled major qualitative evolutionary leaps, such as the one from individual to shared intentionality (cf. Tomasello & Carpenter 2007). Indeed, according to the shared intentionality hypothesis, certain ecological shifts in early human societies might have led to increased needs for cooperation (e.g. for foraging), which demanded the development of skills related to the coordination of roles and perspectives toward joint objectives. Such a progression, eventually, the hypothesis goes, might have led to novel forms of perspectival and symbolic representations, socially recursive inference and self-monitoring. Such qualitative leaps from individual to shared intentionality and language acquisition one could recognize in ontogeny scales as well (cf. Bolis & Schilbach, 2020; Tomasello & Rakoczy, 2003). In Vygotsky’s words “the relation between higher psychological functions was at one time a physical relation between people” (Vygotsky, 1929/1989).

4. Conclusions

Touching the mind without touching the body

The self-construction is a profoundly relational process. The progressive awareness of who we are becoming and what we can do, is indeed scaffolded on the proximal interactions between the new-born and the caregiver. They form a dyadic system where the new-born communicates his or her physiological needs to the caregiver who interprets and reacts to the new-born’s bodily signals, by providing him/her with the necessary resources to survive (see Fotoloupou & Tsakiris,

2017). All the new-born's actions are oriented to express bodily perceptions (i.e., interoception, proprioception, nociception) and always have a structural social goal, that is asking for the caregiver's intervention to reach an ultimate goal: the regulation of the new-born's internal homeostasis. During dyadic routines, the new-born learns to causally associate her sensorimotor and internal states with the caregiver's sensorimotor states. She learns to predict their feelings as a consequence of the social events and to predict the social events as a consequence of her expressed internal feelings. In fact, through the caregiver's body, the new-born acquires awareness of her own body and separates herself from the other. The multisensory experience of the new-born largely emerges from the epidermal contact with the caregiver, which is essential to fulfil basic physiological needs (temperature regulation, breast-feeding, washing, etc.) and to establish the very first affective bond with another human. The integration of sensorimotor information produced during the skin-to-skin contact, as it is suggested by Fotoloupou & Ciaunica (2015), represents the most primitive channel through which we recognize ourselves as subjects-being in-the-world.

Indeed, the sense of touch can be thought of as perhaps the most privileged and primitive modality through which we experience being in a relation with another human and it is this social experience that allows the acquisition of bodily awareness. The very first awareness of ourselves pertains to the concept of minimal self which is the implicit representation of our body and its potentialities, including the sense of being the author of our own actions (sense of agency) and of being the owner of our own body parts (sense of ownership). Borrowing a term used by Fotopoulou 2015, the implicit awareness of ourselves is a basic form of "mentalization", intended as "the progressive integration and organization of sensory and motor signals that constitute the foundations of the minimal self". Crucially, the tactile contact not only is the modality through which, at very first, we build a bridge with another human and consequently the bodily self, but it is also the modality through which we define and characterize the nature of the affective relations. Social touch in fact, represents the primary tool to communicate, regulate emotions and express meanings since infancy, while in adulthood is affected by sexuality and romantic attractions (see Cascio et al., 2019). In a nutshell, social touch creates and keeps tight the bonds among people.

In accord with the Interaction Theory (IT) (De Bruin, van Elk, & Newman, 2012; Gallagher, 2001), it is primarily through interpersonal sensorimotor interactions (i.e. through a second-person perspective, Reddy, 2008; Schilbach 2013), that we can understand and experience our own and other's internal emotional states. During the embodied practice (i.e., gestures and facial expressions production), we experience internal states that we also predict and recognize in the other person. Mutuality and reciprocity, not just the mere observation of others, constitute the foundations of social understanding. Thus, Theory of Mind (ToM) finds its roots in the primitive and very spontaneous embodied practices, where the child evolves in her "mentalization" of the sensorimotor signals exchanged during the interaction with the caregiver. At this regard, Fotoloupou & Tsakiris, 2017, embracing the Interaction Theory (IT) (De Bruin, van Elk, & Newman, 2012; Gallagher, 2001), refer to the Theory of Mind as "an advanced form of more primitive inferential processes of embodied perception and action". Here, implicit Theory of Mind has to be distinguished from Explicit Theory of Mind: the first one is a very early ability to interpret the other's intentions and emotions during social interaction and does not require explicit reasoning about her beliefs, as in the case of the second one. While the embodied practice (Gallagher, 2001) during the new-born caregiver interaction will be the precursor of the Implicit Theory of Mind, this latter will lay the ground for the evolution of more structured cognitive processes based on mental inference.

The evolution of the self and the psychological potential to be connected with the others is a process that starts with bodily exchanges at an implicit level, where gradually we build up a minimal and then a narrative identity, we learn to understand other people, while becoming more and more capable of detaching by the "here and now" of social relationships and

interactions. This level of maturation is reached through what Bolis & Schilbach (2020) term “dialectical attunement”: a dialectic of internalization and externalization, unfolded on both individual and collective levels. Put simply, according to this view, we bodily internalize the statistical regularities of our sensorimotor interactions continuously building up expectations about the world, others and ourselves, while we actively modify the environment in order to make it conform to these expectations (see also Clark, 2013). These processes of self-construction and self-regulation evolve from our interaction with others. From the embodied relations with humans, we understand who we are, then with the development of the language and cognitive functions, we culturally act in the world, and we build and negotiate new meanings, we create abstract concepts, norms and conventions, we move towards abstraction and symbolization. Thanks to the special human ability to abstract from reality, as an ultimate step, we can be connected with others without the need for constant tactile contact. We have indeed internalized the relation that has determined the development of ourselves, and such processes of self-development allow us to promote “more disembodied, that is abstracted, interactions”, in other words: “to touch the minds without touching the body”.

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Competing Interests

None