Symbolic behavior and perspective-taking are forms of derived relational responding and can be learned

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Abstract: Numerous questions remain unanswered concerning the functional determinants of symbolic behavior and perspective-taking, particularly regarding the capabilities of children with autism. An alternative approach that considers these behaviors to be forms of derived relational responding allows for the design of functional intervention programs to establish such repertoires in individuals for whom they are absent.

Tomasello et al. argue that children with autism exhibit deficits in shared intentionality and that the use of symbols is considered to be a particular problem area for this population. However, they fail to elaborate on the extent to which these deficits might be ameliorated, and what implications this might have for their account. Many questions remain unanswered concerning the functional determinants of these behaviors and how they can be added to an individual's behavioral repertoire once they are found to be lacking. We will address these issues within the context of modern behavioral approaches to symbolic behavior and perspective-taking that consider these behaviors to be forms of derived relational responding.

Conflicting definitions of symbols abound in the developmental literature, yet research conducted over the past 30 years within the behavior-analytic tradition on derived relational responding offers a functional account of the kinds of symbolic behaviors that constitute the very core of human language and cognition (Hayes & Hayes 1992; Hayes et al., 2001; Horne & Lowe 1996). The research has shown a remarkable propensity, given appropriate training conditions, for children with autism and other developmental disorders to produce novel behavior indicative of the efficient use of symbols. Derived relational responding, which at the moment appears to be a uniquely human ability (see Dymond et al., 2003), may in fact be a fundamental process involved in language because of its similarity with the bidirectionality of word-referent relations. In the course of early language training, children learn perhaps one of the most important forms of derived relational responding, which is to name and point to objects and events and to derive relations among these events with increasing complexity as the child develops (Lipkens et al., 1993). For instance, on hearing the spoken word "car," pointing to an actual toy car may be taught. This training episode may be described as "hear name, see and point to object." Next, when presented with a picture of a toy car, a child may be taught to point to the actual toy car ("see picture, point to object"). Following such a training history, emergent relations among the stimuli can then be tested; that is, a child may produce the spoken word "car" and point to a picture when shown the actual toy car (called symmetry or mutual entailment), without further training. Similarly, a child may point to a picture on hearing the spoken word, and vice versa (called equivalence or combinatorial entailment), all without additional training.

These derived performances are, we would argue, symbolic because the child spontaneously derives relations among all stimuli after learning only a subset of baseline relations. Children with autism, including those lacking vocal naming abilities, can derive stimulus relations such as equivalence and exclusion but may occasionally require specialized instructional training protocols before they do so (see Carr 2003; Carr et al., 2000; Eikeseth & Smith 1992; O'Donnell & Saunders 2003; Stromer et al., 1996; Wilkinson & McIlvane 2001). Thus, there are no grounds for claiming that symbolic behavior, or derived relational responding, is either problematic or beyond the behavioral capabilities of children with autism and other developmental disorders. Furthermore, an approach that emphasizes the functional components of symbolic behavior also permits inclusion of symbolic responses other than vocal responses (e.g., manual signing) in the communicative repertoires of children with autism. Reference to such alternative repertoires is notably absent from Tomasello et al.'s account.

Perspective-taking skills, when considered to be a form of derived relational responding, may emerge in a similar manner following a history of explicit reinforcement for answering questions that require the child to shift perspectives between *I–You*, *Now–Then*, and *Here–There*, such as "What am I doing here?" and "What are you doing now?" (Barnes-Holmes et al., 2001; Dymond & Barnes 1994, 1997; McHugh et al., 2004). Although the form of these questions may often be identical, the physical environment is altered each time a question is asked or answered. What remains constant across these events are the relational properties of the deictic terms. Across the course of development and throughout daily discourse, a child learns that *I* is always from this perspective *here*, but not from another's perspective *there*. In this way, the perspective-taking functions of answering questions may be present even if the actual deictic terms are absent as alternative words serve the same contextual function and enable a child to learn to respond appropriately as if the actual terms had been used. We contend that it is contextually controlled ontogenetic histories such as these that Tomasello et al. are referring to when they mention the contribution of "specific experiences" and "forms of perspective-shifting discourse" on the emergence of joint attentional activities.

Approaching perspective-taking as a form of derived relational responding allows for the design of intervention programs to establish such skills in individuals for whom they are absent. Directly training perspective-taking skills of varying complexity across multiple exemplars and then testing for generalized responding with novel question sets is, in our view, a more pragmatically useful approach than "theory-of-mind" alternatives that attempt to teach children with autism about informational states. While considerable applied research remains to be done, functional intervention-based approaches have already been shown to be effective in overcoming joint attention deficits in autism (see Dube et al., 2004; Jones & Carr 2004; Whalen & Schriebman 2003). We contend that approaches such as these will be of more practical use than accounts that either fail to specify the conditions under which deficits can be overcome or completely disregard this as a pragmatic goal at all.

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Interaction synchrony and neural circuits contribute to shared intentionality

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Abstract: In the dyadic and triadic sharing of emotions, intentions, and behaviors in families, interactive synchrony is important to the early life experiences that contribute to the development of cultural cognition. This synchrony likely depends on neurobiological circuits, currently under study with brain imaging, that involve attention, stress response, and memory.

If shared intentionality is the apex of evolutionary cognition, as suggested by Tomasello et al. interaction synchrony is among its

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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-

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