Delineating the role of stimulus enhancement and emulation learning in the behavioural re-enactment paradigm

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Want and Harris's critique of the relative neglect of social learning processes in developmental research is well made. It highlights the paradox that in much research the tasks that have been employed in order to investigate imitation in humans have been less complex than in work with non-human primates. Certainly, we agree with their general conclusion that the interpretation of experimental findings has been less parsimonious in work with humans than in the primate literature. Want and Harris provide a thorough review of the potential for social learning processes, including local and stimulus enhancement, mimicry and emulation learning, to account for many of the findings in the human infant literature. We want to focus on the critical importance of delineating the role of stimulus enhancement and emulation learning on children's responses in behavioural re-enactment procedures involving 'imitating' simple actions on objects (Want & Harris, Category 2). This paradigm has led to important claims regarding what underlies infants' responses in the 'imitative' situation, notably that 18-month-olds are able to read the intentions that underlie the model's behaviour (Meltzoff, 1995).

The possibility that behavioural convergence between the adult model and the infant's response may be due to nonimitative learning processes has been considered in developmental studies (Meltzoff, 1988). Control conditions of various types have been designed to control for such possibilities, even if experimenters have not always specified the forms of social learning in question. Control conditions where infants have no pre-exposure to the objects allow us to determine how likely they are to spontaneously produce the target action within the response period. However, to control for the possible effects of stimulus enhancement it is critical to take into account the parts of the objects that are manipulated by the examiner. When the parts of the objects that are touched or manipulated by an adult are not contiguous with the parts of the objects that require manipulation in order to transform the objects from their initial state to their target end state, then the role of stimulus enhancement in the action produced by the infant cannot be determined. Put simply, if the infant's attention is drawn to non target-relevant parts of the objects they may be more likely to act on these parts of the objects, with a consequent reduction in the likelihood that they will act on the objects in such a way as to produce the target acts. This may explain the finding that merely touching the object or manipulating it in some other way than in the full (target) demonstration condition reduces the likelihood of infants reproducing the target acts (Meltzoff, 1988).

In a later study Meltzoff (1995) significantly improved on his earlier design by the use of more complex object sets. He also introduced a novel 'failed attempt' condition in which the experimenter apparently attempted to transform the object set to produce the afforded target end state but at each attempt they 'accidentally' failed to consummate the transformation. These failed attempt procedures involved contact with the same, target-relevant parts of the objects as manipulated in the full demonstration model condition. The finding that infants were as likely to produce the target acts in the failed attempt condition as in the full demonstration condition led Meltzoff to interpret their responses as reproducing the target act the experimenter had intended but failed to produce (see also Bellagamba & Tomasello, 1999).

However, another interpretation is possible. One critical difference between the failed attempt and the adult manipulation conditions is that in the former but not the latter, the target-relevant parts of the objects are manipulated *and* target-relevant actions involving close, spatial juxtaposition of the target-relevant parts are demonstrated by the experimenter. Thus, stimulus enhancement might have resulted in infants being led to touch the objects at the target-relevant parts. Further, in contrast to the adult manipulation condition, emulation learning may have also played a role, in that infants saw the experimenter attempt but not succeed in bringing

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about the target acts and this may have been sufficient to instigate infants to explore the dynamic affordances of the objects. That is, observation of the demonstrated failed attempts might have evoked the infants' knowledge of the causal structure of the test materials and thereby resulted in the infants producing the target acts more frequently than after watching the adult manipulation control acts that were dissimilar and irrelevant to the target acts.

A further question is how do infants in the re-enactment paradigm determine what are, and what are not, intended actions? Why should the infants in the failed attempt (or the adult manipulation) condition not read the actions demonstrated as the intended actions, as this is probably what constitutes the majority of actions they observe in the world around them when adults act on objects? Conversely, why do they reproduce these other demonstrated actions so infrequently (Bellagamba & Tomasello, 1999; Meltzoff, 1995)? One possibility is that in the failed attempt condition the effect of stimulus enhancement is so strong, and the actions afforded by the objects so clear to the infant, that once they have had their attention drawn to the target-relevant parts of the objects they then manipulate these parts and produce the target acts rather than the non afforded outcome of the failed attempt action actually modelled by the experimenter. In contrast, in the adult manipulation condition the spatial contiguity of the target-relevant parts is not as clear a cue to the afforded target act as in the failed attempt display. This may provide a basis for stimulus enhancement but not emulation learning and this by itself is not enough for them to produce the target acts.

A parsimonious interpretation is important in particular when using the behavioural re-enactment paradigm with atypical individuals. There is evidence that infants with autism do not reproduce even simple actions on objects (Charman, Baron-Cohen, Swettenham, Cox, Baird & Drew, 1998). However, by school age simple modelled actions on objects are reproduced by individuals with autism (Charman & Baron-Cohen, 1994). When simple actions on objects are the focus of study it is likely that both social *and* object learning processes may underlie their development. Under the above analysis, the finding that children with autism do produce target acts in response to the modelled 'failed attempt', while they do not reproduce simple modelled gestures (Aldridge, Stone, Sweeney & Bower, 2000), may not pose a challenge to established theories of the development of imitative ability in autism (Rogers, Benetto, McEvoy & Pennington, 1996).

We do not wish to make the case that in everyday situations reading adults' intentions is irrelevant to imitation of actions by children in the second and third year of life. Rather, it is notable than in everyday situations social, vocal and affective cues are part-and-parcel of imitative exchanges. As Want and Harris point out, the challenge for developmental psychologists is to parse apart the role of these different processes in experimental studies. Some work on the role of intentional cues has begun (Carpenter, Akhtar & Tomasello, 1998). We have adopted a different methodological approach that may help in this enterprise.

Adapting Meltzoff's (1995) behavioural re-enactment paradigm, we have investigated how being exposed to the initial and end state of the object set, but not seeing the adult transform the object set (by using a screen), influences infants' responses (Charman & Huang, 2000; see also Bellagamba & Tomasello, 1999). An important methodological advance was to score the sequence of actions children produced within the 20-second response period. Counting the infants' first actions only, the full demonstration model elicited most target acts. However, when the number of target acts produced in the 20-second response period was scored, exposure to the initial and goal state only produced a similar number of target acts as exposure to the failed attempt and the full demonstration of the target act (Charman & Huang, 2000). This suggests that the nonsocial learning processes of stimulus enhancement and emulation learning influence infants' subsequent actions. Under this analysis, in Meltzoff's (1995) study the full demonstration and failed attempt groups performed equally well because of the combined effects of imitative and nonimitative learning processes. We are currently conducting further studies to help us disentangle the role of emulation learning, stimulus enhancement and intention reading within the behavioural re-enactment paradigm.

We are sure that the field will be encouraged to build on some of the suggestions made by Want and Harris to further develop experimental paradigms that will allow us to delineate the roles of social learning process and the reading of others' intentions within the context of what in the developmental literature we have rather too loosely termed 'imitation' paradigms.

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Imitation is mediated by many goals, not just one

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When my 20-month-old daughter gets out of the bath, she often runs to another room, dances in circles, or climbs on a chair. In short, she does anything except make it easy for me to dry her with a towel. Yesterday, for a nice change, my daughter and I bathed together. When we got out of the bath, I gave her a towel, took my own, and started to dry off. This time instead of running away, she paid close attention to what I was doing. She then laughed, and started to dry herself with her towel. Why was her behavior so different in this context?

Want and Harris identify several possible answers to my question in their review of the literature on social learning in human and nonhuman primates. They argue that developmental psychologists studying how and when children reproduce the behavior of others have too freely labeled children's performances as imitation without considering other forms of social learning, such as enhancement, emulation and mimicry. Want and Harris also say that one reason for this lapse may be that developmental psychologists have studied a limited set of behaviors, focusing on gestures and simple actions on objects, and paying less attention to complex actions on objects. Scientists interested in learning by nonhuman animals, by comparison, have extensively studied social learning of complex actions on objects, and in doing so have developed some reasonable procedures for teasing apart the different forms of social learning.

In an attempt to make the same distinctions for human social learning, Want and Harris review developmental studies of social learning and for each of these studies identify which of three aspects of the modeled behavior have been reproduced: actions, affordances and/or goals. According to Want and Harris, mimicry is the reproduction of actions, emulation is a behavior that capitalizes on the demonstrated affordances of objects, and goal emulation is the reproduction of what Want and Harris call a goal (I'd prefer they call it an outcome, but more about that later). Want and Harris seem to have had a hard time committing themselves to what imitation actually is, and propose that imitation is the reproduction of just actions and goals, or in cases of what they dub 'insightful imitation', the reproduction of actions, goals and affordances.

In this commentary I want to focus primarily on one of the three aspects of the modeled behavior which may be reproduced – goals. I will make three comments. First, Want and Harris sometimes use the term goal to mean an outcome, and sometimes use it to refer to a mental state. This inconsistency may be one reason why Want and Harris have a hard time pinning down what imitation really is. Second, although Want and Harris refer to a behavior as having a single goal, I want to argue that nearly every human behavior involves multiple goals, and that the multiplicity of goals is one reason

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