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).

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instead, that Basso read his mind. Marbe tested this hypothesis by asking the trainer to give Basso a series of arithmetic problems and think wrong answers. The result was decisive. Basso repeatedly gave the answer that his trainer was thinking, regardless of the correct answer in arithmetic. He succeeded at mind reading where he failed at arithmetic.

Further tests showed that Basso selected the card that his trainer looked at. The trainer himself was unaware that he was gazing at the correct card or giving any visible hints whatsoever. Earlier, Pfungst (1965) showed that Hans, a German horse, solved arithmetic problems and also spelled out German words by following the gaze of human interlocutors who were also unaware that they were hinting. Soon, experimental procedures that control for inadvertent hints became standard in comparative psychology (B. Gardner & Gardner 1989a; Warden & Warner 1928).

Warden and Warner's dog Fellow, Pfungst's horse Hans, and Marbe's chimpanzee Basso developed and lived in enriched conditions that fostered cognitive and social development. Respected authorities once taught that developmental environment was insignificant compared with species specific genetic endowment:

> Maturational factors . . . are sufficient to ensure the early development of typical . . . behavior as long as nutrition, shelter, space for practice, and perhaps a minimum of kindness from mother substitutes for infants not left with their mothers are provided. (Riesen & Kinder 1952, p. 173)

Mounting evidence revealed dramatic contrasts between individual and institutional child rearing that contradicted traditional doctrine. In institutions, Dennis (1960) and Hunt et al. (1976), for example, reported profound retardation, especially in institutions with a high infant-to-caretaker ratio. Some infants could neither sit alone nor creep at age 1, and many could not walk at age 2. Experimentally lowering infant-to-caretaker ratio produced dramatic effects. Mean age for sitting alone dropped from 39 weeks to 27 weeks and, for standing and cruising while holding onto the crib edge, from 69 weeks down to 41 (Hunt et al. 1976, pp. 207–8).

The human pattern of institutional deficit reappears in lab-reared chimpanzees. Riesen and Kinder (1952) recorded age of onset of motor milestones for 14 infant chimpanzees reared at Yerkes Laboratories (Orange Park, FL) with the items of Gesell and Thompson's (1929) test for human infants. They found a parallel pattern of development with laboratory infants somewhat ahead of human infants. B. Gardner and Gardner (1989b, Table 3) compares cage-reared chimpanzees in Riesen and Kinder (1952) with wild chimpanzees reared by their own mothers and observed by Goodall (1967) and Plooij (1984). Just as human infants reared by their own mothers are ahead of human infants reared in institutions, so chimpanzee infants reared in the wild are well ahead of chimpanzee infants reared in cages; for example, sit when propped at 10 weeks for wild and 19 weeks for caged infants; and stand alone at 12 weeks for wild and 39 weeks for caged infants.

Comparisons between human children and other animals such as those cited in Tomasello et al. continue to overlook effects of behavioral and social environment. Such experiments compare chimpanzees that live in cages – lucky if they have a rubber tire to play with or a rope to swing from – with human children that live in the rich environment of suburban homes. In these studies, developmental age is number of years that an animal has lived under deprived conditions. Most modern psychologists would expect human children to lose rather than develop intelligence under comparable conditions. Indeed, older captives often score lower than younger captives on cognitive tasks (e.g., Povinelli et al. 1993; Tomasello et al. 1987). Studies of caged chimpanzees led Hare et al. (2002) to conclude, "Dogs are more skillful than great apes at a number of tasks in which they must read human communicative signals indicating the location of hidden food." In a report by Povinelli and Eddy (1996), chimpanzees reared and maintained under cognitively and socially deprived conditions failed to discriminate between an ordinary human being and one with a bucket over his head, or even to learn this discrimination after repeated trials.

Credible comparisons depend on comparable conditions. In cross-fostering, parents of one genetic stock rear offspring of a different genetic stock (R. Gardner & Gardner 1989; Goodenough et al. 1993; Stamps 2003). This well-established method controls for and measures interaction between genetic evolution and developmental environment (evo-devo) (Robert 2004; Wagner et al. 2000). Cross-fostering began for chimpanzee Washoe after she was 9 or 10 months old, whereas Moja, Pili, Tatu, and Dar were cross-fostered from birth. B. Gardner and Gardner (1989b) compared the age of onset of 50 early postural, locomotor, manipulative, perceptual, and social behaviors for Moja, Pili, Tatu, and Dar with norms established for human infants by Dennis and Dennis (1937), Shirley (1931/1933), and Cohen and Gross (1979). The cross-fosterlings were ahead of human infants on some items such as fixating objects and playing with own hands, but the sequence of development was highly correlated, rho = 0.77 (B. Gardner & Gardner 1989b, pp. 439–41, Tables 1 and 2). Table 3 of B. Gardner and Gardner (1989b) compares cage-reared, wild-reared, and cross-fostered chimpanzees on overlapping items. On these milestones of development, cross-fostered chimpanzees are slightly ahead of wild chimpanzees reared by their own mothers, whereas both wild and cross-fostered infants are dramatically advanced compared to cage-reared infants. With respect to these milestones of the first year, cross-fostering provided a favorable developmental environment.

More advanced development under cross-fostering enables more advanced comparisons with studies of human children. Size of vocabulary, appropriate use of sentence constituents, number of utterances, proportion of phrases, and inflection, all grew robustly throughout 5 years of cross-fostering, but more slowly than in human children. Growth was patterned growth and patterns were consistent across chimpanzees. Wherever there are comparable measurements, patterns of growth for cross-fostered chimpanzees paralleled in detail characteristic patterns reported for human infants (B. Gardner & Gardner 1998). In studies by Bodamer and Gardner (2002) and Jensvold and Gardner (2000), conversational probes evoked conversationally contingent rejoinders from cross-fosterlings who used conversational devices to maintain topics of conversation the way human adults and human children use these devices (Brinton & Fujiki 1984; Ciocci & Baran 1998; Garvey 1979; Halliday & Hansen 1976; Wilcox & Webster 1980). Contingencies were comparable to contingences reported for human children (Bloom 1991, 1993) and more comparable to older children than to younger children.

Modern evolutionary and developmental biology (evo-devo) demands that evolutionary theorists recognize the powerful contribution of developmental conditions. Tomasello et al. need to face this challenge.

What are the consequences of understanding the complex goal-directed actions of others?

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Abstract: Four issues that build on the ideas offered by Tomasello et al. are discussed: the developmental course of shared intentionality and its relation to other developing abilities and experiences, and the conceptualization of three key features of the process: motivation, plans and the development of planning, and culture.

Humans have extraordinary social and cognitive capabilities. These capabilities develop side by side, bootstrapping one another over the course of infancy and childhood. As a result, children gain access to the ideas and behaviors of others, and they come to under-

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