central precursors. During the third month of life, human infants begin to partake in synchronous social interactions, a context in which infants learn to recognize and respond to the communicative intents of others, share emotions, take turns in a vocal exchange, match the partner's gaze directions and facial expressions, and respond to microshifts in attentive states and levels of social involvement (Feldman et al. 1999; Tronick 1989). These early face-to-face interactions between parents and infants are composed of microlevel behavioral units that follow dyad-specific rhythmic patterns, and infants at that stage can anticipate the partner's rhythms and coordinate their behavior accordingly. Although the centrality of face-to-face communication varies across societies, infants of all cultures become active partners in a matched social dialogue at around the same age (Richter 1995) – an experience uniquely human, as no other species sensitizes its young to such coordinated responsivity to facial social signals. Mothers and fathers synchronize with their infants to the same degree but use different modes of interpersonal synchrony – mothers by focusing on a rhythmic face-to-face exchange, and fathers by constructing chains of highly aroused play with an object focus (Feldman 2003). During that stage, infants can also meaningfully participate in triadic social interactions with their mothers and fathers. Three-month-old infants shift their social orientation between the parents during triadic play following the interacting parent switching his or her gaze from infant to spouse, and such capacity suggests an early awareness to a social signaling system between independent others (Feldman et al. 2003). At about 4 months of age, mothers begin to attribute intentionality to their infants' behaviors, thus creating the mental context for the emergence of the infant's intentional action (Feldman & Reznick 1996). Such close involvement with the social world – prior to the emergence of reaching and grasping that allow for a meaningful involvement with the world of objects – precedes the shared intentionality and the triadic infant-other-object relationships of the later part of the first year and suggest a biological preparedness provided by the early synchrony of affective states for the development of tool use, mind reading, symbolization, and creativity (Feldman & Greenbaum 1997).

The biological basis for the infant's capacity to partake in synchronous social dialogue is provided by the organization of physiological oscillators during the neonatal period, such as the biological clock and heart rhythms, and more organized sleep–wake cyclicity and heart-rate variability of the neonate predict a tighter synchronous match between mother and child at 3 months (Feldman, in press). Because of the infant's immature physiological regulation, the organization of biological processes such as sleep and wakefulness, thermoregulation, autonomic regulation, and activity level depend on the external regulation afforded by the mother's proximity, contact, and social stimuli (Hofer 1995), and this dependence sensitizes the infant to minor alterations in maternal closeness and communicative signals. While engaging the infant in coordinated interpersonal timing, mothers entrain the infant's biological rhythms and transform the predictable periodic rhythms of physiological oscillators into a stochastic–probabilistic process that is open to the external signals of the social and nonsocial environment and can incorporate the changing states and emerging intents of the interacting partner into the stream of behavior (Fogel 1993; Trevarthen 1979). Parent–infant synchrony in the first months of life has a formative role in brain maturation and was found to predict children's self-regulation, symbolic play, cognitive skills, and behavior adaptation in later childhood (Feldman & Eidelman 2004; Feldman et al. 1996, 1999). Interaction synchrony is also sensitive to risk conditions stemming from both parent and child, and the degree of synchrony tends to decrease in cases of maternal depression, prematurity, or multiple birth (Field 1994; Lester et al. 1985). Thus, the experience of synchrony provides a link between brainstem-mediated homeostatic functions, to limbic structures involved in the identification and sharing of emotions, to cortical systems responsible for the regulation of behavior and the sharing of mental states.

The brain basis of the developing parent-infant bond may be approached with functional neuroimaging. Noninvasive dense-array measurement of electroencephalographic baby brain signals during social situations may soon be possible. The use of functional magnetic resonance imaging to study parental brain responses to emotionally charged baby stimuli was pioneered by Lorberbaum et al. (2002), who used standard baby cries as stimuli for parents. Thalamocingulate circuits as well as medial and orbitofrontal cortices, midbrain, hypothalamus, striatum, and septal regions were selectively more active in response to baby cry. Building on this work, Swain et al. (2003) have been studying primiparous and multiparous mothers and fathers at multiple time points using own baby cry and picture stimuli with the hypothesis that early parenting brain responses may share activations with certain psychopathologies such as obsessive–compulsive disorder (Leckman et al. 2004). Brain regions relatively activated by own versus other baby stimuli include midbrain, thalamus, basal ganglia, amygdala, insula, and cingulate. In addition, parental responses appear to shift over the first 3 to 4 months postpartum as the relationship develops (Swain et al. 2004). Several other groups are working in this area, using different experimental paradigms and populations (Bartels and Zeki 2004; Leibenluft et al. 2004; Nitschke et al. 2004; Ranote et al. 2004; Seifritz et al. 2003; Swain et al. 2003); and this approach promises to reveal brain structures necessary for parent-infant attachment, including behavioral synchrony and shared intentionality. Thus far, emotion-control centers are found to be activated by baby signals across investigators – areas in agreement with the animal literature on pup-directed maternal behavior (Leckman and Herman 2002; Numan and Sheehan 1997). Combinations of well-controlled stimuli, sensitive psychometric data, and ethologically valid stimuli may clarify the specific importance of these brain circuits to mediate normal parental behavior in humans and lay the foundation for future studies of baby brain development and abnormalities of parent-infant bonding related to such conditions as postpartum depression and infant psychopathology.

What is internalised? Dialogic cognitive representations and the mediated mind

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Abstract: Two aspects of Tomasello et al.'s account would benefit from further elaboration: (1) the construction of dialogic cognitive representations through social interaction, and (2) the cognitive consequences of operating with such representations. Vygotskian ideas on internalisation and verbal mediation may help us better to understand how dialogic cognitive representations can transform human cognition.

Tomasello et al. argue compellingly for the importance of shared intentionality for individuals' ability to engage in species-unique forms of cognition. On their account, the main developmental outcome of the intertwining of intentional agent understanding with motivated intention-sharing is a form of cognitive representation rich enough to incorporate both first-person and third-person perspectives on an episode of social interaction. Phylogenetically and ontogenetically, such dialogic cognitive representations underlie humans' capacity to engage with others as thinkers. This account, which sees the fundamentals of cultural cognition as being established at around 14 months, has the drawback of attributing considerable cognitive sophistication to quite young infants, while at the same time appearing to leave little scope for later development to build upon these prelinguistic forms of social–cognitive understanding. Tomasello et al.'s "small difference that made a big difference" (sect. 6, para. 2) is therefore probably too small. Two spe-

https://doi.org/10.1017/S0140525X05300124 Published online by Cambridge University Press

cific aspects of their account would benefit from further elaboration: (1) the ontogenetic process through which dialogic cognitive representations are constructed, and (2) the cognitive implications of the developing ability to operate with such representations.

With regard to the first of these issues, Tomasello et al. are upfront about the fact that they have no satisfactory developmental account of the creation of dialogic cognitive representations. Along with others who have addressed related questions (e.g., see Carpendale & Lewis 2004; Symons 2004), they appeal to Vygotsky's notion of internalisation to explain how dialogic representations of others' intentional relations become transferred to the intrapsychological plane (Vygotsky 1987). The problem is that, if you are going to have internalisation, you have to have something that is internalised. For Vygotsky, what is internalised is semiotically (primarily linguistically) mediated interaction with others. For example, the Vygotskian account of the development of inner speech sees it as beginning with the gradual internalisation of dialogues with others, developing through the intermediate stage of private speech (incorporating dialogic exchanges with self), and ultimately "going underground" to form inner speech. Crucially, this process entails the internalisation of the multiple perspectives represented in the dialogue, with their triadic intentional relations remaining intact (Fernyhough 1996, 2004). As a number of authors have noted (e.g., see Bakhtin 1986; Hermans 1996), semiotic systems such as natural language are uniquely equipped to make manifest this simultaneous multiplicity of perspectives.

A more whole-hearted embracing of Vygotskian internalisation would thus allow Tomasello et al.'s dialogic cognitive representations to accommodate the intentional relations of the individuals with whom the child is in collaboration, or to "encompass simultaneously both first-person and third-person perspectives" (note 9). What they might have to let go of, however, is the idea that language is entirely derivative of these important social–cognitive accomplishments. Natural-language discourse, as a special case of semiotically mediated activity, does not have to wait until shared intentionality is fully established. Rather, it can get started during the (ontogenetically earlier) stages of dyadic and triadic engagement, and can thereby play a part in the transition to collaborative engagement, and the full, dialogic, reciprocal intention-sharing that Tomasello et al. have shown to be so important. To put it another way, the cognitive benefits of using words as tools for thought – in this case, language's ability to represent the multiple perspectives manifested in dialogue – might be a way of offsetting the daunting cognitive challenges that participation in collaborative engagement (especially as early as 14 months) must present. Thus, language is indeed more than "a set of coordination devices for directing the attention of others" (sect. 6, para. 3); it is a psychological tool (Vygotsky 1978) which comes to mediate children's mental lives and reduce the processing demands of operating with complex representations (Clark 1998).

With regard to the second issue, Tomasello et al. appear slightly to undersell the implications of being able to operate with dialogic cognitive representations. If, as I suspect they would want to claim, possession of such representations buys the individual the ability to reason in reflexive, multiperspectival internal dialogues, then the implications for cognition are profound (and would certainly go beyond the reference to "social norms and their constitutive conventional practices" [sect. 5.2, para. 11]). Rather, internal dialogue endows the individual with a way of thinking that is flexible, open-ended, and capable of encompassing different perspectives on reality at the same time (Fernyhough 1996). For example, false-belief understanding (which typically requires the simultaneous accommodation of one protagonist's informed perspective alongside another protagonist's naïve perspective) can be construed as a product of dialogic thinking (Fernyhough 2004). The authors imply that a fully fledged theory of mind must be developmentally dependent upon the ability to operate with dialogic cognitive representations, but they do not have much to say about the other correlates and sequelae of this developmental achievement. For example, one consequence of the difficulties faced by individuals with autism in sharing intentional states with others may be the cognitive inflexibility that characterises the disorder, and which on this view would stem from an inability to engage in mediated internal dialogue (Fernyhough 1996). In addition, it would be interesting to consider how individual differences in the motivation to share intentions, on the part of both infants and the adults who provide much of their social context, might affect children's later development. The authors note that there is currently little data on such individual differences in infancy, and it will be interesting to see how future research addresses this gap. As far as adults are concerned, the construct of mind-mindedness (Meins 1997; Meins et al. 2003) can be construed as involving the willingness, as well as the capacity, to share intentions with others. Presumably Tomasello et al.'s account will have something to say about how individual differences in caregivers' intention-sharing motivation will affect infants' developing capacities for collaborative engagement and the cultural–cognitive achievements that flow from that.

Animal cognition meets evo-devo

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Abstract: Sound comparative psychology and modern evolutionary and developmental biology (often called evo-devo) emphasize powerful effects of developmental conditions on the expression of genetic endowment. Both demand that evolutionary theorists recognize these effects. Instead, Tomasello et al. compares studies of normal human children with studies of chimpanzees reared and maintained in cognitively deprived conditions, while ignoring studies of chimpanzees in cognitively appropriate environments.

Karl Marbe, distinguished German experimental cognitive psychologist, studied Basso, a chimpanzee in the Frankfurt zoo, that solved arithmetic problems (Marbe 1917). Asked in German "How much is six plus four?" Basso selected a card bearing the number "10" as in Figure 1. Verifying that Basso was usually correct, Marbe interviewed the zookeeper and trainer who drilled Basso on simple problems as one might drill a small schoolchild, but without believing that Basso could do arithmetic. He believed,



Figure 1 (Gardner). Array for testing chimpanzee Basso (Marbe 1917) as in infant tests (e.g., Tomasello & Haberl 2003).

https://doi.org/10.1017/S0140525X05300124 Published online by Cambridge University Press