Imitation as a learning mechanism and research tool: how does imitation interact with other cognitive functions?

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Want and Harris highlighted the lack of scrutiny that human imitation research has received regarding the specific mechanism of learning. Given the available data, they proposed a developmental progression from mimicry to imitation and imitation to emulation. Importantly, they recognized that the learning mechanism employed, however, also depends on the child's general knowledge, task complexity and social motivational factors. An overriding problem described by the authors was the unknown interrelationships between different learning mechanisms and the social dynamic of the imitation situation. In addition, the authors were concerned that the developmental trajectory of tool-use learning in human childhood is relatively uncharted. They proposed that investigating imitation of tool use was the best way to uncover imitation mechanisms because imitation of 'simple actions' cannot address the question.

Some clues to their concerns are already available in the literature of simple action tasks. As mentioned by the authors, the simple imitation tasks do a good job of ruling out local or stimulus enhancement by using adult manipulation controls (e.g. Meltzoff, 1985). Furthermore, one important safeguard that was not mentioned by Want and Harris, was that in some tasks used with infants the goal or outcome of the event is *hidden*, and therefore, is unlikely to be produced by emulation because the affordances are not visible to the infant (Barr, Dowden & Hayne, 1996; Meltzoff, 1985). As the authors pointed out, imitation is a highly adaptive mechanism in situations when it is not readily apparent how the demonstrator is solving the problem.

While the tasks described above allow us to distinguish between imitation and emulation, they do not distinguish between mimicry and imitation. Some studies of sequencing may, however, have begun to address that issue by examining how including irrelevant components disrupts sequencing. In general, infants' imitation of a sequence of actions that can only be performed in a specific order (*enabling sequence* – such as making a rattle by placing a ball in a container, putting a lid on it, and shaking it) is consistently superior to their imitation of a sequence of actions that can be performed in any order (*arbitrary sequence*; e.g. Bauer & Mandler, 1989; Bauer, 1992). Want and Harris reported that children tend to reproduce irrelevant actions when reproducing causally related sequences. The authors did not point out, however, that the irrelevant components are reliably omitted or displaced to the end of the sequence during re-enactment by children between the ages of 19 months and 7 years (Bauer, 1992; Bauer & Mandler, 1989; Hudson & Nelson, 1983; Price & Goodman, 1990). Importantly, these studies did include pretest baseline levels. Bauer and Mandler (1989), for example, added the irrelevant component of attaching a sticker during the demonstration of making a rattle (an enabling sequence). Both 19- and 25-month-olds displaced attaching the sticker to the end of the sequence so as to maintain the enabling sequence order. The irrelevant action was not displaced in a systematic way for arbitrary sequences. The act of omission or displacement during the enabling sequence imitation reflects infants' knowledge of the causal structure of the event and not mimicry of that event.

Although Want and Harris suggest that studies of tool use may shed new light on the development of imitation, there are methodological problems with this approach. One of the problems of a focus on tool use might be that tool use necessarily requires more complex motor skills than other object manipulations and inability to imitate tool use may reflect motor incompetence, rather than imitative difficulty *per se*. It also requires a number of other cognitive abilities. Tool use is relational in nature. It potentially requires combinatorial, relational, causality and sequencing ability, abilities that develop concurrently with imitation. Reliance on tool use to differentiate mimicry, imitation and emulation from one another may be confounded by infants' developmental ability to combine information. In a recent diary study of imitation by 12- to 18-month-olds under naturalistic conditions, imitation of tool use such as painting the wall

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or nailing wood was relatively rare (< 1% of imitated total actions by 12- and 15-month-olds and only 2% by 18-month-olds).

A useful task, however, may be one developed during the 1930s by Richardson. In the Richardson (1934) study, for example, 15 infants were examined monthly from 7 to 12 months of age. Infants were tested in a crib, separated by a grill barrier from a toy mounted on the end of a lever screwed to a tabletop. To get the toy, the infant had to rotate the lever counterclockwise. This could be accomplished by either pushing the near end of the lever to the right, away from the infant and in a direction opposite that of the toy's movement, or pulling the distal portion of the lever to the left, toward the infant and in the same direction as the toy movement. At 7 months, 70% of the infants approached the lever, but less than half touched it. The number of infants who manipulated the lever, either effectively (rotating) or ineffectively (tugging, scratching, poking), increased over succeeding weeks, with the percent producing ineffective responses peaking at 9 months and declining thereafter. Between 10 and 12 months, almost half of the infants were obtaining the toy on two consecutive trials with no more than one erroneous move per trial; in every instance, infants were correct after trial 1, if not on trial 1. Richardson interpreted these data in terms of infants' insight into the use of tools. It would be interesting to see if infants would imitate the target action at 7 months of age. If they did, it would probably indicate imitation rather than emulation given that they were unable to solve the task independently prior to 10 months of age. Given that there are two ways of producing the desired result and thus demonstrating it, this would act as a stimulus enhancement and emulation control. Adding an irrelevant component to the demonstration may distinguish between mimicry and imitation, and developing different versions of the apparatus may be useful for studying transference of responding across problems.

Finally, I will comment on the development of imitation relative to other cognitive domains because I believe that it is not possible to assess the mechanisms of imitation without considering cognitive development as a whole. The complexity of tool use demonstrates that imitation does not develop in a vacuum independent of other developing cognitive abilities. The development of imitation is also undoubtedly linked to the development of an increasingly flexible representational system (Piaget, 1962). Want and Harris seem to suggest that blind imitation can lead only to inflexible knowledge but that emulation would lead to flexible knowledge. The infant's memory system is necessarily conservative with regard to generalization to new situations. This specificity is not unique to imitation and probably has a functional component. Infants will act on objects that have predictive value. The fact that young infants will not respond to stimuli that are even slightly different and potentially lack predictive value compensates for their lack of inhibitory control. Therefore, it is not the imitation mechanism that is inflexible *per se*, but rather a more general function of the cognitive inflexibility in memory processing early in infancy. There are a number of mechanisms, however, that allow infants to transfer imitative responding across objects. First, when 6-month-olds are given pre-exposure to two objects, they transfer responding between the objects (Barr, Marrott & Rovee-Collier, 2000). Second, if infants are provided with two demonstrations with different exemplars, they transfer imitative responding to a third exemplar (Hayne, 2000). Third, language cues facilitate generalization performance for older but not younger infants (Herbert & Hayne, 2000). Fourth, as infants get older generalization to novel stimuli does occur spontaneously in imitation tasks (Hayne, MacDonald & Barr, 1997; Hayne, Boniface & Barr, 2000) and operant conditioning memory tasks (Hartshorn *et al*., 1998) as well as object segregation and object individuation tasks (Needham & Modi, 1999; Wilcox, 1999). Increasing memory flexibility may also be related to increasing emulation and insightful imitation. This is an empirical question.

A somewhat related issue is how an imitation mechanism may interact with other learning mechanisms. We have recently found, for example, that if an imitation task, typically remembered for 1 day by 6-month-olds, is associated with an operant task that is remembered for 2 weeks, the imitation task can also be remembered for 2 weeks (Barr, Vieira & Rovee-Collier, 2001). This finding suggests that imitation may be combined with other learning mechanisms to increase retention of otherwise rapidly forgotten information.

Overall, the age of onset of mimicry, imitation and emulation may be a developmental progression, and the development of tool use and other tasks may also follow that progression. The authors, however, seem to be racing to document the earliest age at which each learning mechanism is available. The probability that a learning mechanism will be implemented is most likely due to the interaction of a number of variables, including age, task complexity, the model, the number of exposures and the presentation mode (see Barr & Hayne, 1999). Examining the interaction of these variables with a variety of tasks may be a more systematic way to investigate the functional application of the different mechanisms. In addition, it is crucial to examine imitation within the cognitive context of the developing organism and not in isolation.

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To 'ape' or to emulate? Young children's use of both strategies in a single study

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In answer to the question 'How do children ape?', Want and Harris (this volume) argue that due to the state of the literature on social learning, at present we are not sure. Their nevertheless compelling synthesis of findings from human and non-human primate studies led them to conclude that it is only after the age of 4 that human children's cognitive abilities are sufficiently sophisticated to permit emulation (i.e. replication based on understanding of causal relations). If children learn vicariously before the age of 4, they most likely do so via mimicry (i.e. blind imitation). Indeed, Want and Harris state that for young children '. . . emulation learning of causal relations may be impossible when faced with a completely novel task' (p. 6). In situations in which children younger

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