

the development of sensory-motor thought among monkeys, gorillas, and humans. All three species achieve the six stages of this development in the same sequence, with monkeys slower than gorillas, who are in turn slower than humans. Despite the fact that Piaget's theory is cited, B&R do not follow a developmental approach to understanding imitation. Given that monkeys and apes mirror the human stages in sensory-motor thought, parallels in imitation, including the timing of its hierarchical nature, should be observed.

One of the essential points of B&R's analysis is that the action and program levels of imitation are not on a continuum, but form "two discrete categories, with little sign of intermediates at present" (sect. 3, para. 4). Earlier in the target article they allude to the distinction between Piaget's (1945/1962) Stages 1 through 5 on the one hand and Stage 6 on the other. These two categories correspond, in a crude way, to the action and program levels of imitation, respectively. However, a detailed reading of Piaget indicates that there is a continuum between the action and program levels of imitation and that this continuum hinges on the underlying processes mediating cognitive growth.

Let us now turn to Piaget's (1945/1962) theory and relate it to B&R's model. Piaget asserts that in Stage 1 the newborn starts life with inborn reflexes as its initial schemas, assimilation and accommodation processes that can modify these schemas, and the capacity to have these reflexes triggered by a variety of external stimuli. True imitation is absent in this stage; for example, crying triggered by the crying of other babies is not imitation.

In Stage 2, an additional capacity emerges: primary circular reactions. These are essentially self-imitative acts in which infants are able to repeat actions they have just performed. In this stage, children can imitate others provided they have previously produced the activity through their own circular reactions. These are action-level imitations and should be observed in apes, despite B&R's caveat that "to be sure of imitation, the act should not already be part of the animal's repertoire" (sect. 1.5, para. 2).

In Stage 3, another new capacity emerges: secondary circular reactions. These allow two sensory systems such as vision and touch to be coordinated. This leads to the infant's ability to repeat actions that produce desired effects in the environment; for example, kicking its feet on the bed, which moves a hanging mobile. Imitation in this stage is restricted to movements the child has previously made and seen, and hence are at the action level. Children cannot defer imitation at this stage because they do not have the capacity for representation.

In Stage 4, yet another new capacity emerges: mobile indices. These are not mental representations or signals, but rather behaviors that children can perform to mediate between perceived movements of others and their own imitative behavior. For example, in imitating its father sticking out his tongue, the infant bites its lips (a mobile index) and then sticks out its tongue. The index is mobile in the sense that it can be used to mediate a variety of actions. Mobile indices allow the child to imitate actions it has already made, but unlike the actions in Stage 3, they are not visible to the infant; for example, sticking out the tongue or opening and closing the mouth. Thus, action-level imitation has moved to a new level of complexity, but is still restricted to behaviors that are already in the child's repertoire.

In Stage 5, the child can now imitate models performing novel actions, including those not visible to it. The new capacity of tertiary circular reactions emerges at this stage. These allow the child to experiment actively in the environment by repeating self-initiated behaviors to see what results. These tertiary circular reactions allow the child to imitate novel actions "through systematic and controlled trial and error." Thus, Stage 5 is a bridge between action and program levels of imitation.

In Stage 6, the child has acquired the capacity to form representations, or mental images. This allows it to form images of the actions of a model, store them, and defer imitation to a later time, well after the model's action has been performed. In a sense, the child can now imitate the model internally and defer external im-

itation to a more suitable time or place. In addition, imitation can now occur for more complex actions than seen in Stage 5. This stage corresponds to the program level of imitation.

The next period of development is "representative intelligence," which occurs from ages 2 to 7 years, and in which images and symbolic functions play the major roles in imitation. Children become less concerned with attempting to match the details of models, but focus more on the overall pattern of the actions. B&R present data that suggest that the great apes can imitate at this level of complexity.

In summary, a Piagetian developmental approach enlarges our view of imitation in apes. It points to research that can be performed to determine whether the same developmental processes are involved with humans and apes. This research should demonstrate with apes that there are intermediate states between the action and program levels of imitation.

## Splitting, lumping, and priming

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**Abstract:** Byrne & Russon's proposal that stimulus enhancement, emulation, and response facilitation should be lumped together as priming effects conceals important questions about nonimitative social learning, fails to forge a useful link between the social learning and cognitive psychological literatures, and leaves unexplained the most interesting feature of phenomena ascribed to "response facilitation."

Byrne & Russon's (B&R's) imaginative target article contains both splitting and lumping proposals. The recommendation that imitative social learning should be split into two varieties (action-level and program-level imitation) has significant weaknesses, not the least of which is its complete lack of empirical support. The data reported by B&R only illustrate the claim that imitation can occur at a hierarchical program level and could be interpreted in various other ways. The mere fact that B&R can describe behaviour in terms of goals and subgoals is not evidence that the behaviour was executed under hierarchical control.

In our commentary, we will concentrate on the suggestion that stimulus enhancement, emulation, and response facilitation should be lumped together as instances of *priming*. There are three problems with this proposal: it conceals important questions about nonimitative social learning, it fails to forge useful links between this kind of learning and the cognitive psychological literature on priming, and it leaves unexplained the most interesting feature of phenomena ascribed to "response facilitation."

The first problem arises from the idiosyncratic way in which B&R characterize stimulus enhancement. They describe stimulus enhancement as if it were an associative phenomenon, in which a conditioned stimulus (CS; e.g., a location) acquires excitatory strength as a result of being observed in conjunction with an unconditioned stimulus (US; e.g., a conspecific eating). This is odd because, ever since Spence (1937) coined the term *stimulus enhancement*, it has been treated as a variety of single stimulus learning in which conspecific behaviour draws the observer's attention to a stimulus, but does not act as a reinforcer. *Observational conditioning* (Mineka et al. 1984) is the term traditionally used for learning that is thought to depend on socially mediated exposure to a CS-US relationship. Of course, B&R may use terms in whatever way they please, but putting the label *stimulus enhancement* on observational conditioning is likely to cause confusion among those familiar with the terms and to conceal important outstanding questions about social learning. The conventional distinction between stimulus enhancement and observational conditioning

amounts to an untested hypothesis that conspecific observation can attract an animal to an object via associative and nonassociative routes. By drawing attention to the role of Pavlovian mechanisms in social learning, the term *observational conditioning* also raises the largely unexplored possibility that animals can learn inhibitory as well as excitatory relationships by observation (Heyes 1994).

The second problem arises from inconsistencies between the mechanism proposed to account for nonimitative social learning and the cognitive psychological literature on priming. According to B&R's priming account, an internal representation will be primed only if activated while a conspecific is seen to receive a reward. In contrast, neither of the main types of priming phenomena manipulated by cognitive psychologists require reward presentation. Under certain conditions, mere preexposure to a priming item can result in either short-term facilitation of responses appropriate to a different probe item (associative priming) or relatively long lasting facilitation of responses to the same probe item (repetition priming). Furthermore, the assumption that only familiar items may be primed is inconsistent with experiments indicating that priming can involve novel items (Squire 1992). This evidence undermines the only original prediction generated by B&R's account of nonimitative effects, implying instead that putative observational priming effects could produce novel behaviours. The observational priming proposal does not harness the explanatory power of cognitive psychology to make useful predictions about nonimitative social learning.

The third problem is that the observational priming proposal does not adequately explain several experimental effects categorised by B&R as "response facilitation." They suggest that behavioural concordance occurred in these experiments because the observation of a conspecific making a response primed an internal representation mediating the execution of a matching response. This proposal, however, has overlooked the most interesting aspect of these effects: the information about a response available to the experimental animals during observation differed in important respects from that available to them during later execution of the same response.

One respect in which observed and executed responses differ is the availability of proprioceptive information. It is unlikely that response representations code only the visual appearance of a response (and not also proprioceptive information), yet the observational priming proposal does not provide a mechanism through which the visual information available through observation of behaviour could prime response representations. A demonstration of cross-modal priming in animals would be striking because such effects do not occur equally across all sensory modalities even in adult humans (Driver & Baylis 1993).

Visual information provided by observed and executed responses also differs because of the disparate viewpoints of performer and onlooker. This is easily illustrated using the example of rats tested with the bidirectional control procedure (e.g., Heyes et al. 1992). These animals encounter a conspecific face-to-face while exposed to demonstrations of lateral responses. Hence a rat reproducing, for example, a left response, is presented with retinal images of its own limb movements (left translation) that are radically different from those of the limb movements of its demonstrator (right translation). Although these experiments have limitations as tests of imitation (Gardner 1997), observational priming clearly does not adequately explain behavioural concordance in our rats. Priming is even unlikely to occur when observer-demonstrator differences in viewpoints are less marked. Visual repetition priming effects are strongly influenced by the specific appearance of the priming stimulus (Squire 1992).