The Role of Cognition in Classical and Operant Conditioning

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For the past 35 years, learning theorists have been providing models that depend on mental representations, even in their most simple, deterministic, and mechanistic approaches. Hence, cognitive involvement (typically thought of as expectancy) is assumed for most instances of classical and operant conditioning, with current theoretical differences concerning the level of cognition that is involved (e.g., simple association vs. rule learning), rather than its presence. Nevertheless, many psychologists not in the mainstream of learning theory continue to think of *cognitive* and *conditioning* theories as rival families of hypotheses. In this article, the data pertaining to the role of higher-order cognition in conditioning is reviewed, and a theoretical synthesis is proposed that provides a role for both automatic and cognitively mediated processes. © 2004 Wiley Periodicals, Inc. J Clin Psychol 60: 369–392, 2004.

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Classical conditioning used to be viewed as a type of learning that involves the acquisition of elicited responses (i.e., responses, like the defensive eye blink, that are preceded reliably by an identifiable eliciting stimulus and that are experienced phenomenologically as automatic or reflexive). Similarly, instrumental (operant) conditioning was regarded as a type of learning that involves the acquisition of emitted responses (i.e., responses, like a wink of the eye, that can occur in the absence of reliable or well-defined antecedent stimuli and are experienced as voluntary). An implicit assumption of these old definitions was that what is acquired is a stimulus–response (S–R) association rather than a belief about the antecedents of an outcome (O, i.e., an expectancy).

When operant and classical conditioning are defined narrowly as types of learning in which S–R associations are formed, one can question whether they exist at all. Thus, Brewer (1974) provocatively titled his review of the conditioning literature, *There is No Convincing Evidence for Operant or Classical Conditioning in Adult Humans*. Contemporary conditioning theorists regard instrumental and classical conditioning as procedures that lead to behavior change (see Bolles, 1979). One advantage of defining instrumental and classical conditioning empirically in this way is that it is theoretically neutral. There can be no doubt but that instrumental and classical conditioning procedures reliably lead to changes in behavior. What are at issue are the inferred processes by which these changes are produced. In contrast to the early views expressed above, most contemporary learning theorists, even those who are mechanistically minded, regard classical conditioning as reflecting S–O (a.k.a. S–S) associations and instrumental learning as reflecting R–O associations (Rescorla, 1988, 1991; also see Kirsch, 1985).

In what he deemed his most important use of the term, Kuhn (1970) characterized paradigms as exemplars of seemingly permanent solutions to particular scientific problems, exemplars that serve as models for subsequent research in the area. Classical and instrumental conditioning are paradigms in this sense of the term. They have provided models for study a variety of phenomena, including phenomena that are central to clinical psychology. Outstanding examples of the application of classical conditioning procedures to clinical concerns include their use to induce (Watson & Rayner, 1920) and treat (Jones, 1924; Wolpe, 1958) phobic anxiety. The application of operant conditioning to clinical phenomena is evident in the creation and elimination of behaviors that might be symptomatic of psychiatric disorders (Haughton & Ayllon, 1965) and in the operation of token economies (Allyon & Azrin, 1968). Similarly, the behavior of rats that have been trained in a Skinner box on a variable ratio schedule of reinforcement can serve as an exemplar for analyzing and studying the behavior of humans standing in front of slot machines in Las Vegas. In the latter case, even the topography is isomorphic, including the lever that is pressed and the cup, in which the reinforcing pellets or chips are delivered, underneath it. However, this topographical similarity is the exception rather than the rule.

Kuhn (1970) noted that scientists can "agree in their identification of a paradigm without agreeing on . . . a full interpretation of it" (p. 44). This particularly is clear with respect to classical and operant conditioning. There can be no doubt that these procedures result in learning and that they have inspired treatments that have been shown to be effective in clinical trials. However, almost since their inception, their interpretation was the focus of intense theoretical debate. The central issue at the core of this debate was the following question: Are these phenomena automatic, mechanistic processes, in which higher-order cognition, if present at all, is merely an epiphenomenon (e.g., Hull, 1943; Pavlov, 1927; Skinner, 1953; Watson, 1913), or are they processes that are mediated cognitively (e.g., Bolles, 1979; Rotter, 1954; Tolman, 1932, 1948)? In recent years, a consensus has emerged that cognitive processes play an important role in learning (Miller

& Oberling, 1998; Rescorla, 1988, 1991). Nevertheless, it will be argued that there are some instances in which learning bypasses entirely higher-order cognition.

Contemporary mechanistic accounts of classical and operant conditioning typically involve the hypothesis that direct associations between the stimulus and outcome representations or the response and outcome representations are formed during conditioning. Obviously the outcome representations activated by these associations constitute a low-level form of outcome expectancy. Thus, there is now virtually universal agreement that conditioning involves the production of expectancies. The remaining theoretical differences about this issue concern the level of cognition and whether these cognitions can be represented adequately as simple associations. Higher-order cognitive alternatives to these mechanistic interpretations have centered on the concept of expectancy as more than just the activation of simple binary associations. An expectancy is a future-oriented belief; it is a belief that something will happen. Therefore, they also have been described as subjective probabilities (Rotter, 1954). From a cognitive perspective (e.g., Kirsch, 1985), instrumental learning situations produce expectancies that particular behaviors will produce particular outcomes (e.g., that food can be found in a particular location), and classical conditioning produces expectancies that certain stimuli will be followed by other stimuli (e.g., that food will be presented soon after the bell is sounded).

Expectancies have been portrayed as S–O associations, but not all S–O associations are expectancies. For example, a particular melody might function as a cue stimulus evoking a representation of a person in one's past. However, this representation is not an expectancy because it does not produce the belief that the person will appear because there also are present contextual cues that tell us that the person will not appear. In addition, there are types of S–R associations that can be regarded as expectancies (Kirsch, 1985). These are associations in which what is invoked by the stimulus is a representation of the response rather than the response itself. In this article, old and relatively recent data pertaining to the role of higher-order cognition in conditioning will be reviewed, and a theoretical synthesis that provides a role for both automatic and cognitively mediated processes will be proposed.

Data Indicating Higher-Order Cognitive Mediation

Tolman's Challenge to Mechanistic Explanations of Learning

Following the ascendancy of behaviorism, mechanistic explanations were prevalent among learning theorists (e.g., Hull, 1943). The major exception was Tolman (1932, 1948), whose research program was aimed largely at providing anomalies for image-free mechanistic learning theories. Tolman and his colleagues produced a large body of data supporting the hypothesis that rats running in mazes behaved as if they had access to information, built cognitive maps of the mazes, and expected to find food in particular locations (Bolles, 1979). The nature of Tolman's challenge to image-free mechanistic theory can be illustrated with the following examples.

Vicarious Trial and Error: "Catching On." Tolman's (1939) studies of vicarious trial and error (VTE) supported his idea of cognitive maps. VTE refers to the behaviors of "hesitating, looking back and forth" that rats engage in at choice points in a maze or discrimination task (e.g., choosing whether food is behind a black or white door) or before going one way or another in a maze. Rats seemed to display more VTEs when they *catch on* to which stimuli to pay attention to in a visual discrimination task or later "make

sure of which stimulus is which." Tolman claimed this behavior indicates that the rat actively selects and compares stimuli in constructing a cognitive map of the task.

"Hypothesis" Experiments. Krech and Crutchfield (1948) defined learning as a "reorganization of the cognitive field" (p. 112). Tolman (1948) credited Krechecsky (Krechevsky, 1932) with designing experiments suggesting that rats develop systematic choices or *hypotheses* in progressing down difficult mazes. For example, rats try a variety of different behaviors, such as choosing right-handed or dark doors, which continues at above-chance levels until a solution to the maze or discrimination task is achieved. Such trial-and-error behavior was viewed as goal directed and was thought to reflect the development of tentative cognitive maps that are subject to revision as learning occurs.

"Place Learning." If a rat forms a cognitive map of a maze, then it should learn something about the relation among stimuli and have the ability to discriminate the *place* where food was located in its learning environment. Tolman, Ritchie, and Kalish (1946) found that rats that were trained to run a maze in a direct path for food, when blocked from running down the original path to the food and confronted with radiating paths, tended to run down the path that was in the direction of where the food was placed originally or selected a path that ran perpendicularly to the side of the room where the food was placed. Accordingly, the rats appeared to have learned the place where the reward was located, allowing the inference that they had formed a cognitive map of the maze.

In a direct test of the hypothesis that rats in mazes learn locations rather than responses, Tolman et al. (1946) alternately placed rats in one of two different start locations. Half of the rats (designated *place learners*) were reinforced for running to the same location, which required a different response (turning left or right) depending on which location they had started from. The others (designated *response learners*) were reinforced for making the same response, which took them to a different location depending on where they had started from. The logic of the study was that the place-learning task should be the easier of the two if rats learn locations, whereas the response-learning task should be easier if rats learn responses. In fact, all of the place learners learned their task within 8 trials, whereas after 72 trials, only 3 of 8 response learners had learned the task. Nevertheless, both tasks were learned by at least some of the subjects, making it clear that rats are opportunistic and are capable of either type of learning.

Response Prevention. Additional support for the cognitive map hypothesis comes from studies in which animals have been prevented from making a response for which they previously have been reinforced. In these studies, the use of an alternate response to reach the same reinforced location is interpreted as support of the cognitive hypothesis. For example, a rat prevented from turning right can traverse the right path of a T maze by turning left in a $\frac{3}{4}$ circle, until it is facing the goal box. Numerous studies have shown that learning occurred when responses were prevented in a variety of ways, including a) immobilizing rats by an administration of curare and testing learning when the drug was no longer active (Girden, 1942), b) crushing rats' motor nerves (Kellogg, Scott, Davis, & Wolf, 1940), and c) lesioning midbrain regions (Beck & Doty, 1957).

Latent Learning. The most controversial research paradigm was that purporting to demonstrate latent learning (e.g., Blodgett, 1929; Tolman & Honzik 1930). These experiments revealed that rats allowed to spend time in a maze without food reinforcement for reaching the goal showed little improvement in the time required to reach the goal or in

the number of errors made. However, immediately after food was dispensed, the rats' error curves "dropped astoundingly," indicating that the rats had learned to navigate the maze even when they were not reinforced for doing so, but that this learning was not expressed behaviorally in the absence of reinforcement. In other experiments, it was shown that rats learned to locate food even when they were satiated (Thistlewaite, 1951) and when exposure to the maze is provided by having the rat ride in a small cart (Mc-Namara, Long, & Wilke, 1956). According to Tolman, these sorts of demonstrations implied the existence of cognitive maps that formed during nonreinforced trials.

Brewer's (1974) Review

In 1974, William Brewer reviewed more than 200 "dissociation" studies, which he claimed distinguished between "conditioning theory" and "cognitive theory" (i.e., between mechanistic and higher-order cognitive interpretations of conditioning). According to Brewer, these studies of autonomic responses, motor responses, and complex responses (e.g., semantic generalization, conditioned meaning, verbal operant conditioning) in humans provide strong support for a cognitive interpretation. Below are the types of studies he reviewed and the logic by which they support a higher-order cognitive interpretation of conditioning.

Informed pairing: Simply informing participants about the CS–US (i.e., S–O) relation, with no actual pairing, results in acquisition of the CR and informing participants of response–reinforcement (i.e., R–O) contingencies produces instrumental learning.

Informed unpairing: After operant or classical conditioning, extinction can be produced by informing participants that the contingencies are no longer in effect, without any actual extinction trials.

Instructed conditioning: Participants instructed to produce a CR in response to a CS or to emit an operant response do so, without any actual conditioning trials.

Instructed nonconditioning: Participants are told to not produce a CR or operant response, following which they are given conditioning trials. Cognitive theory is supported when the response is not emitted.

Instructed extinction: After standard operant or classical conditioning, participants told to stop emitting the learned response do so.

Masking: Misleading instructions can be used to mask CS–US or response–reinforcement relations.

Awareness of contingency: Awareness of contingencies can be assessed and often is found to be correlated with the emission of conditioned responses, the cognitive hypothesis being that they will be emitted only by participants who are aware.

Modified contingency expectancy: After conditioning, participants are provided with information that produces expectations about contingencies that are different from those of the conditioning trials. For example, removing the shock electrodes in an aversive conditioning paradigm should eliminate the expectancy of shock.

Response expectancies: After conditioning in situations in which different responses are possible, participants' hypotheses about the response are assessed and correlated with their CRs. Alternatively, participants' response expectancies can be manipulated by the provision of verbal information.

Reinforcement expectancy: Participants' responses in a classical conditioning paradigm are correlated with information they have been given about the intensity of a strongly aversive US, or their responses are correlated with their hypotheses about the purpose of an ambiguous reinforcer (e.g., a spoken "hmm").

Brewer (1974) interpreted the data from these experiments as indicating "all the results of the traditional conditioning literature are due to the operation of higher mental processes, as assumed in cognitive theory, and that there is not and never has been any convincing evidence for unconscious, automatic mechanisms in the conditioning of adult human beings" (p. 27). A number of later reviews (Boakes, 1989; Lovibond & Shanks, 2002; Shanks & St. John, 1994), focusing primarily on data reported after Brewer's (1974) review, have echoed Brewer's conclusions regarding the failure of research to support mechanistic views of conditioning. Other reviewers, however, have reached alternate interpretations of the data (e.g., see Manns, Clark, & Squire, 2002; Weins & Öhman, 2002, for contrary conclusions), especially regarding the hypothesis that learning requires awareness of the contingencies (Morris, Ohman, & Dolan, 1998; Schacter, 1987).

Rescorla's Reviews of Classical and Operant Conditioning

Two influential reviews by Robert Rescorla, first of classical conditioning (1988) and then of instrumental conditioning (Rescorla, 1991), constituted further challenges to simple mechanistic views of learning. Rescorla's (1988) review entitled, *Pavlovian conditioning: It's not what you think it is*, updated his earlier (1968) conceptualization of classical conditioning as involving the acquisition of information, as opposed to a "low level mechanical process in which the control over a response is passed reflexively from one stimulus to another" (Rescorla, 1988, p. 152). In his early experiments, Rescorla manipulated the contingency (i.e., correlation) between CSs and USs by presenting various combinations of CSs alone, USs alone, and contiguous CS–US pairings. What appeared to be important for the acquisition of conditioned responding was not the total number of contiguous pairings, but the overall relationship between the CS and US. According to this informational hypothesis, behavioral control is established when there is a positive or negative correlation between the CS and US, but not when there is no correlation. Accordingly, conditioned responses are elicited when the CS predicts that the US is likely to occur, but inhibited when the CS predicts that the US is less likely than the USs base rate. It was as if the animals were attuned to the informational value of the CS that established relations among events, just as is predicted by modern conditioning theories, in which cognitions (and expectancies in particular) play a central role.

According to this perspective, animals (including humans) are goal-directed, active information seekers who form rich and varied representations of their environment in the course of responding to an array of stimuli that come to be associated with one another in potentially complex ways. Conditioning is responsive to different properties of the stimuli that organisms encounter, to differences in associability among stimuli, and to the signaling properties of stimuli with respect to the relations that exist among other stimuli. Learning occurs when organisms are *surprised* (Kamin, 1968; Rescorla & Wagner, 1972) and modify their Pavlovian associations in response to the "discrepancy between the actual state of the world and the organism's representation of that state" (Rescorla, 1988; p. 153). Outcomes that are *surprising* provide new information, facilitate a rich representation of the world, and permit conditioning in as few as a single trial. This line of theorizing allows Tolman's concept of expectancy to be applied readily to contemporary associative learning theory. However, this insight did not result in an unquestioned triumph of higher-order cognition. Notably, simple expectancies can be captured in mechanistic formulations such as the Rescorla–Wagner model (e.g., Allan, 1993). Here subjects are assumed insensitive to direct correlations between cues and outcomes, but the asymptotic state of their mechanistic S–O formulation is difficult to distinguish from such a

sensitivity. Moreover, at their current states of development, simple mechanistic models do some things (e.g., predict recency effects and cue competition) better than do higher-order cognitive models (e.g., López, Shanks, Almaraz, & Fernández, 1998). However, as each family of models evolves, it can be seen that there is little that each family (simple mechanism or higher-order cognition) cannot explain in principle. Contrasting families of models, rather than contrasting two specific models, is dangerous because improved models within each family are often in preparation (Miller & Escobar, 2001). Nevertheless, contrasting cognitive and mechanistic approaches encourages model development and highlights critical phenomena.

S–O Associations in Classical Conditioning

Historically (e.g., Hull, 1943), the associations that are learned during conditioning are between stimuli and responses. Thus, they are S–R associations. In simple cognitive theories (including virtually all contemporary conditioning theories), associations are hypothesized to be formed between representations of two stimuli (i.e., S–O associations), between representations of stimuli and responses (S–R), or between representations of responses and outcomes (R–O). S–O (or R–O) associations generally are interpreted as cognitions in which a stimulus (or response) comes to elicit an expectancy for the occurrence of another stimulus. Contemporary research suggests that expectancies in classical conditioning involve associations that vary in complexity. Simple S–O associations are inferred from conditioning procedures that result in conditioned responses following trial-by-trial presentation of a CS in some relationship with the US. More complex associations are inferred from procedures that provide the opportunity to combine two simple S–O associations (e.g., sensory preconditioning or second-order conditioning), and even greater complexity in associative structure is inferred from procedures that allow for the encoding for higher-order relationships (e.g., occasion setting; Miller & Oberling, 1998).

Simple S–O Associations. Credible evidence of S–O associations in classical conditioning is provided by experiments using *sensory preconditioning procedures* (e.g., Rizley & Rescorla, 1972). In this procedure, animals are presented first with contiguous pairings of two neutral stimuli such as a light and a tone. During this initial phase of the procedure, there is no behavioral evidence that the animals associate the two stimuli. Next, only one of the neutral stimuli, for example the tone, is paired with a US until it elicits a CR. When the stimulus that was not paired with a US (the light in this example) is presented alone in the final test phase, it too is found to elicit a CR. Note that because the light was never paired with a US, it was never experienced as contiguous with a response; therefore, it could not have gained eliciting properties as a result of an S–R association. The generally accepted explanation of the sensory-preconditioning phenomenon is that the animals acquire a latent tone–light association in the first phase and a tone–US association in the second phase. When the light is presented in the final test phase, the light evokes a mental representation of the tone, which in turn evokes an expectancy of the US and generates a CR. Although sensory preconditioning procedures provide strong support for simple S–O associations, they also show more complex cognitive processes. That is, these results indicate that rats are able to take two separate S–O associations (Light–Tone and Tone–US) and through a transitive inference process infer a third association (Light–US).

Additional evidence for this simple cognitive account of classical conditioning comes from *US devaluation procedures* (e.g., Holland & Rescorla, 1975). In the first phase,

experimental and control groups are given standard CS–US pairings until CRs are observed. According to early mechanistic views of conditioning, Phase-1 conditioning reflects an S–R (CS–UR) association, but, according to both contemporary mechanistic and simple cognitive accounts, conditioning results in an S–O (CS–US) association, which can be thought of as a mental link between the representations of the stimulus events. To differentiate between the S–R and S–O accounts of conditioning, the value of the US is reduced (devalued) for the experimental group, but not for the control group during Phase 2 of the experiment. For example, in procedures in which the US is food, satiating the animal or conditioning a taste aversion to the US can achieve devaluation. The S–R account predicts that devaluing the US should have no effect on the CSs subsequent ability to elicit CRs because the US is not part of the association that controls conditioned responding. The S–O account, however, includes a *forward-looking* association and a mental representation of the anticipated US. The experimental group, therefore, should expect a devalued US and thereby respond less to the CS relative to the control group. Devaluation experiments involving classical conditioning paradigms as diverse as sexual-approach conditioning in birds (Holloway & Domjan, 1993) and food conditioning in rats (e.g., Holland & Rescorla, 1975) have provided evidence of S–O associations.

A wide range of simple classical conditioning procedures result in robust and reliable conditioned responding. This observation suggests the even simple associative learning may vary in complexity. In most conditioning procedures, the CS onset precedes US onset, but this temporal precedence is not necessary for conditioning to be seen. Conditioned responses occur when a CS is presented simultaneously with, or following, an aversive US in just a few trials, and sometimes after just one trial (e.g., Ayres, Haddad, & Albert, 1987; Mahoney & Ayres, 1976). Conditioning with just one CS–US pairing indicates that temporal contiguity is a sufficient condition for the establishment of a simple association between internal representations of a CS and US. Additional experience with repeated CS–US trials, however, provides the opportunity for the subject to obtain more information through contingency learning, information that may result in new learning involving the causal (Rescorla, 1988) and temporal (Miller & Barnet, 1993) relationship between stimuli or the behavioral expression of that information (Miller & Matzel, 1988).

Regarding variation in the behavioral expression of simple associations, expectancy theory does not have much to contribute. For instance, expectancy theory does not account for the form that the conditioned response takes in conditioning procedures. A number of studies indicate that the form of the conditioned response is influenced by the type of CS used. For example, Holland (1977) found that rats exposed to tone–food pairings developed a head jerk to the tone, whereas rats exposed to otherwise identical light–food pairings exhibited rearing behavior to the light. In addition, the length of the interval between the CS and the US can affect response topology in ways that are not always consistent with *rational* expectancies. With a short tone–food interval, Holland (1980) observed a startle response to the tone, whereas with a long tone–food interval, he saw orientation to the food hopper in response to the tone. Results like these support the view that the activation of conditioned responding involves biologically *preprogramed* (mechanistic) behaviors that are organized around important biological functions (e.g., feeding, mating, and defense) and are elicited by stimuli that anticipate the arrival of a US (Timberlake & Lucas, 1989). Moreover, recent studies have demonstrated that an abstraction such as response variability can be reinforced (e.g., Neuringer, 2002). Expectancy accounts of simple associative learning also fail to explain basic learning phenomenon that point to failures of behavioral expression rather than to failure to form an S–O association. One example is the *US preexposure effect*. Repeated exposure to a US retards the course of classical conditioning later when a CS is paired with the US in the same context. The US

preexposure effect apparently occurs when the context accrues sufficient excitatory strength to block conditioning to the discrete CS (Randich & LoLordo, 1979). This result usually is interpreted as reflecting the failure of a subject to acquire a CS–US association because the added CS was redundant and provided no new information. However, Matzel, Brown, and Miller (1987) demonstrated that unreinforced exposure to the context after CS–US training reduced the US preexposure effect, suggesting that the CS–US associations indeed were formed during the training phase, but was not expressed in behavior.

Higher-Order Associations. Although the context can serve as a CS in a CS–US association when the context is the best predictor of the US, it also can enter a higher-order relationship with a CS–US relationship when the latter is embedded within the context. In one study, Bouton and King (1983) found that when a discrete CS was paired with a shock US in one context and extinguished in another context, the subjects showed conditioned fear of the discrete CS when retested in the original training context. This renewal of conditioned fear was not evident in subjects that experienced training and extinction in the same context. Thus, expectancies can be altered by the contexts in which test trials occur. Furthermore, independent assessment of the ability of the context to elicit conditioned responding indicated that demonstrable excitatory and inhibitory conditioning of the context was not necessary for the context to control fear to the discrete CS. These results were interpreted as supporting the role of the context as an occasion setter. Occasion setters are viewed as stimuli that provide information about when a CS–US contingency is in effect (Schmajuk & Holland, 1998). Occasion setters are not restricted to contextual stimuli, but can occur in other procedures that provide two-level hierarchical arrangements of discrete events. For example, in the *serial feature–positive discrimination procedure*, a discrete stimulus (the feature) precedes another discrete stimulus (the CS) when the latter is paired with a US, but not when it is presented without a US. Evidence suggests that the discrete CS enters a simple association with the US, but its expression is dependent upon a conditional cue function of the feature. Interestingly, when the feature is presented simultaneously with the other CS instead of preceding it, simple associations appear to develop between the feature and the US rather than higher-order conditional associations (Ross & Holland, 1981). Moreover, just as occasion setters can disambiguate otherwise ambiguous CSs, so too can higher-order occasion setters disambiguate otherwise ambiguous first-order occasion setters (Arnold, Grahame, & Miller, 1991).

R–O and S–(R–O) Associations in Operant Conditioning

R–O Associations. Traditional cognitive explanations of behavioral change in instrumental conditioning procedures posit the formation of an association between an emitted response and an outcome that has followed it in the past (R–O; Bolles, 1979). These R–O associations are the basis of outcome expectancies, that is, they support expectancies that an emitted response will lead to a particular outcome. Devaluation procedures, from which evidence of S–O associations in classical conditioning was derived, also have been adapted for instrumental conditioning procedures, in which they provide evidence of R–O associations. In these instrumental learning studies, an outcome (e.g., sucrose solution or food pellets) can be devalued by pairing it with the administration of a substance or toxin that creates a food aversion, for example. In one study using simple schedules of reinforcement (i.e., a single manipulandum), rats that learned to press a lever for food on a ratio schedule of reinforcement (Phase 1) and then experienced a devaluation of the reinforcer outcome in the home cage (Phase 2) responded less on the lever in a

subsequent extinction test (Phase 3) compared to rats that did not experience the deval-uation (Dickinson, Nicholas, & Adams, 1983). Rescorla and colleagues have used con-current schedules of reinforcement such that in the first phase rats were trained to emit one response for one type of outcome (e.g., food pellets) and a second response for another outcome (e.g., sucrose) followed by home–cage devaluation of one of the out-comes. These studies also have demonstrated consistently a reduction in responding for the devalued outcome during the test phase (e.g., Colwill & Rescorla, 1985a; 1985b). Such results are not predicted by an S–R mechanistic account of conditioning because the S–R association that presumably was selected in Phase 1 should have been unchanged by the home–cage devaluation of the outcome, and as a result, responding should have persisted in the Phase-3 test. The S–O mechanistic and cognitive accounts, however, explain it in terms of the devaluation procedure reducing the value of the reinforcer outcome and consequently operant responding motivated by the expectation of the out-come responding should decline.

S–(R–O) Associations. In his review of associative relations in instrumental learn-ing, Rescorla (1991) made a strong case for the establishment of associations that went beyond simple binary stimulus–response or response–outcome associations. In addition to S–R and R–O associations, Rescorla posited S–(R–O) associations, which can be understood as expectancies of particular outcomes (O) when certain responses (R) are emitted in the presence of an occasion setting (discriminative) stimulus (S). For example, in the typical operant conditioning procedure with rats, the discriminative stimuli of an operant chamber occasions the expectation that responding will lead to imminent arrival of food. Higher-order cognitive accounts describe instrumental conditioning as resulting in motivated action directed toward an expected goal (outcome), whereas contemporary mechanistic theories describe instrumental conditioning as resulting in motivated action because it was reinforced previously. In both cases, S–(R–O) associations are at the heart of modern conditioning theory. In contrast, prior S–R mechanistic explanations specu-lated that the reinforcing outcome selects a stimulus–response association, but does not become a component of the association—the prior reinforcement history simply compels the rat to respond in the presence of distinctive stimuli.

Cognitive Mediation in Clinical Research

Much of the data pertaining to the debate about higher-order cognitive mediation is derived from basic research on animal behavior. However, there also have been studies of clinical phenomena in which this issue has been addressed. In particular, studies of sys-tematic desensitization and placebo analgesia have evaluated automatic and cognitive accounts of these phenomena.

Systematic Desensitization. Systematic desensitization (Wolpe, 1958) is a treatment for phobic anxiety that was inspired by Clark Hull's (1943) theory of conditioning. Pho-bic anxiety is posited to be a classically conditioned response. The idea behind the ther-apy is to associate the anxiety-arousing cues (the CS) with a new CR, one that is incompatible with anxiety (e.g., relaxation). Another explanation of systematic desensi-tization is extinction. According to the extinction hypothesis, in the absence of reinforce-ment by an aversive event (i.e., a US), repeated (or prolonged) exposure to the anxiety cues causes the CR (anxiety) to extinguish. One nice feature of the extinction hypothesis is that it works for other exposure-based treatments (e.g., flooding), as well as systematic desensitization.

The idea that exposure treatments are due to automatic conditioning processes has been tested in three studies (Gauthier, Laberge, Dufour, & Fevre, 1987; Kirsch & Henry, 1977; Southworth & Kirsch, 1988). In the first of these, Kirsch and Henry (1977) compared the effects of systematic desensitization and two credible expectancy modification procedures. One of these procedures was designed specifically to rule out conditioning hypotheses. In an *operant desensitization* condition, visualizations of anxiety-related scenes were paired with painful electric shocks, which subjects were told would "punish the anxiety." This expectancy modification procedure was as effective as standard systematic desensitization in reducing public-speaking fear. Because aversive stimuli are assumed to be the USs leading to the acquisition of fear as a CR, the substantial degree of fear reduction produced by *operant desensitization* cannot be accounted for by extinction or counter conditioning. Furthermore, because the addition of the electric shock was the only procedural difference between *operant* and traditional desensitization, it is reasonable to suspect that the effects of the two procedures were due to a common causal mechanism. Substantial correlations between pretreatment ratings of treatment credibility and treatment-outcome measures suggest that expectancy modification was the common causal agent.

A second test of mechanistic explanations of exposure treatments was a study of the effects of *in vivo* exposure on agoraphobia (Southworth & Kirsch, 1988). Over a two-week period, participants in this study were give ten sessions of *in vivo* exposure, during which they were asked to walk away from their homes until they became anxious and then to turn around and return. Half of the participants were told that the purpose of this was to lower their anxiety. The others were told that the purpose was to assess their anxiety and that treatment would not begin until after the two-week period. Clients provided with therapeutic expectancies showed substantially greater improvement and improved more rapidly than those who were led to believe that *in vivo* exposure was for the purpose of assessment, even when the distance and time walked was equated between the two groups. These data indicate that the therapeutic effects of *in vivo* exposure can be suppressed by disguising its therapeutic intent. These data were replicated by Gauthier et al. (1987) in a study of dental phobia. The findings of both of these studies are problematic for not only traditional S–R models of learning, but contemporary conditioning theories as well.

Placebo Effects. According to classical conditioning models of placebo effects (Ader & Cohen, 1991; Herrnstein, 1962; Wickramasekera, 1980), active medications are USs and the vehicles in which they are delivered (i.e., the pills, capsules, syringes, etc.) are CSs. The medical treatments that people experience during their lives constitute conditioning trials, during which the vehicles are paired with their active ingredients. These pairings endow the pills, capsules, and injections with the capacity to evoke therapeutic effects as CRs.

There are a number of studies demonstrating that classical conditioning procedures can enhance placebo analgesia (Voudouris, Peck, & Coleman, 1985, 1989, 1990). The placebo effect was enhanced in these studies by surreptitiously lowering the intensity of a pain stimulus whenever a part of the body treated with a placebo anesthetic was stimulated. The lowered intensity of the pain stimulus was the US and the placebo was the CS. This procedure increased the pain-reducing effect of the placebo, when subsequently it was tested without lowering the intensity of the pain stimulus.

Although the Voudouris et al. (1985, 1989, 1990) studies convincingly demonstrated conditioned enhancement of placebo pain relief, they did not discriminate between S–O mechanistic and higher-order cognitive interpretations of this phenomenon. In a follow

up to these studies, Montgomery and Kirsch (1997) investigated the effect of verbal information on this conditioning procedure. Recall that in the initial studies, the lowering of the intensity of the pain stimulus was done surreptitiously. Participants did not know that the intensity was lowered, and they therefore attributed the reduction in pain to the effect of the supposed topical anesthetic. Montgomery and Kirsch replicated this effect, but they also included an *informed-pairing* control condition in which participants were told that the intensity of the stimulus was being lowered. As in the condition replicating the original studies, participants in the informed-pairing condition were given trials in which reduced pain was paired with the application of a placebo. However, they also were given accurate information about how the reduction in pain was being produced. This verbal information completely reversed the effect of conditioning trials on the placebo response, which is not anticipated by even modern conditioning theories. In addition, regression analyses indicated that the effects of conditioning trials were mediated completely by participants' verbally rated expectancies.

In contrast to these data, conditioning with various drugs as USs has been reported to result in CRs that are the opposite of the URs (Siegel, 1983). For example, conditioning trials with morphine as the US produces increased sensitivity to painful stimuli as a response to the CS, and conditioning trials with tranquilizers like chlorpromazine as the US produces increased activity as a response to the CS. These data have been interpreted as indications of compensatory CRs, failures to identify accurately the actual US and/or UR when these drugs are administered (Donahoe & Palmer, 1994; Eikelboom & Stewart, 1982; Siegel, Baptista, Kim, McDonald, & Weise-Kelly, 2000). On one hand, these interpretations render this phenomenon consistent with current conditioning theories. On the other hand, regardless of interpretation, these data are inconsistent with a classical conditioning model of placebo effects. If increased pain sensitivity and activation are the CRs that are acquired when morphine and chlorpromazine are administered, then the pain-reducing effect of placebo morphine and the sedating effects of placebo tranquilizers cannot be CRs produced by the same mechanism. These data especially are important because the effects of placebo analgesics and tranquilizers are particularly well established.

In contrast, these data are not inconsistent with expectancy accounts of placebo effects because those effects are consistent with people's expectations. Most people expect morphine to reduce pain and tranquilizers to decrease activity, and the placebo effect is consistent with those expectations. Eikelboom and Stewart provided an account of how both mimetic and compensatory conditioned drug effects could arise from S–O mechanistic conditioning, but it also is possible that expectancy produces mimetic conditioned drug effects that are strong enough to override the conditioned effects of compensatory drug effects. In addition, expectancies can produce two conflicting response tendencies: an automatic mimetic response and a voluntary compensatory response. For example, in addition to an automatic response decrement, placebo alcohol can produce a voluntary compensatory response that is associated with the motivation to resist the expected deleterious effects, especially when the potential outcome is highly consequential (Vogel-Sprott & Fillmore, 1999).

Data Indicating Automatic Conditioning

Taken together, the data reviewed above provide clear evidence of cognitive mediation in both classical and operant conditioning. Other data, however, reveal conditioning phenomena that do not appear to be mediated cognitively. The data reviewed in this section seem to be explained more easily by automatic S–R processes and are consistent with a stimulus substitution model of conditioning (Pavlov, 1927).

Evaluative Conditioning

Evaluative conditioning occurs when a neutral conditional stimulus (CS) is paired with an affectively valenced, liked or disliked, unconditional stimulus (US) and results in a transfer of affect from the US to the CS (see Baeyens, Eelen, Crombez, & Van den Bergh, 1992). Two aspects of evaluative conditioning have been thought to distinguish it from traditional autonomic conditioning: (a) conditioning without awareness (Baeyens, Eelen, & Van den Bergh, 1990; Martin & Levey, 1978) and (b) resistance to extinction (Baeyens, Eelen, Van den Bergh, & Crombez, 1989). Although mechanistic interpretations of much of the evaluative conditioning literature have been challenged (e.g., Davey, 1994; Field & Davey, 1999; Lovibond & Shanks, 2002; Shanks & St John, 1994), studies of the evaluative conditioning of taste properties of odors (e.g., Stevenson, Prescott, & Boakes, 1995; Stevenson, Boakes, & Prescott, 1998) have yielded more convincing evidence of conditioning without awareness, leading Lovibond and Shanks to speculate that the gustatory system possesses special learning characteristics that operate outside of awareness. Studies of learning during anesthesia in nonhuman animals (e.g., Rabin & Rabin, 1984) also provided support for the possibility of learning without awareness.

S–R Persistence Following Devaluation

Recall that devaluation procedures were cited as support for a cognitive account of instrumental (as well as classical) conditioning. Specifically, devaluation of a stimulus that had been used to reinforce a particular response resulted in reduction of the response in simple (Dickinson, Nicholas, & Adams, 1983) and concurrent (Colwill & Rescorla, 1985a) schedules of reinforcement. However, the equally important observation that outcome devaluation does not always affect instrumental performance provides support for an S–R mechanistic interpretation of instrumental learning. When rats are trained on simple schedules of reinforcement, outcome devaluation reduces responding maintained on ratio, but not interval schedules of reinforcement (e.g., Dickinson et al., 1983). Thus, depending on the schedule of reinforcement, instrumental performance can be autonomous of its outcome. One explanation is that simple interval schedules fail to establish R–O associations because, unlike ratio schedules, the relationship between responding and rate of outcomes received is weak at moderate and high rates of responding (Dickinson, 1989). A seemingly contradictory finding is that interval schedules are effective in producing behaviors that are sensitive to outcome devaluation when they are used in concurrent schedules of reinforcement (Colwill & Rescorla, 1985a). Dickinson (1989) posited that the availability of different behaviors and their consequent outcomes in concurrent procedures provide the opportunity to learn strong response–outcome correlations. Thus, when there is sufficient opportunity to learn response–outcome correlations (e.g., simple ratio schedules and concurrent schedules), R–O associations control performance. However, when the response–outcome correlation is weak (e.g., simple interval schedules), S–R associations maintain performance.

Persistence following devaluation also has been observed in procedures that typically yield expectancy-based performance. Adams (1982) demonstrated that extended training on a ratio schedule renders outcome devaluation ineffective. Behavioral autonomy following extended practice appears not to be a result of the increase in the number of training reinforcers (Adams, 1982; Dickinson,1989), nor of simple repetition. Repetition of responding, for example, does not preclude expectancy-based performance when different behavior–outcome relationships are experienced in the same session (i.e., concurrent schedules; Colwill & Triola, 2002) or in alternating sessions (Colwill & Rescorla,

1985a; 1988). Dickinson (1989) had noted that the change from goal-directed expectancy to behavior that is autonomous of its outcomes might reflect changes in the response–outcome correlations that are experienced with extensive training in simple ratio schedules. Thus, the variability in rate of responding (and the consequent rate of reinforcement) that occurs early in training is reduced considerably with extended training (Dickinson, 1985). These observations suggest that, in the absence of consistent behavior–outcome correlations, instrumental performance is maintained by an S–R mechanistic process and is autonomous of the consequent outcomes.

Interestingly, a recent study suggests that behavioral autonomy from outcome status also can be observed in situations with consistent behavior–outcome correlations. Using the concurrent procedure, Dickinson, Wood, and Smith (2002) found that devaluation reduced instrumental performance when the outcome was food, but not when it was ethanol. This result is consistent with the view that alcohol-seeking behavior is maintained by S–R mechanistic habitual responding rather than goal-directed expectancy.

There also is evidence that cognitive and mechanistic processes can contribute to the same action. Although the response reduction after devaluation reported by Colwill and Rescorla (1985a, 1985b) strongly supports an explanation in terms of cognitive R–O associations, there are aspects of their data that are consistent with an S–R mechanistic interpretation. Devaluation of the reinforcing stimulus decreased the associated response, but it did not eliminate it altogether after brief or extended training. So why did the rats work at all to receive an outcome that had been devalued through taste aversion? A plausible explanation is that an S–R association maintained the residual responding (Colwill & Rescorla, 1985b; Dickinson, 1989; Nevin & Grace, 2000).

Resistance to Change and Excessive Behavior

Persistence of instrumental performance following outcome devaluation indicates that under some circumstances instrumental performance is resistant to post-conditioning changes in the consequent outcome. Resistance to change, or what Nevin has termed *behavioral momentum*, also is observed when response contingencies are altered in multiple schedules of reinforcement (e.g., Nevin & Grace, 2000). In this procedure, two or more schedules of reinforcement are correlated with distinctive stimuli. For example, responding is reinforced in the presence of one stimulus under a VI − 1 min schedule and in the presence of a second stimulus under a VI − 3 min schedule. The two stimulus–response–outcome contingencies are presented successively and separated by a brief time-out period. When noncontingent food is introduced in the time-out periods to disrupt performance, behavior under the richer schedule (VI − 1 min) is disrupted much less than behavior under the leaner schedule (VI − 3 min). This differential resistance to change also is observed when reinforcer value, rather than rate, is varied across stimulus situations. Nevin has shown that the overall rate of responding is determined by the response–outcome contingency, but resistance to change is determined by the overall rate of outcomes obtained in the stimulus situation (Nevin, Tota, Torquato, & Shull, 1990). The latter result was interpreted as indicating that resistance to change is modulated by a simple association between the discriminative stimulus (S^D) and the outcome. Good evidence for S^D–O associations come from transfer tests used to assess R–O associations (Colwill & Rescorla, 1988; Colwill & Triola, 2002). For example, an S^D present during one outcome will enhance performance of another response if it was trained with the same outcome, but not if it was trained with a different outcome. This result indicates that in instrumental conditioning procedures both R–O expectancy and simple S^D–O associations control instrumental performance (Colwill & Rescorla, 1988).

A dramatic example of the mechanistic control of behavior comes from studies demonstrating that a consistent history of intermittent delivery of reinforcers in a discriminative context (S^D) can generate bizarre and excessive (*adjunctive*) behavior in animals and humans (Falk, 1994). For example, when food-deprived rats are reinforced with food pellets on a fixed-interval schedule, they develop concurrent, excessive drinking (polydipsia). The consistent intermittency of food-pellet delivery is the important factor since schedule-induced drinking also occurs when the food is presented in the absence of an R–O contingency (i.e., a fixed time schedule). This procedure for producing chronic and excessive oral drug self-administration under strong stimulus control has been proposed as an animal model of drug abuse (e.g., Falk & Tang, 1988). Discriminative control of drug intake, whether it reflects resistance to change in the face of the disruptive effects of excessive drug use (Nevin & Grace, 2000) or schedule-induced self-administration (Falk & Tang, 1988), may be analogous to the phenomenon of relapse in humans. Relapse in recovering addicts is much more likely when drug abusers return to a situation previously associated with drug-taking behavior (Brownell, Marlatt, Lichtenstein, & Wilson, 1986) and is much less likely when drug users are removed suddenly from their drug-taking context to a radically different context. An example of the latter is that a very small percentage of soldiers who became addicted to heroin in Vietnam relapsed within three years of their return home (Robins, Helzer, Hesselbrock, & Wish, 1980; however, see Fish, 1998, for an alternative explanation).

Second-Order Conditioning

Evidence of S–R associations also is provided by studies of second-order conditioning procedures. In this procedure, animals are conditioned with standard pairings of a CS (e.g., a tone) and a US pairings (the first-order conditioning phase). In the next phase (the second-order conditioning phase), a second CS (e.g., light) is paired with the first-order CS that was conditioned in Phase 1, but with the US omitted. The result is that this second CS elicits CRs. A cognitive account explains the conditioning of the second-order light CS in much the same way it explained the sensory preconditioning experiment: After sufficient light–tone pairings, the light arouses a mental representation of the tone, which in turn arouses the expectation of a US, thereby generating a CR. However, unlike the sensory preconditioning results, an S–R association also can account for second-order conditioning; the second-order light CS may be conditioned as a result of contiguous pairings with the CR that was elicited by the tone CS. To differentiate these two accounts, Rizley and Rescorla (1972) extinguished responding to the tone after the second-order conditioning phase and subsequently presented the second-order light CS in a final test phase. The cognitive account predicts that extinction of the first-order tone CS should abolish responding to the second-order CS because the former should no longer arouse an expectancy of the US. The results failed to confirm this prediction, suggesting that the second-order conditioning, at least in this situation, was most likely a result of an association between the second-order CS and the CR elicited by the first-order CS. The ineffectiveness of US devaluation in reducing the CR-eliciting properties of second-order USs also provides evidence of S–R associations (Holland & Rescorla, 1975).

Conditioned Taste Aversions and Flavor Preferences

In the taste-aversion conditioning procedure, a taste stimulus (CS) is paired with a substance that produces gastrointestinal malaise (US). Because of this pairing, the subject

avoids consumption of the taste the next time it is encountered. Why? One explanation is that the taste is avoided because there is an expectation that consumption of the taste will cause gastrointestinal malaise (Rozin & Zellner, 1985). That is, behavior is guided by the information (danger) provided by the taste CS. An expectancy explanation of taste-aversion learning, however, does not account for the affective and hedonic changes that have been observed in humans and animals (Berridge, 2000). Pleasant tastes (e.g., sugar solutions) elicit positive affective facial and ingestive responses, but when paired with gastric malaise, there is a shift to negative defensive reactions (e.g., gaping and head shaking) that typically are seen with distasteful substances. In one study (Pelchat, Grill, Rozin, & Jacobs, 1983), a sweet taste was paired with treatments to produce upper-intestinal discomfort (LiCl toxicosis), lower-intestinal discomfort (lactose ingestion), or pain (electric shock). All three treatments led to avoidance of the taste stimulus, but only LiCl shifted the hedonic reaction to the taste stimuli from *like* to *dislike*. Whereas avoidance of the taste stimuli in the absence of shifts in hedonic quality may reflect an expectancy of the negative consequences of ingestion, the observed changed in the sensory evaluation of an initially preferred taste suggests an S–R automatic, noncognitive conditioning process (Rozin & Zellner, 1985).

Similar results have been observed in studies of conditioned flavor preferences. Rats learn to prefer a novel, mildly sweet flavor CS paired with intragastric infusions of nutrients (e.g., glucose) over another mildly sweet flavor CS paired with intragastric infusions of water (e.g., Drucker, Ackroff, & Sclafani, 1994). Evidence suggests that such conditioned flavor preferences sometimes reflect an increased positive hedonic value instead of an anticipation of the positive consequences of ingestion. For example, flavor preferences conditioned with intragastric nutrient infusion as a US are very resistant to extinction in both deprived and nondeprived animals (Drucker et al., 1988), enhance sham-feeding responses (Myers & Sclafani, 2001a), and shift taste reactivity toward responses typically seen with higher concentrations of sweet solutions (Myers & Sclafani, 2001b). However, as with conditioned taste aversions, not all conditioned flavor preferences appear to be mediated by changes in the hedonic properties of the flavors. When the CSs are initially unpalatable flavors rather than mildly sweet flavors, robust conditioned flavor preferences are not accompanied by enhanced positive hedonic reactions (Myers & Sclafani, in press). Together, these taste-aversion and flavor-preference studies suggest that the modulation of food choice through conditioning reflects two different processes—anticipation of the consequences of ingestion and a more mechanistic change in sensory evaluation (Rozin & Zellner, 1985; Myers & Sclafani, in press).

Conditioning with Subliminally Presented CSs

Additional evidence of automatic conditioning without awareness comes from experiments where the CSs are visual stimuli presented subliminally. Visual stimuli presented briefly (less than 300 msec) and immediately followed by a masking visual stimulus are not perceived consciously, yet are evaluated effectively as measured by explicit ratings or elicited autonomic responses. Words with extreme negative (e.g., *cancer*) or positive (e.g., *friend*) valence, when presented subliminally, elicit affective reactions that habituate with repeated subliminal presentations (Dijksterhuis & Smith, 2002). Phobic individuals presented with subliminal fear-relevant stimuli show increased electrodermal responses (Öhman & Soares, 1994). Because participants are not aware of visually masked stimuli if used as a CS in a Pavlovian conditioning paradigm and conditioned responding is observed, then conditioning will have occurred necessarily without the awareness of a

CS–US contingency. Several studies have reported conditioned responding to masked visual CSs despite lack of awareness of the CS or the CS–US contingency. For example, conditioned electrodermal responses have been observed when masked stimuli of *angry* faces or *threatening* animals were paired with an unpleasant shock US in nonphobic participants (Esteves, Parra, Dimberg, & Öhman, 1994; Öhman & Soares, 1998; Parra, Esteves, Flykt, & Öhman, 1997) . Masked stimuli that did not have an initial negative evaluation (e.g., pictures of a happy face or a flower), however, did not result in a conditioned electrodermal response (Öhman & Soares, 1998). Thus, it appears that automatic conditioning occurs only to preattentively perceived CSs that evoke some affective negative evaluation.

Conditioned Immunosuppression

Robert Ader (1985) conducted experiments that are procedurally similar to taste-aversion conditioning, but instead of conditioning a taste aversion, he conditioned immunosuppression. In this procedure, rats are allowed to consume a sweet tasting solution (CS) just before cyclophosphamide injections (US). The drug cyclophosphamide reduces the number of T-lymphocytes produced by the immune system of rats. When rats drink the taste CS in the absence of the drug, they show a reduced number of T-lymphocytes relative to control animals that received noncontingent pairings of the sweet taste and drug. The observation of conditioned immunosupression suggests that a normal, adaptive physiological function can be brought under control of an arbitrary stimulus such as a taste. It seems highly unlikely that rats could expect immunosupression or even have any representation of the phenomenon.

Conditioning in Simple Organisms

Evidence for automatic S–R associations also are provided by studies of conditioning in simple animals. For example, *Aplysia californica*, a large marine snail with a relatively simple nervous system of only a few hundred neurons, shows learned behavior in both classical and instrumental conditioning procedures (Carew, Hawkins, & Kandel, 1983). This simple invertebrate has an external gill that is withdrawn reflexively into a body cavity for protection. A mild tactile stimulus applied to tissue surrounding the gill produces little defensive gill withdrawal. However, after pairing this mild stimulus (CS) with a strong shock to the tail (US), the CS reliable elicits a robust gill-withdrawal response. It seems unlikely that an organism with such a simple nervous system would be capable of forming representations.

Conclusions

Data concerning two interpretations of classical and operant conditioning have been reviewed. One is the hypothesis that conditioning is an S–R mechanistic process in which expectancy and other cognitive factors are, at best, epiphenomena. From this perspective, conditioning trials produce conditional responses and perhaps expectancies, but there is no causal relation between expectancy and response. The other is cognitive theory, including S–O associations, according to which expectancy is hypothesized to mediate the effects of conditioning. From this perspective, conditioning trials produce expectancies, and it is the expectancy that produces the response.

Most traditional operant and classical conditioning phenomena can be explained by either S–R mechanistic or cognitive accounts (both simple S–O and higher order), and experiments that have been designed as critical tests of these rival hypotheses have yielded mixed results. On one hand, this review indicates abundant data disconfirming mechanistic S–R hypotheses and supporting cognitive interpretations in some situations. These data have led contemporary conditioning theorists to abandon earlier formulations in favor of approaches that are more consistent with cognitive theories. On the other hand, there are data indicating the occurrence in other situations of conditioned associations that are unlikely to be mediated cognitively. How can these data be reconciled?

Early debates about the nature of conditioning were based on the premise that it was exclusively either cognitive or mechanistic. A less parochial interpretation suggests that there are two types of conditioning processes, those that are mediated cognitively and those that are not. In addition, there appear to be learning processes that are not based on conditioning at all (e.g., learning by observation or through verbal communication). These aspects of the data suggest an unparsimonious proliferation of unconnected processes.

Conversely, there are data indicating important commonalities between conditioning and other forms of learning. Two examples of these are the informed-pairing and informed-unpairing studies reviewed by Brewer (1974). Participants in these studies who had been informed verbally about environmental contingencies behaved as they would have had they actually undergone conditioning or extinction trials. Similarly, verbally induced expectancies have been shown to produce patterns of responding that emulate various schedules of reinforcement (e.g., Wasserman & Shaklee, 1984). These data suggest a coordinated system of learning processes rather than a proliferation-independent learning mechanisms.

Cognition in complex organisms evolved from and incorporated more simple learning processes. Clearly, classical and operant conditioning of simple S–R associations are among the most basic processes. However, behavioral flexibility requires greater complexity. Thus, more complex organisms have evolved the ability to form representations (i.e., based on both R–O and S–O relationships) via conditioning procedures, as well as the ability to infer those relationships from other sources of information. It can be speculated that the more complex the organism, the smaller the role of automatic conditioning processes and the greater the role of representational cognition. This speculation is consistent with the data reviewed in this article showing that the provision of information generally overrides the effect of conditioning trials, especially in human participants, but also in laboratory animals.

Finally, the construct of *set* may bridge the apparent divide between automatic conditioning processes and representational cognitive processes. Simple S–R associations may be thought of as response sets. They are functionally anticipatory in that they prepare the organism for efficient automatic emission of the response when the appropriate stimulus conditions are encountered (Kirsch & Lynn, 1999). Similarly, S–O and R–O associations can be thought of as stimulus sets that prepare the organism to perceive environmental stimuli in particular ways. Examples include placebo effects and the effect of set on perceptions of ambiguous stimuli. Explicit expectancies are consciously accessible stimulus and response sets. Stimulus and response sets that are not consciously accessible could be thought of as implicit expectancies, although in doing so one might risk the danger that they could be reified gratuitously as a higher-level construct implying unconscious cognitions. Classical and operant conditioning are two of the means by which response sets are formed, but they also can be acquired vicariously though observation and through the provision of verbal information.

References

Adams, S.D. (1982). Variations in the sensitivity of instrumental responding to reinforcer devaluation. Quarterly Journal of Experimental Psychology, 3B, 77–98.

Ader, R. (1985). Conditioned taste aversions and immunopharmacology. Annals of the New York Academy of Sciences, 443, 293–307.

Ader, R., & Cohen, N. (1991). The influence of conditioning on immune responses. In R. Ader & D.L. Felten (Eds.), Psychoneuroimmunology (2nd ed., pp. 611–646). San Diego, CA: Academic.

Allan, L.G. (1993). Human contingency judgment: Rule-based or associative? Psychological Bulletin, 114, 435–448.

Allyon, T., & Azrin, N.H. (1968). The token economy: A motivation system for therapy and rehabilitation. New York: Appleton-Century-Crofts.

Arnold, H.M., Grahame, N.J., & Miller, R.R. (1991). Higher-order occasion setting. Animal Learning & Behavior, 19, 58–64.

Ayres, J.J., Haddad, C., & Albert, M. (1987). One-trial excitatory backward conditioning as assessed by conditioned suppression of licking in rats: Concurrent observations of lick suppression and defensive behaviors. Animal Learning & Behavior, 5, 212–217.

Baeyens, F., Eelen, P., Crombez, G., & Van den Bergh, O. (1992). Human evaluative conditioning: Acquisition trials, presentation schedule, evaluative style and contingency awareness. Behaviour Research and Therapy, 30, 133–142.

Baeyens, F., Eelen, P., & Van den Bergh, O. (1990). Contingency awareness in evaluative conditioning: A case for unaware affective-evaluative learning. Cognition and Emotion, 4, 3–18.

Baeyens, F., Eelen, P., Van den Bergh, O., & Crombez, G. (1989). Acquired affective evaluative value: Conservative but not unchangeable. Behaviour Research and Therapy, 27, 279–287.

Beck, E.C., & Doty, R.W. (1957). Conditioned flexion reflexes acquired during combined catalepsy and de-efferentiation. Journal of Comparative Physiological Psychology, 50, 211–216.

Berridge, K.C. (2000). Measuring hedonic impact in animals and infants: Microstructure of affective taste reactivity patterns. Neuroscience and Biobehavioral Reviews, 24, 173–198.

Blodgett, H.C. (1929). The effect of the introduction of reward upon the maze performance of rats. University of California Publications in Psychology, 4, 113–134.

Boakes, R.A. (1989). How one might find evidence for conditioning in adult humans. In T. Archer & L.G. Nilsson (Eds.), Aversion, avoidance and anxiety: Perspectives on learning and memory. England: Lawrence Erlbaum Associates.

Bolles, R.C. (1979). Learning theory (2nd ed.). New York: Holt, Rinehart & Winston.

Bouton, M.E., & King, D.A. (1983). Contextual control of the extinction of conditioned fear: Tests for the associative value of the context. Journal of Experimental Psychology: Animal Behavior Processes, 9, 248–265.

Brewer, W.F. (1974). There is no convincing evidence for operant or classical conditioning an adult humans. In W.B. Weimer & D.S. Palermo (Eds.), Cognition and the symbolic processes (pp. 1–42). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brownell, K.D., Marlatt, G.A., Lichtenstein, E., & Wilson, G.T. (1986). Understanding and preventing relapse. American Psychologist, 41, 765–782.

Carew, T.J., Hawkins, R.D., & Kandel, E.R. (1983). Differential classical conditioning of a defensive withdrawal reflex in Aplysiacalifornica. Science, 219, 397–420.

Colwill, R.M., & Rescorla, R.M. (1985a). Post-conditioning devaluation of a reinforcer affects instrumental responding. Journal of Experimental Psychology: Animal Behavior Processes, 11, 120–132.

Colwill, R.M., & Rescorla, R.A. (1985b). Instrumental responding remains sensitive to reinforcer devaluation after extensive training. Journal of Experimental Psychology: Animal Behavior Processes, 11, 520–536.

Colwill, R.M., & Rescorla, R.A. (1988). The role of response-reinforcer associations increases throughout extended instrumental training. Animal Learning & Behavior, 16, 105–111.

Colwill, R.M., & Triola, S.M. (2002). Instrumental responding remains under the control of the consequent outcome after extended training. Behavioural Processes, 57, 51–64.

Davey, G.C.L. (1994). Is evaluative conditioning a qualitatively distinct form of classical conditioning? Behaviour Research and Therapy, 32, 291–299.

Dickinson, A. (1985). Actions and habits: The development of behavioral autonomy. In L. Weiskrantz (Ed.), Animal intelligence (pp. 67–78). Oxford, UK: Clarendon Press.

Dickinson, A. (1989). Expectancy theory in animal conditioning. In S.B. Klein & R.R. Mowrer (Eds.), Contemporary learning theories: Pavlovian conditioning and the status of traditional learning theory (pp. 279–308). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dickinson, A., Nicholas, D.J., & Adams, C.D. (1983). The effect of the instrumental training contingency on susceptibility to reinforcer devaluation. Quarterly Journal of Experimental Psychology: Comparative & Physiological Psychology, 35(B), 35–51.

Dickinson, A., Wood, N., & Smith, J.W. (2002). Alcohol seeking by rats: Action or habit? Quarterly Journal of Experimental Psychology: Comparative & Physiological Psychology, 55B, 331–348.

Dijksterhuis, A., & Smith, P. (2002). Affective habituation: Subliminal exposure to extreme stimuli decreases their extremity. Emotion, 2, 203–214.

Donahoe, J.W., & Palmer, D.C. (1994). Learning and complex behavior. Boston: Allyn and Bacon.

Drucker, D.B., Ackroff, K., & Sclafani, A. (1994). Nutrient-conditioned flavor preference and acceptance in rats: Effects of deprivation state and nonreinforcement. Physiology and Behavior, 56, 701–707.

Eikelboom, R., & Stewart, J. (1982). Conditioning of drug-induced physiological responses. Psychological Review, 89, 507–528.

Esteves, F., Parra, C., Dimberg, U., & Öhman, A. (1994). Nonconscious associative learning: Pavlovian conditioning of skin conductance responses to masked fear-relevant facial stimuli. Psychophysiology, 31, 375–385.

Falk, J.L. (1994). Schedule-induced behavior occurs in humans: A reply to Overskeid. Psychological Record, 44(1), 45–62.

Falk, J.L., & Tang, M. (1988). What schedule-induced polydipsia can tell us about alcoholism. Alcoholism: Clinical & Experimental Research, 12, 577–585.

Field, A.P., & Davey, G.C.L. (1999). Reevaluating evaluative conditioning: A nonassociative explanation of conditioning effects in the visual evaluative conditioning paradigm. Journal of Experimental Psychology: Animal Behavior Processes, 25, 211–224.

Fish, J. (1998). How to legalize drugs. Northvale, NJ: Jason Aronson.

Gauthier, J.G., Laberge, B., Dufour, L., & Fevre, A. (1987, August). Therapeutic expectancies and exposure in the treatment of phobic anxiety. In S.L. Williams (Chair), Psychological mechanisms in performance based treatment of severe phobias. Symposium conducted at the meeting of the American Psychological Association, New York.

Girden, E. (1942). Generalized conditioned responses under curare and erythroidine. Journal of Experimental Psychology, 31, 105–119.

Haughton, E., & Ayllon, T. (1965). Production and elimination of symptomatic behavior. In L.P. Ullman & L. Krasner (Eds.), Case studies in behavior modification (pp. 94–98). New York: Holt, Rinehart & Winston.

Herrnstein, R.J. (1962). Placebo effect in the rat. Science, 138, 677–678.

Holland, P.C. (1977). Conditioned stimulus as a determinant of the form of the Pavlovian conditioned response. Journal of Experimental Psychology: Animal Behaviour Processes, 3, 77–104.

Holland, P.C. (1980). CS-US interval as a determinant of the form of Pavlovian appetitive conditioned responses. Journal of Experimental Psychology: Animal Behavior Processes, 6, 155–174.

Holland, P.C., & Rescorla, R.A. (1975). The effect of two ways of devaluing the unconditioned stimulus after first- and second-order appetitive conditioning. Journal of Experimental Psychology: Animal Behavior Processes, 1(4), 355–363.

Holloway, K.S., & Domjan, M. (1993). Sexual approach conditioning: Tests of unconditioned stimulus devaluation using hormone manipulations. Journal of Experimental Psychology: Animal Behavior Processes, 19, 47–55.

Hull, C.L. (1943). Principles of behavior. New York: Appleton-Century-Croft.

Jones, M.C. (1924). A laboratory study of fear: The case of Peter. Pedagogical Seminar, 31, 308–315.

Kamin, L.J. (1969). Predictability, surprise, attention, and conditioning. In B.A. Campbell & R.M. Church (Eds.), Punishment and aversive behavior (pp. 279–296). New York: Appleton-Century-Crofts.

Kellogg, W.N., Scott, V.B., Davis, R.C., & Wolf, I.S. (1940). Is movement necessary for learning. Journal of Comparative Psychology, 29, 43–74.

Kirsch, I., & Henry, D. (1977). Extinction versus credibility in the desensitization of speech anxiety. Journal of Consulting and Clinical Psychology, 45(6), 1052–1059.

Kirsch, I., & Lynn, S.J. (1999). Automaticity in clinical psychology. American Psychologist, 54, 504–515.

Krechevsky, I. (1932). "Hypotheses" in rats. Psychological Review, 39, 516–532.

Krech, D., & Crutchfield, R.S. (1948). Theory and problems of social psychology. New York: McGraw-Hill.

Kuhn, T.S. (1970). The structure of scientific revolutions (2nd ed.). Chicago: University of Chicago Press.

López, F.J., Shanks, D.R., Almaraz, J., & Fernández, P. (1998). Effects of trial order on contingency judgments: A comparison of associative and probabilistic contrast models. Journal of Experimental Psychology: Learning, Memory, and Cognition, 24, 672–694.

Lovibond, P.F., & Shanks, D.R. (2002). The role of awareness in Pavlovian conditioning: Empirical evidence and theoretical implications. Journal of Experimental Psychology: Animal Behavior Processes, 28, 3–26.

Mahoney, W.J., & Ayres, J.J. (1976). One-trial simultaneous and backward fear conditioning as reflected in conditioned suppression of licking in rats. Animal Learning & Behavior, 4, 357–362.

Manns, J.R., Clark, R.E., & Squire, L.R. (2002). Single-cue delay eyeblink conditioning is unrelated to awareness. Cognitive, Affective and Behavioral Neuroscience, 1, 192–198.

Martin, I., & Levey, A.B. (1978). Evaluative conditioning. Advances in Behaviour Research and Therapy, 1, 57–102.

Matzel, L.D., Brown, A.M., & Miller, R.R. (1987). Associative effects of US preexposure: Modulation of conditioned responding by an excitatory training context. Journal of Experimental Psychology: Animal Behavior Processes, 13, 65–72.

McNamara, H.J., Long, J.B., & Wilke, E.K. (1956). Learning without response under two conditions of external cues. Journal of Comparative Physiology and Psychology, 49, 477–480.

Miller, R.R., & Barnet, R.C. (1993). The role of time in elementary associations. Current Directions in Psychological Science, 2, 106–111.

Miller, R.R., & Escobar, M. (2001). Contrasting acquisition-focused and performance-focused models of behavior change. Current Directions in Psychological Science, 10, 141–145.

Miller, R.R., & Matzel, L.D. (1988). The comparator hypothesis: A response rule for the expression of associations. In G.H. Bower (Ed.), The psychology of learning and motivation (pp. 51–92). San Diego, CA: Academic.

Miller, R.R., & Oberling, P. (1998). Analogies between occasion setting and Pavlovian conditioning. In N.A. Schmajuk & P.C. Holland (Eds.), Occasion setting: Associative learning and cognition in animals (pp. 3–35). Washington, DC: American Psychological Association.

Montgomery, G.H., & Kirsch, I. (1997). Classical conditioning and the placebo effect. Pain, 72, 107–113.

Morris, J.S., Ohman, A., & Dolan, R.J. (1998). Conscious and unconscious emotional learning in the human amygdala. Nature, 393, 467–470.

Myers, K.P., & Sclafani, A. (2001a). Conditioned enhancement of flavor evaluation reinforced by intragastric glucose: I. Intake acceptance and preference analysis. Physiology & Behavior, 74, 481–493.

Myers, K.P., & Sclafani, A. (2001b). Conditioned enhancement of flavor evaluation reinforced by intragastric glucose: II. Taste reactivity analysis. Physiology & Behavior, 74, 495–505.

Myers, K.P., & Sclafani, A. (in press). Conditioned acceptance and preference but not altered taste reactivity responses to bitter and sour flavors paired with intragastric glucose infusion. Physiology & Behavior.

Neuringer, A. (2002). Operant variability: Evidence, functions, and theory. Psychonomic Bulletin & Review, 9, 672–705.

Nevin, J.A., & Grace, R.C. (2000). Behavioral momentum and the Law of Effect. Behavioral & Brain Sciences, 23, 73–130.

Nevin, J.A., Tota, M.E., Torquato, R.D., & Shull, R.L. (1990). Alternative reinforcement increases resistance to change: Pavlovian or operant contingencies? Journal of the Experimental Analysis of Behavior, 53(3), 359–379.

Öhman, A., & Soares, J.J.F. (1994). Unconscious anxiety: Phobic responses to masked stimuli. Journal of Abnormal Psychology, 103, 231–240.

Öhman, A., & Soares, J.J.F. (1998). Emotional conditioning to masked stimuli: Expectancies for aversive outcomes following nonrecognized fear-relevant stimuli. Journal of Experimental Psychology: General, 127, 69–82.

Parra, C., Esteves, F., Flykt, A., & Öhman, A. (1997). Pavlovian conditioning to social stimuli: Backward masking and the dissociation of implicit and explicit cognitive processes. European Psychologist, 2, 106–117.

Pavlov, I.P. (1927). Conditioned reflexes. New York: Live-right.

Pelchat, M.L., Grill, H.J., Rozin, P., & Jacobs, J. (1983). Quality of acquired responses to tastes by Rattus norvegicus depends on type of associated discomfort. Journal of Comparative Psychology, 97(2), 140–153.

Rabin, B.M., & Rabin, J.S. (1984). Acquisition of radiation and lithium chloride-induced conditioned taste aversions in anesthetized rats. Animal Learning and Behavior, 12, 439–441.

Randich, A., & LoLordo, V.M. (1979). Associative and nonassociative theories of the UCS pre-exposure phenomenon: Implications for Pavlovian conditioning. Psychological Bulletin, 86, 523–548.

Rescorla, R.A. (1968). Probability of shock in the presence and absence of cs in fear conditioning. Journal of Comparative & Physiological Psychology, 66, 1–5.

Rescorla, R.A. (1988). Pavlovian conditioning: It's not what you think it is. American Psychologist, 16, 151–160.

Rescorla, R.A. (1991). Associative relations in instrumental learning: The eighteenth Bartlett memorial lecture. Quarterly Journal of Experimental Psychology, 43B, 1–23.

Rescorla, R.A., & Wagner, A.R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A.H. Black & W.F. Prokasy (Eds.), Classical conditioning II: Current research and theory (pp. 64–99). New York: Appleton-Century-Crofts.

Rizley, R.C., & Rescorla, R.A. (1972). Associations in second-order conditioning and sensory preconditioning. Journal of Comparative & Physiological Psychology, 81, 1–11.

Robins, L.N., Helzer, J.E., Hesselbrock, M., & Wish, E. (1980). Vietnam veterans three years after Vietnam: How our study changed our view of heroin. In L. Brill & C. Winick (Eds.), The yearbook of substance use and abuse (pp. 213–230). New York: Human Sciences Press.

Ross, R.T., & Holland, P.C. (1981). Conditioning of simultaneous and serial feature-positive discriminations. Animal Learning & Behavior, 9, 293–303.

Rotter, J.B. (1954). Social learning and clinical psychology. New York: Prentice-Hall.

Rotter, J.B., Fitzgerald, B.J., & Joyce, J.N. (1954). A comparison of some objective measures of expectancy. Journal of Abnormal and Social Psychology, 49, 111–114.

Rozin, P., & Zellner, D. (1985). The role of Pavlovian conditioning in the acquisition of food likes and dislikes. Annals of the New York Academy of Sciences, 443, 189–202.

Schacter, D.L. (1987). Implicit memory: History and current status. Journal of Experimental Psychology: Learning, Memory, and Cognition, 134, 501–518.

Schmajuk, N.A., & Holland, P.C. (Eds.). (1998). Occasion setting: Associative learning and cognition in animals. Washington, DC: American Psychological Association.

Shanks, D.R., & St. John, M.F. (1994). Characteristics of dissociable human learning systems. Behavioral and Brain Sciences, 17, 367–447.

Siegel, S. (1983). Classic conditioning, drug tolerance, and drug dependence. In R.G. Smart, F.B. Glaser, Y. Israel, H. Kalant, R.E. Popham, & W. Schmidt (Eds.), Research advances in alcohol and drug problems, Vol. 7 (pp. 207–246). New York: Plenum.

Siegel, S., Baptista, M.A.S., Kim, J.A., McDonald, R.V., & Weise-Kelly, L. (2000). Pavlovian psychopharmacology: The associative basis of tolerance. Experimental and Clinical Psychopharmacology, 8, 276–293.

Skinner, B.F. (1953). Science and human behavior. New York: Macmillan.

Southworth, S., & Kirsch, I. (1988). The role of expectancy in exposure-generated fear reduction in agoraphobia. Behaviour Research and Therapy, 26, 113–120.

Stevenson, R.J., Boakes, R.A., & Prescott, J. (1998). Changes in odor sweetness resulting from implicit learning of a simultaneous odor-sweetness association: An example of learned synesthesia. Learning and Motivation, 29, 113–132.

Stevenson, R.J., Prescott, J., & Boakes, R.A. (1995). The acquisition of taste properties by odors. Learning and Motivation, 26, 433–455.

Thistlewaite, D. (1951). An experimental test of the reinforcement interpretation of latent learning. Journal of Comparative and Physiological Psychology, 44, 431–444.

Timberlake, W., & Lucas, G.A. (1989). Behavioral systems and learning: From misbehavior to general principles. In S.B. Klein & R.R. Mowrer (Eds.), Contemporary learning theory: Instrumental conditioning theory and the impact of biological constraints on learning (pp. 237–275). Hillsdale, NJ: Erlbaum.

Tolman, E.C. (1932). Purposive behavior in animals and men. New York: Century.

Tolman, E.C. (1939). Prediction of vicarious trial and error by means of the schematic sowbug. Psychological Review, 46, 318–336.

Tolman, E.C. (1948). Cognitive maps in rats and men. Psychological Review, 55, 189–208.

Tolman, E.C., & Honzik, C.H. (1930). Introduction and removal of reward, and maze performance in rats. University of California Publications in Psychology, 4, 257–275.

Tolman, E.C., Ritchie, B.F., & Kalish, D. (1946). Studies in spatial learning. I. Orientation and the short-cut. Journal of Experimental Psychology, 36, 13–24.

Vogel-Sprott, M., & Fillmore, M.T. (1999). Expectancy and behavioral effects of socially used drugs. In I. Kirsch (Ed.), How expectancies shape experience (pp. 215–232). Washington, DC: American Psychological Association.

Voudouris, N.J., Peck, C.L., & Coleman, G. (1985). Conditioned placebo responses. Journal of Personality and Social Psychology, 48, 47–53.

Voudouris, N.J., Peck, C.L., & Coleman, G. (1989). Conditioned response models of placebo phenomena: Further support. Pain, 38, 109–116.

Voudouris, N.J., Peck, C.L., & Coleman, G. (1990). The role of conditioning and verbal expectancy in the placebo response. Pain, 43, 121–128.

Wasserman, E.A., & Shaklee, H. (1984). Judging response-outcome relations: The role of response-outcome contingency, outcome probability, and method of information presentation. Memory & Cognition, 12, 270–286.

Watson, J.B. (1913). Psychology as the behaviorist views it. Psychological Review, 20, 158–177.

Watson, J.B., & Rayner, R. (1920). Conditioned emotional reactions. Journal of Experimental Psychology, 3, 1–14.

Wickramasekera, I. (1980). A conditioned response model of the placebo effect: Predictions from the model. Biofeedback and Self Regulation, 5, 5–18.

Weins, S., & Öhman, A. (2002). Unawareness is more than a chance event. Comment on Lovibond & Shanks (2002). Journal of Experimental Psychology: Animal Behavior Processes, 28, 27–31.

Wolpe, J. (1958). Psychotherapy by reciprocal inhibition. Stanford, CA: Stanford University Press.