CHAPTER

17

Genuine Imitation?

CECILIA M. HEYES

Department of Psychology
University College London
London WC1E 6BT
United Kingdom

Grindley (1932), a student of Conwy Lloyd Morgan, used an apparatus of his own construction (see Fig. 1), four guinea pigs (Jim, Henry, Tom, and Roger), and a bidirectional control procedure to address a pressing question of his time: Can behavior be modified, not only through contact with relationships among stimuli (i.e., by Pavlovian conditioning) but also through exposure to contingencies between actions and their consequences (i.e., by instrumental learning)? He first trained each of his guinea pigs to turn its head either to the left or right when a buzzer sounded by rewarding the animals with a bite of carrot. The time between buzzer onset and head turning decreased over trials, suggesting that the animals had learned something, but it was not clear to Grindley how or what they had learned. The buzzer may have come to elicit head turning simply because the two events were contiguous, and thus head turning may have been strengthened through Pavlovian conditioning. Alternatively, the consequence of the act, access to the carrot, may have been important. The food reward may have "reinforced," retroactively, the association between the buzzer stimulus and head-turning response, or, as we would now think more likely in cases of instrumental learning, the animals may have discovered that head turning was followed by food.

To distinguish the Pavlovian and instrumental hypotheses, Grindley reversed the contingency. After the animals had acquired head turning in one direction, he withheld the reward for that response, and required them to turn their heads in the opposite direction to get the carrot. Under the new contingency, the guinea pigs

Social Learning in Animals: The Roots of Culture

pushes the joystick, a tone sounds and he receives a food pellet. When the demonstrator has made 50 reinforced responses, he is removed and the observer is immediately placed in the chamber with the joystick. The observers have been magazine training in this compartment, but they have not previously encountered the joystick. During the second stage of the procedure, which begins when the observer is placed in the joystick compartment, and ends when it has pushed the joystick 50 times, the observers are rewarded with food each time they make a response, regardless of its direction.

The (Putative) Imitation Effect

In the basic procedure, observer rats show a reliable tendency to push the joystick in the same direction as their demonstrators; those who observe left pushing, push predominantly to the left, and those who observe right pushing, push predominantly to the right (Heyes & Dawson, 1990; Heyes, Dawson, & Nokes, 1992). The left-hand panel of Fig. 3 provides an example of this effect. It shows that, when all 50 test responses are taken into account, observers of left responding showed a stronger left bias than observers of right responding. In other experiments (e.g., Heyes et al., 1992), the effect has also been found early in the test session, when the observers have made just a few responses.

This result made us think that something interesting was happening, but it was far from conclusive evidence that the observer rats were being influenced by the directionality of the demonstrators' behavior. Clearly, they were not pushing the joystick so that it moved in the same direction within their visual field as it had during observation. If that were the case, then observers would have pushed in the opposite direction to their demonstrators, e.g., observers of left pushing would have pushed more to the right. However, rather than being influenced by the demonstrators' behavior, the observers' bias may have been due to what they saw of the *joysticks'* behavior. For example, they could have been acting such that the joystick moved in the same direction in space, or toward the same part of the chamber, as it had when they watched it before testing. This movement may have become attractive to them, a conditioned reinforcer, because it was immediately followed during the observation phase by food-related cues, the tone and sound of the magazine.

However, the results of two subsequent experiments suggested that, in the bidirectional control procedure, it is the demonstrators' action which influences the observers' behavior. In one of these experiments (Heyes, Jaldow, Nokes, & Dawson, 1994), we tested rats that had observed the joystick moving automatically to the left or to the right, driven by an invisible mechanism. A demonstrator was in the

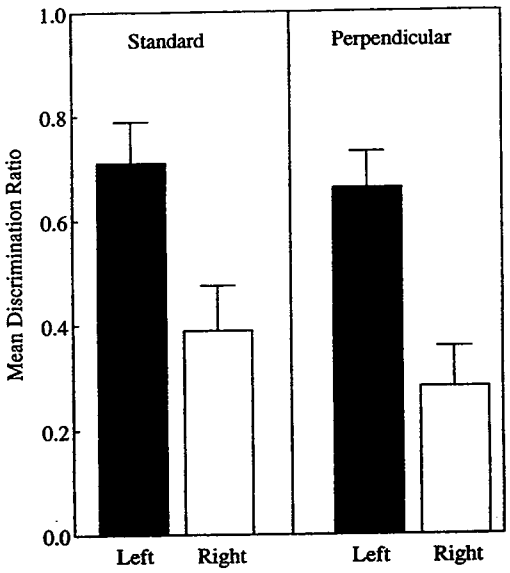

Fig. 3. Mean discrimination ratios [left responses/total responses (50)], and their standard errors, for observers of left and right pushing tested with the joystick in the same position as for the demonstrator (left panel) and when it was displaced to a perpendicular wall between observation and testing (right panel). (From Heyes et al. 1992. Reprinted with permission of the Experimental Psychology Society.)

joystick compartment when the observer witnessed these ghostly movements, but all the demonstrator did was collect the food pellets as they arrived after each joystick displacement. Under these conditions, the observers did not show a systematic directional preference.

In the second experiment, demonstrator rats pushed the joystick during the observation phase, but between observation and testing the joystick was moved to the front wall of the chamber (Heyes et al., 1992, see Fig. 4). Thus, its plane of movement on test was perpendicular to its plane of movement during observation. In spite of this transposition, there was still behavioral concordance between the demonstrators and their observers. For example, observers that had seen demonstrators pushing to the left (L1 in Fig. 4), pushed more to the left (L2) than observers of right pushing (R1), although when an observer pushed to the left, the joystick moved in the opposite direction, in absolute space and relative to cues within the chamber, to that in which it moved when a demonstrator pushed to the left.

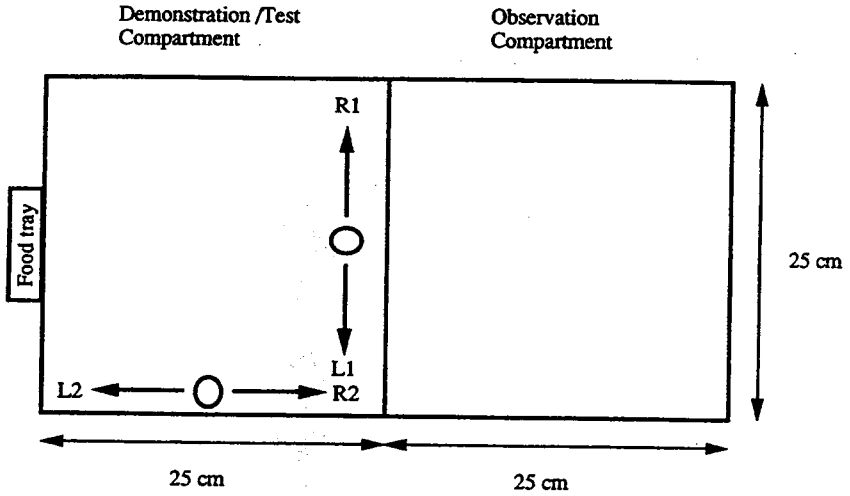

Fig. 4. Plan of the apparatus used by Heyes et al. (1992, Experiment 2), showing the position and plane of movement of the joystick during the observation phase and test phase for Standard groups (L1, R1), and during the test for Perpendicular groups (L2, R2). Responses effecting movement of the joystick toward locations marked L were scored as "left", and those effecting movement towards locations marked R were scored as "right". (Reprinted with permission of the Experimental Psychology Society.)

These data, which are shown in the right-hand panel of Fig. 3, therefore suggest that the rats are not merely learning by observation that food arrives when the joystick moves in a particular direction, or to a particular location. This would be stimulus learning by observation, or "observational autoshaping" (Hogan, 1988), a variety of Pavlovian conditioning. Instead, the subjects appear to be learning by observation to move the joystick in one of two directions relative to the actor's body. At minimum, they seem to be using the demonstrator's body, perhaps its vertical body axis, as a point of reference defining direction of joystick movement, and identifying their own body as being at that reference point on test. This looks to us like response learning by observation; a social-learning equivalent of instrumental learning.

Further Findings

In subsequent experiments we have begun to investigate the psychological processes mediating the bidirectional control effect by examining the conditions in which it

occurs. We have found, for example, that it seems to require that the demonstrators are rewarded with food and a tone, but that these stimuli need not be contiguous with the demonstrator's responses; a delay of at least 5 sec is tolerated (Heyes, Jaldow, & Dawson, 1994).

Furthermore, it appears that the direction of a demonstrator's behavior can influence that of an observer's behavior even when the observer has learned to push the joystick prior to observation. For example, observers that have been rewarded consistently for pushing in one direction, say left, learn to push to the right faster if they have observed a right-pushing demonstrator than if they have seen a left-pushing demonstrator immediately before their first test session in which right responses are rewarded (Heyes & Dawson, 1990). In a procedurally similar experiment we found that observation of conspecific responding can facilitate not only acquisition, but also extinction, of a joystick response in rats. When rats are rewarded for pushing in one direction, say left, and then reward is withheld, the response extinguishes faster if they have observed a demonstrator responding to the left without reward than if they have observed a demonstrator responding to the right without reward (Heyes, Jaldow, & Dawson, 1993). We call this effect "observational extinction."

IS THE BIDIRECTIONAL CONTROL EFFECT "IMITATION"?

Definition by Exclusion

In the literature on social learning in animals, imitation has been defined largely by exclusion, by characterizing other forms of social learning and saying "Imitation is *not* that" (e.g., Thorndike, 1898; Thorpe, 1963; Galef, 1988; Whiten & Ham, 1992; Heyes, 1994a; Zentall, this volume). Therefore, in deciding whether the basic bidirectional control effect demonstrated imitation in rats, our first step was to check whether it belonged to any other, established category of social learning. (The history and membership of these categories is discussed in Galef, 1988; Heyes, 1994a; Zentall, this volume.)

Local or Stimulus Enhancement

Observation of the demonstrator pushing the joystick may have drawn the observer's attention to the joystick and thereby resulted in the observers approaching and pushing the joystick sooner than they would have done if they had not seen

the demonstrators. However, this kind of local or stimulus enhancement process is not sufficient to explain why the observers pushed the joystick in the same direction as the demonstrators.

Byrne and Tomasello (1995) have suggested that the rats may have learned during observation that the joystick should be moved toward a particular part of the chamber, for example, toward location L1 in Fig. 4, and that in the perpendicular test condition (Heyes et al., 1992) the rats thought they were moving it to L1 when they were in fact pushing it the other way, toward L2. Although it was presented as a local enhancement explanation of the bidirectional control effect, this hypothesis suggests that observational conditioning (see below) is responsible for the effect. Regardless of the label we assign to it, the hypothesis is implausible. As Byrne and Tomasello (in press) pointed out themselves, rats generally have an "excellent sense of space," and, even if they were confused, the hypothesis does not explain why any error that occurred should have been so systematic (Heyes, 1995).

Social Facilitation

The bidirectional control effect does not seem to be an example of social facilitation as that term was used by either Zajonc (1969) or Thorpe (1963). According to Zajonc, social facilitation occurs when the presence of other animals "energizes all responses made salient by the stimulus situation confronting the individual at the moment" (Zajonc 1969). Even if one overlooks the fact that demonstrators are not present when observers are tested in the bidirectional control procedure, a social facilitation account would not explain why the most "salient" response for observers was the response they had seen the demonstrator making.

Thorpe's definition of social facilitation resembles Morgan's (1900) characterization of "instinctive imitation," and refers to phenomena that some authors call "mimesis" or "contagion." It specifies that social facilitation occurs when "the performance of a more or less instinctive pattern of behaviour by one [animal] will tend to act as a releaser for the same behaviour in others" (Thorpe 1963). The bidirectional control effect does not fit this definition because, not only is the demonstrator absent when the observer is tested, but it is highly unlikely that right and left joystick pushing are discrete, instinctive responses, *and* that rats are "prewired" such that the sight of each of these acts is a releaser of the same behavior in the observer. Rather, joystick pushing seems to be just the kind of arbitrary response that Thorndike (1898) urged us to use in studying learning.

Observational Conditioning

The bidirectional effect would be an example of observational conditioning (Cook, Mineka, Wolkenstein, & Laitsch, 1985) if it were due to the observers

learning during observation an association between movement of the joystick in a particular direction in absolute space, or relative to features of the operant chamber, and reward. However, our transfer data showed this could not have been the case. When the two were put in opposition, the observers reproduced direction of movement relative to the actor's body, not direction of movement in absolute space or relative to cues inside the chamber.

Matched-Dependent Behavior (or Following)

If the observers in the bidirectional control experiments had been rewarded on test only when they pushed the joystick in the same direction as their demonstrators, the results would have provided an example of matched-dependent behavior (Miller & Dollard, 1941). In fact, the observers were rewarded with food for each joystick response, regardless of direction.

Vocal Mimicry/Copying

Imitation was distinguished from vocal imitation or mimicry by Morgan (1900), Thorndike (1898), and Thorpe (1963) among others. The bidirectional control effect obviously does not involve a vocal behavior, nor does it conform to Miller and Dollard's (1941) characterization of a related phenomenon, copying. According to Miller and Dollard, copying occurs when the demonstrator, or another agent, deliberately rewards responses that are the same as those of the demonstrator and punishes those that are different. In our experiments, the demonstrators were not present when the observers had access to the joysticks, and the experimenters rewarded both same and different responses.

Thus, the bidirectional control effect does not seem to belong to any established category of nonimitative social learning.

Positive Definitions

Although, in practice, imitation has been defined largely by exclusion, as a default category, there have been some influential positive definitions, attempts to say what imitation is, rather than what it is not. Therefore, a second natural step in deciding whether the bidirectional control effect, or any other set of observations, provides evidence of imitation, is to consider how it measures up to these positive definitions.

Thorndike (1898) characterized imitation as learning to do an act from seeing it done, and thus emphasized that, in imitation learning, it is experience of the demonstrator's specific act or action (not his mere presence, or presence in a particular place, or activity of some general kind) that is the critical input, or independent variable, and it is execution of the same act (not location or level of

activity) that is the critical output, or dependent variable. The bidirectional control effect seems to meet Thorndike's criteria. Observers of left and right pushing are exposed to an equal extent to the presence of the demonstrator, in the same location, and engaging in the same degree of activity. The variable that makes a difference to the observer is the direction of the demonstrator's action, and the effect that it has on the observer is to bias him in favor of responding in the same direction.

Novelty and Lack of Instinctive Tendency

Thorpe's (1963) definition of imitation was more precautionary than Thorndike's: "By true imitation is meant the copying of a novel or otherwise improbable act or utterance, or some act for which there is clearly no instinctive tendency". Acutely sensitive to the risk of confounding "true imitation" with social facilitation, Thorpe thus tried to indicate in his definition how one would know when an animal had learned an act from seeing it done; the act learned would be novel and noninstinctive. As a consequence, however, there are practical and conceptual problems in deciding whether *any* example of social learning meets Thorpe's criteria for true imitation.

On the conceptual side, Thorpe's insistence that an imitated act have no instinctive tendency is compromised by subsequent developments in evolutionary theory which show that instinctiveness or innateness must be regarded as a degree property e.g., Mayr (1974); Plotkin, & Odling-Smee (1981). Similarly, Thorpe's emphasis on the novelty of imitated behavior apparently calls for a crisp conception of behavioral novelty which neither he, nor any user of his definition, has provided. What, for example, is the critical dimension of novelty: context, magnitude, force, topography? Can a behavior be entirely novel on any or all of these dimensions, or should it be assumed that all behavioral novelty derives from the recombination of existing elements? Even if these questions had been addressed, and answered in a principled way, it would be difficult to apply Thorpe's definition without two further, practical resources: some sort of scale of novelty, and a comprehensive behavioral history for any putative imitator. (See Whiten & Custance, this volume, for a discussion of related concerns.)

Given these problems, all that can be said is that, like any other putative demonstration of imitation, the bidirectional control effect *may* meet Thorpe's criteria. The joystick-pushing response is novel in that, prior to the experiments in which the basic effect was found, the rats had not been given the opportunity to displace a rigid, vertical object, either to the right or to the left. In addition, as noted above, it is implausible that rats are not only equipped with discrete genetic programs for left and right joystick pushing, but that the sight of each is a releaser for the same in the observer.

In their formal definitions of imitation, considered above, Thorndike and Thorpe did not refer to psychological processes. However, many authors, including Thorpe, have suggested that any behavior which conforms to these definitions must be generated by a particular, complex psychological process, including, most prominently, "ideation," "self-consciousness" and "intentionality," or "metarepresentation."

Ideation

Of these, the bidirectional control effect seems most likely to involve ideation. Following Stout (1899), Thorpe defined ideation as "the occurrence of perceptions, in the absence of the corresponding external stimulation, in the form of images which are in some degree abstract or generalised and which can be the subject of further comparison and reorganisation by learning processes" (Thorpe, 1963). Investigation of the mechanisms underlying the bidirectional control effect is only just beginning, but a hypothesis consistent with the current data is: To push the joystick in the same direction as its demonstrator, the observer forms a psychological representation of what it saw the demonstrator doing (since this is based on visual information, it might be described as an image), and then either "reorganizes" this representation, adding kinesthetic and proprioceptive information, such that it is capable of driving motor output—execution of the same behavior by the observer—or "compares" the image of the demonstrator's action with existing motor programs, thus selecting among and modifying the latter so that one of them will effect execution of the same behavior.

Self-Consciousness

In contrast, it is not at all clear that the bidirectional control effect involves something we would want to call self-consciousness. While it is likely to involve representations of bodies and body movements, those of the observer and of the demonstrator, there is no reason to suppose that either the content or the quality of these representations would justify use of the term self-consciousness. As the content or referent of a representation, "my body" and "myself" are rather different, and there is surely no more or less reason to assume that body representations are conscious, than to assume that any other psychological representations are objects of phenomenal awareness (Heyes, 1994b).

Metarepresentation/Intentionality

Similarly, there is no reason to suppose that the bidirectional control effect is "intentional" (Tomasello, this volume) or mediated by metarepresentational processes (Whiten & Ham, 1992), by an appreciation, on the part of the observer, of the

beliefs, desires, or goals of the demonstrator. It would seem that the observer must represent the demonstrator's action, retain a mental image of what it saw the demonstrator doing, and it may be necessary for the observer to detect that this action is followed by positive events (e.g., the sound of the food-delivery mechanism, the appearance of a food pellet). However, it does not appear to be necessary for the observer explicitly to represent the demonstrator's knowledge of the relationship between joystick pushing and reward, or the demonstrator's desire for food. I can imitate a windmill, for example, without attributing to it a desire to grind corn.

Cultural Transmission

A final positive definition of imitation refers not to psychological processes that may mediate the phenomenon, but to a population-level process that imitation may itself support: cultural transmission. A number of authors (e.g., Piaget, 1962; Huxley, 1963; Dawkins, 1976; Boyd & Richerson, 1988; Galef, 1992; Tomasello, Kruger, & Ratner, 1993) have suggested that imitation is distinct from other forms of social learning in having the potential to support the nongenetic transmission of behavior in a way that would allow human-like traditions to develop. The bidirectional control effect is a dubious example of imitation when measured against this standard. In free-living animals, the learning processes involved in the effect, whatever they may be, could presumably allow one individual to acquire a behavior from another. However, what is important with respect to culture is the degree to which socially acquired behavior is retained in the absence of explicit reward for that behavior, and, perhaps, when alternative behavioral variants have positive consequences (Heyes, 1993a), and the preliminary indications are that, under these circumstances, the bidirectional control effect is swiftly eliminated. For example, when observers are rewarded on test for pushing the joystick in one direction, say left, those that have observed right responding make more right responses than left observers only at the very beginning of the test session. When 10 responses have been made, the concordance between observers and demonstrators disappears (Heyes, Nokes, & Ray, unpublished).

GENUINE IMITATION

So, what can we conclude about the bidirectionalcontrol effect? To summarize, the foregoing discussion suggests that the bidirectional control effect does not belong in any established category of nonimitative social learning, and conforms to both

Thorndike's definition of imitation and Thorpe's definition in terms of ideation. However, there is no evidence that the effect is mediated by self-consciousness or metarepresentational processes, and it is, inevitably, unclear whether it meets Thorpe's specifications that imitated behavior must be novel and without instinctive tendency.

This mixed bag of results might lead us to conclude that the bidirectional control effect is not genuine imitation if the survey had not also illustrated some serious weaknesses and inconsistencies in our definitions of imitation. Thorpe's formal definition depends on a superceded conception of the innate-acquired distinction and an underspecified dimension of novelty, while the definition by exclusion strategy, and both Thorpe's and Thorndike's "operational" definitions, circumscribe a different class of phenomena from those that characterize imitation with reference to a particular unobservable process. Thus, as the bidirectional control example illustrates, a behavioral phenomenon can both fail to conform to any established category of nonimitative social learning, and meet operational definitions of imitation, and yet fail to imply self-consciousness, metarepresentation/intentionality, or the potential to support cultural transmission.

Evidently, the established, historical definitions cannot be simply combined; for a usable conception of imitation, they must be assigned differential weight or otherwise modified and refined. But how should this be done? Three potential solutions to this problem, outlined in caricature below, have some support in the current literature on social learning.

The Essentialist Solution

The first potential solution is to assign primary significance to the idea that imitation is a variety of social learning involving metarepresentation or second-order intentionality—this is the "essence" of imitation—and attempt to make the other, definition-by-exclusion strategy isolate phenomena that imply intentionality by elaborating new categories of nonimitative social learning. Behavioral phenomena that we are tempted to call imitation, that do not conform to any established type of nonimitative social learning, and that do not imply intentionality, can thus be recovered from limbo and assigned to one of the new categories.

"Response facilitation" (Byrne, 1994), "mimicry" (Tomasello, this volume), and "emulation" (Tomasello, Davis-Dasilva, Camak, & Bard, 1987; Tomasello, this volume) or "goal emulation" (Whiten & Ham, 1992), are among the new categories of social learning apparently coined with this solution in mind. For example, Galef, Manzig, and Field's (1986) evidence of imitation in budgerigars has been ascribed to "response facilitation" (Byrne & Tomasello, 1995; Heyes, 1995), several potential

examples of imitation in nonenculturated chimpanzees have been put down to mimicry (Tomasello, this volume), and it has been suggested that the bidirectional control effect is an example of emulation (Whiten & Ham, 1992; Byrne & Tomasello, 1995).

In general terms, emulation occurs when "the learner observes and understands a change of state in the world produced by the manipulations of another" (Tomasello, this volume), and in the case of the bidirectional control effect, Byrne and Tomasello suggest that "the joystick itself, and its position relative to a wall (any wall) is used as a landmark for orientation. Then, on the emulation explanation, the observer notes the position of the stick and how it moves relative to the wire grid wall and then transfers that orientation to the joystick in its new position relative to the new wall it is up against."

Postponing, briefly, consideration of whether this is a satisfactory account of the bidirectional control effect, it should be noted that the "essentialist" solution has several substantial virtues. First, it is decisive; it recognizes that our conception of imitation is confused and tries to do something about it. Second, this solution focuses attention on one of the most interesting questions about imitation: what psychological processes does it involve? Third, the policy of seeking new types of nonimitative social learning could stimulate empirical and theoretical developments.

The problem with the essentialist solution is that it is liable to stifle empirical research, and isolate theoretical developments from empirical input. This is a risk because it identifies as the essence of imitation a process—metarepresentation or second-order intentionality—which, in practice and possibly in principle, cannot be identified empirically in nonlinguistic animals (Heyes, 1993b, 1994c); a metaphysical rather than a theoretical process. Consequently, if imitation is defined by this process, the decision to treat a behavioral phenomenon as imitation rather than, for example, mimicry or emulation, depends on guesswork rather than empirical enquiry. One can only size up the animals in question, ponder the act they are performing, and see whether, intuitively, it seems likely that the observer attributed a goal or mental state to the demonstrator. Most intuitions dictate that this *is* likely in the case of apes, especially enculturated ones, and *not* in the case of budgies, rats, and other species that are distantly related to humans.

The problem is, to some extent, exemplified by Byrne and Tomasello's emulation account of the bidirectional control effect. It is unclear not only how the emulation hypothesis could account for the effect (joystick movement was parallel to the nearest wall for observers of both left and right pushing, yet the test performance of these groups was different), but also how the hypothesis could be

tested against our own, imitation interpretation. However, the problem is deeper than this example suggests. Even if it were possible to show empirically that the bidirectional control effect, or any other prima facie example of imitation, is *not* emulation, mimicry, response facilitation, or of an established type of nonimitative social learning, this eliminative achievement would not be sufficient to imply that the phenomenon in question is mediated by metarepresentation or intentionality. There could be an as-yet-unidentified category or categories of nonimitative, nonintentional, nonmetarepresentational social learning to which it belongs.

The Positivist (No-Nonsense) Solution

In contrast with the essentialist solution, the positivist solution is to assign primary significance to operational definitions of imitation, especially Thorpe's (1963), and attempt to overcome any opacity in these definitions by assuming that, in this context, "novel" behavior means "topographically novel" behavior. Whether the phenomena thus circumscribed as imitation imply ideation, self-consciousness, metarepresentation, or any other psychological process is of lesser importance. Researchers who seem to favor something of this no-nonsense kind include Galef (1988), Zentall (this volume), and Moore (this volume).

The great strength of the positivist solution is that it emphasizes the importance of high-quality empirical work. If imitation is distinguished from other forms of social learning in terms of observable conditions, then it is clear that, to find out which animals can imitate (if any), and under what circumstances, it is necessary to conduct carefully designed experiments. However, the positivist solution is weak on reasons; it is not clear why imitation should be understood to involve the reproduction of topographically novel behavior, and why, if it is not understood to signify complex psychological processing or the potential for culture, imitation is of scientific interest.

The bidirectional control experiments can be used, once more, to illustrate these weaknesses. Imagine that further studies had revealed that, in addition to pushing the joystick in the same direction as their demonstrators, observer rats reproduce the topography of the demonstrator's behavior: use the same forelimb, bend it at the same angle, crouch if the demonstrator crouched, and rear if he reared. What would these further studies have added to our understanding of the psychology of animals? They would no more suggest self-consciousness than the current effect because it would still be "bodies," rather than more inclusive "selves," that needed to be represented, and there is no reason to suppose that a highly specific body representation is more likely to be represented consciously than a

gross body representation. Similarly, a more precise topographic match between observers and demonstrators would not bring us any closer to knowing whether rats are capable of metarepresentation. Mental state attribution is no more necessary for precise than for gross behavioral matching. Furthermore, data of this kind apparently would not secure a role for this type of social learning in cultural transmission because even a behavior that is acquired through precise and faithful copying may be lost through relearning before there has been an opportunity for retransmission.

Of course, an advocate of the positivist solution need not argue that topographic matching would imply self-consciousness, metarepresentation, or a connection with culture. However, surely there should be *some* rationale for defining imitation in terms of topographically novel behavior, and an argument or evidence linking it with underlying psychological mechanisms would be one such reason.

It may be claimed, in the form of an alternative rationale, that imitation should be understood to refer to copying of topographically novel behavior because it is only when the behavior is topographically novel that one can be sure that the animal has learned to do the act from seeing it done (Thorndike, 1898). This rationale seems to be faithful to Thorpe's purpose in emphasizing novelty, but it begs two questions: Why does topographic matching of a novel response necessarily provide more decisive evidence that Thorndike's requirement has been met than, for example, directional matching of a novel behavior or topographic matching or a familiar response? Why is behavior that meets Thorndike's criteria of scientific interest?

The Realist Solution

The realist solution, like the essentialist solution, acknowledges that, for most contemporary psychologists, the purpose of studying observable behavior is to find out about unobservable psychological processes. However, in sympathy with the no-nonsense or positivist approach, it emphasizes that the unobservable entities and processes we postulate to explain behavior should be theoretical rather than metaphysical; it should be possible to test hypotheses about them. (See Brody, 1972; Boyd, 1983; Hull, 1984, for more general discussion of the validity of essentialist, positivist, and realist perspectives in science.)

More specifically, the realist approach, which I favor, consists of adhering to Thorndike's definition of imitation, the oldest scientific definition, and acknowledging that the social-learning phenomena it circumscribes are of interest because they are likely to be mediated by complex, as-yet-underspecified psychological

processes. Theorizing about these, about the not-directly-observable mechanisms underlying imitation, is important, but the hypotheses must be testable. Of the theoretical discussions in the existing literature, Thorpe's (1963) characterization of imitation as a form of ideation seems most likely to yield testable hypotheses. The tests themselves can be conducted using any species and procedure that has provided evidence of imitation according to Thorndike's definition.

Ultimately, however, if the realist solution is successful in stimulating empirical work and enabling us to find out more about the psychology of social learning, it is likely that Thorndike's definition will be superceded by one that specifies a process, and some behavioral phenomena that conformed to Thorndike's definition will be reassigned to a nonimitative category. If it has not already been found to fall short of Thorndike's definition, the bidirectional control effect might well be one of these. However, in the meantime, bidirectional control procedures may be valuable instruments in the investigation of imitation.

REFERENCES

Boyd, R. (1983). On the current status of scientific realism. *Erkenntnis,* **19,** 45–90.

Boyd, R. and Richerson, P. J. (1988). An evolutionary model of social learning: The effects of spatial and temporal variation. In T. R. Zentall & B. G. Galef (eds.), *Social learning: Psychological and biological perspectives* (pp. 29–48). Hillsdale, NJ: Erlbaum.

Brody, B. A. (1972). Towards an Aristotelian theory of scientific explanation. *Philosophy of Science,* **39,** 20–31.

Byrne, R. W. (1994). The evolution of intelligence. In P. J. B. Slater & T. R. Halliday (Eds.), *Behaviour and evolution* (pp. 223–265). Cambridge: Cambridge University Press.

Byrne, R. W., & Tomasello, M. (1995). Do rats ape? *Animal Behaviour,* **50,** 1417–1420.

Cook, M., Mineka, S., Wolkenstein, B., & Laitsch, K. (1985). Observational conditioning of snake fear in unrelated rhesus monkeys. *Journal of Abnormal Psychology,* **93,** 355–372.

Dawkins, R. (1976). *The Selfish Gene.* Oxford: Oxford University Press.

Galef, B. G. (1988). Imitation in animals: History, definition and interpretation of data from the psychological laboratory. In T. R. Zentall & B. G. Galef (Eds.), *Social learning: Psychological and biological perspectives* (pp. 3–28). Hillsdale, NJ: Erlbaum.

Galef, B. G. (1992). The question of animal culture. *Human Nature,* **3,** 157–178.

Galef, B. G., Manzig, L. A., & Field, R. M. (1986). Imitation learning in budgerigars: Dawson and Foss (1965) revisited. *Behavioral Processes,* **13,** 191–202.

Grindley, G. C. (1932). The formation of a simple habit in guinea pigs. *British Journal of Psychology,* **23,** 127–147.

Heyes, C. M. (1993a). Imitation, culture and cognition. *Animal Behavior,* **46,** 999–1010.

Heyes, C. M. (1993b). Anecdotes, training, trapping and triangulating: Can animals attribute mental states. *Animal Behavior,* **46,** 177–188.

Heyes, C. M. (1994a). Social learning in animals: Categories and mechanisms. *Biological Reviews,* **69,** 207–231.

Heyes, C. M. (1994b). Reflections on self-recognition in primates. *Animal Behavior,* **47,** 909–919.

Heyes, C. M. (1994c). Social cognition in primates. In N. J. Mackintosh (Ed.), *Animal Learning and Cognition* (pp. 281–305). New York: Academic Press.

Heyes, C. M. (1995). Imitation and flattery: a reply to Byrne and Tomasello. *Animal Behavior,* **50,** 1421–1424.

Heyes, C. M., & Dawson, G. R. (1990). A demonstration of observational learning using a bidirectional control. *Quarterly Journal of Experimental Psychology,* **42B,** 59–71.

Heyes, C. M., Dawson, G. R., & Nokes, T. (1992). Imitation in rats: Initial responding and transfer evidence. *Quarterly Journal of Experimental Psychology,* **45B,** 81–92.

Heyes, C. M., Jaldow, E., & Dawson, G. R. (1993). Observational extinction: Observation of nonreinforced responding reduces resistance to extinction in rats. *Animal Learning and Behavior,* **21,** 221–225.

Heyes, C. M., Jaldow, E., & Dawson, G. R. (1994). Imitation in rats: Conditions of occurrence in a bidirectional control procedure. *Learning and Motivation,* **25,** 276–287.

Heyes, C. M., Jaldow, E., Nokes, T., & Dawson, G. R. (1994). Imitation in rats: The role of demonstrator action. *Behavioral Processes,* **32,** 173–182.

Heyes, C. M., Nokes, T., and Ray, E. (unpub.). Imitation in rats: Observational learning can both facilitate and retard subsequent individual learning.

Hogan, D. E. (1988). Learned imitation by pigeons. In T. R. Zentall & B. G. Galef (Eds.), *Social learning: Psychological and biological perspectives* (pp. 3–28). Hillsdale, NJ: Erlbaum.

Hull, D. L. (1984). Contemporary systematic philosophies. In E. Sober (Ed.), *Conceptual issues in evolutionary biology* (pp. 567–602). Cambridge, MA: Bradford Books, MIT Press.

Huxley, J. (1963). *Evolution: The modern synthesis.* New York: Hafner.

Mayr, E. (1974). Behavioral programs and evolutionary strategies. *American Scientist,* **62,** 650–659.

Miller, N. E., & Dollard, J. (1941). *Social learning and imitation.* New Haven CT: Yale University Press.

Morgan, C. Lloyd (1900). *Animal behaviour.* London: Edward Arnold.

Piaget, J. (1962). *Play, dreams and imitation in childhood.* New York: Norton.

Plotkin, H. C., & Odling-Smee, F. J. (1981). A multiple-level model of evolution and its implications for sociobiology. *Behavioral and Brain Sciences,* **4,** 225–268.

Stout, G. F. (1899). *A manual of psychology.* London.

Thorndike, E. L. (1898). Animal intelligence. *Psychological Review Monographs,* **2,** No. 8.

Thorpe, W. H. (1963). *Learning and instinct in animals.* London: Methuen.

Tomasello, M., Davis-Dasilva, Camak, L., & Bard, K. (1987). Observational learning of tool-use by young chimpanzees. *Human Evolution,* **2,** 175–183.

Tomasello, M., Kruger, A. C., & Ratner, H. H. (1993). Cultural learning. *Behavioral and Brain Sciences,* **16,** 495–592.

Visalberghi, E., & Fragaszy, D. M. (1992). Do monkeys ape? In S. Parker & K. Gibson (Eds.), *Language and intelligence in monkeys and apes* (pp. 247–273). New York: Cambridge University Press.

Whiten, A., & Ham, R. (1992). On the nature and evolution of imitation in the animal kingdom: reappraisal of a century of research. *Advances in the Study of Behavior,* **21,** 239–283.

Zajonc, R. B. (1969). Coaction. In R. B. Zajonc (Ed.), *Animal social psychology* New York: Wiley.