Social and Associative Learning

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Abstract

It has been assumed that the formation of S-R links, whereby stimuli previously experienced contiguously with the execution of a response come to elicit that response, is either sufficient to explain social learning, or, particularly in the case of observational learning, that it is inadequate to do so. Contemporary learning theory conceives of learning rather differently; as the formation and association of mental representation. It is argued in this thesis that the problems which affected learning theory in the behaviourist era, and those which arise in trying to understand social learning, are similar. Therefore, it is reasoned, social learning theory might escape its difficulties by understanding learning to involve the cognitive processes that contemporary associative learning theory proposes.

The purpose of the empirical work in this thesis was to develop paradigms to investigate the extent to which social learning can be encompassed by contemporary associative learning theory. In particular, procedures were designed to expose observers to the conditions necessary for learning in isolated animals, and it was assumed that if social learning effects depend on these same conditions, it would suggest that they are mediated by the same associative mechanisms. In particular, evidence was sought that, like asocial learning, social learning is: 1) contingency dependent (Chapter 3); 2) subject to blocking and overshadowing (Chapter 4); 3) sensitive to both S-S and R-O relationships (Chapter 5); and 4) subject to the effects of stimulus pre-exposure (Chapter 6). In each case, the associative predictions were, to an extent, supported. However, it is concluded that in order to establish whether a particular socially learned behaviour is controlled by an associative structure involving mental representations, additional experiments are required to rule out S-R learning.

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Chapter 1

Implications of a Contemporary Learning Theory for Social Learning.

1. Introduction

Classical reflex theory states that because behaviour is the external manifestation of the functioning brain, the mind can be analyzed as a set of responses to stimuli. The output response being automatically triggered by the input stimulus (Sechenov, 1866). Although a descendent of classical reflex theory, contemporary learning theory is more modest in its aspirations, and no longer claims to provide an exhaustive account of how the mind functions. Consistent with this, perhaps, in recent papers it has been questioned whether learning theory can explain how an animal learns in situations where learning is influenced by the observation of a conspecific (Galef, 1990). Galef argues that social learning could benefit from the "rigour and sophistication" of the methodology of learning theory. However, he reasons that the mechanisms that are postulated by a general learning theory are inadequate "for determining what animals could learn socially or how social learning proceeded", because, according to Galef, much of what an animal learns is species- and situation-specific. This chapter attempts to establish both the utility and the validity of a learning theoretic analysis of social learning.

Unlike classical reflex theory, contemporary learning theory differentiates types of associative learning, and asserts that associative learning involves the acquisition of information and is mediated by psychological mechanisms that are not directly observable in behaviour (Mackintosh, 1983). The first section of this chapter describes the varieties of learning that are postulated by learning theory and social learning theory. It is argued that because social learning researchers have accepted only that there are varieties of learning, and not that learning is 'cognitive', i.e., involves the acquisition of information, it is behaviourism and not contemporary learning theory that has been applied in the analysis of social learning to date.

An attempt is then made to provide a stronger justification for a learning theoretic analysis of social learning, by considering some of the ramifications of cognitivism for the study of learning (discussed in Mackintosh, 1983). It will be argued that many of the problems that faced a pre-cognitive, S-R learning theory, are those which arise in trying to understand social learning. Therefore, the success of cognitivism in explicating difficulties encountered by a behaviouristic analysis of individual learning, provides encouragement for the view that it will be similarly useful in the analysis of social learning.

Chapter 2 begins to address the question of whether there is any empirical evidence that social learning is associative. Data from the existing social learning literature are examined to see whether, in the course of their behaviourist analysis, researchers have inadvertently provided evidence to support a contemporary associative learning theoretic account of social learning. While accepting the limitations of this kind of *post hoc* analysis, it is argued that the existence of patterns of data characteristic of the operation of an associative mechanism, suggest the validity of an associative social learning theory.

Chapters 3-6 report original experiments which sought evidence for some of the characteristic effects of an associative mechanism on socially learned behaviour. The experiments in Chapter 3 used a truly random control procedure (Rescorla, 1967) to examine whether, like individual learning, information about events that are contingently related is acquired socially. Chapter 4 investigated whether information that is acquired socially is subject to the principle of relative validity, a known determinant of asocial (or 'individual') learning (Wagner, 1969). According to the principle of relative validity, an observer would be expected to learn about a good predictor of an outcome at the expense of a poor predictor. The two lever/two action procedure used in Chapter 5 had two purposes. First, to provide robust effects of observational conditioning and observational learning, and, second, to investigate the conditions which selectively favour observational conditioning and observational learning. The experiments in Chapter 6 sought to verify parallelism between social and asocial learning by showing that pre-exposure to a stimulus in a social context will retard subsequent conditioning to that stimulus (Lubow, 1973).

1.1 Types of learning

1.1.1 Varieties of Conditioning

A shock administered to a dog's paw will automatically elicit a flexion response. Limb flexion is a pre-wired, or unconditioned response (UR) triggered by a motivationally significant stimulus, a shock (unconditioned stimulus, or US). If, on a sufficient number of occasions, the shock administered to the dog's paw is preceded by the sound of a buzzer (conditioned stimulus or CS), the dog will come to flex its paw when it hears the buzzer, and before the shock has been delivered. The flexion response to the buzzer is called a conditioned response (CR).

Early investigators of conditioning, such as Pavlov (1927) and Thorndike (1911), thought that all conditioned behaviour could be accounted for in terms of connections between stimuli and responses, S-R links. However, their accounts of the conditions necessary for S-R links to be formed were different.

Pavlov believed that as a consequence of the correlation between the buzzer and shock presentations, the buzzer comes to substitute for the shock and thereby elicits paw flexion, the initial UR to shock. According to this view, temporal contiguity between a stimulus and a response is a sufficient condition for conditioning.

Thorndike's law of effect (Thorndike, 1911) explains all conditioning as the strengthening of new responses by their consequences. For example, if a rat's lever press response is rewarded with food, an S-R link between the sight of the lever and lever-pressing is formed as a result of a combination of contiguity between S and R, and the strengthening action of a subsequent reinforcing event on the response that precedes it.

Unlike his predecessors, Skinner (1938) recognised the need for both a principle of contiguity and the law of effect, each being sufficient for conditioning. That is, Skinner distinguished between two types of conditioning, one reliant on contiguity, the other on the law of effect.

1.1.2 Varieties of social learning

A typical social learning experiment might involve the exposure of an 'observer' animal to a conspecific 'demonstrator' that is earning food by lever-pressing (e.g. Huang, Koski and DeQuardo, 1983). Subsequently the observer is given access to the lever, and an assessment is made of the degree to which its behaviour matches that of its demonstrator. A social learning effect would have been found if, in comparison with a control animal that has been confined to the apparatus prior to the test without a demonstrator present, the observer makes a greater number of lever-press responses.

The principal aim of social learning research has been to investigate whether, and under what circumstances, the observer's behaviour corresponds to that of the demonstrator's because of imitation. That is, its purpose has been to show whether an observer can learn through observation of the response, to make the response (Thorndike, 1898).

Implicit in the requirement that observational learning (imitation) only be inferred from matching behaviour if the demonstrator's behaviour constituted the critical input for that learning, is the assumption that some other input could also have been sufficient to generate matching behaviour. The varieties of other potential inputs have been used to distinguish types of social learning (for exhaustive reviews of putative categories of social learning, see Galef, 1988; and Heyes, 1994).

Taking again the example of one animal observing another press a lever for food reward, if the observer animal learned to press the lever faster than the control animal because the demonstrator's lever-pressing behaviour had increased the observer's exposure to the lever, this would be an example of local enhancement (Spence, 1937). In the case of matching behaviour generated by local enhancement, the observer does not learn about the demonstrator's behaviour *per se*. Rather, behaviour ordinarily elicited by the sight of a stimulus, in this case a lever, is released sooner in an observer because of a socially induced increase in exposure to the eliciting stimulus.

Cook, Mineka, Wolkenstein and Laitsch (1985) have proposed observational conditioning as an additional distinct category of social learning. Observational conditioning is understood to be a social analogue of Pavlovian conditioning, in which the demonstrator's behaviour constitutes a US eliciting a matching response from the observer. If, on a sufficient number of occasions, the observer's UR is released contiguously with the presentation of a CS, this CS becomes capable of eliciting a CR similar in form to the UR.

Thus, it has been suggested in the literature on social learning that exposure to the behaviour of another animal can result in; 1) earlier elicitation of behaviour (local enhancement), 2) unconditional elicitation of a matching response (observational conditioning), and 3) acquisition *de novo* of the response observed (imitation or observational learning).

I want to emphasize three influences that are apparent in theories of social learning, but which are rejected by contemporary learning theory because of its shift to cognitivism. They are the influences of psychological behaviourism, positivism, and S-R theorising.

In accordance with psychological behaviourism, socially acquired behaviour, not information, has been the explanandum for social learning research. In particular, the aim has been to explain the occurrence of matching behaviour, i.e., the behaviour produced by an observer which resembles the behaviour of its demonstrator (Heyes, 1994). The positivist influence is evident in the kind of research programme that has been developed. Investigations of matching behaviour have tried to isolate its necessary and sufficient conditions (Zentall, 1996). The various inputs (discussed earlier) proposed as sufficient causes for matching behaviour define the types of social learning thought to occur. To identify a category of social learning empirically, all other sufficient inputs for matching behaviour must be eliminated (Zentall, 1996). Thus, the production of matching behaviour would, for example, be classified as imitative if it could not have resulted from observational conditioning or local enhancement (Zentall, 1996). To account for the development of matching behaviour, it has been assumed that the various social inputs generate responses in the observer which become linked to occurrent stimuli, i.e., S-R links are formed. By virtue of these S-R links, when the stimulus is re-encountered it elicits the response. In the case of observational conditioning, stimuli present at the time of conditioning come to control responses that were initially elicited unconditionally by some aspect of the demonstrators' behaviour (Mineka and Cook, 1988). With imitation, behaviour is said to be acquired directly (Thorndike, 1911).

Some researchers have claimed that, in the case of observational learning, cognitive processing of some kind is required. Tomasello (1996), and Whiten and Ham (1992) believe that only animals capable of representing the beliefs and desires of a demonstrator could imitate its action. However, even in these cases where the psychological theorising about imitation has been cognitive, the research programme has remained a positivist one; types of social learning are identified using an eliminitivist strategy (Byrne and Tomasello, 1995; Zentall, 1996). Thus, for example, Byrne and Tomasello (1995) suggest that matching behaviour is evidence for imitative learning if it has been generated by a procedure that eliminates the conditions necessary for social stimulus learning.

1.2 Cognitivism and theories of learning

1.2.1 A cognitive account of learning

When an animal learns to press a lever for food, or to flex its leg in response to a buzzer that has been followed by a shock to its paw, it is possible to describe this as the animal learning to perform a new response in a novel situation. The cognitive reappraisal of learning has been driven by the failure of this S-R description of learning to account for certain empirical phenomena. S-R theory cannot, for example, readily explain behaviourally silent learning (Dickinson, 1980).

For example, using a sensory preconditioning procedure, Rizley and Rescorla (1972) repeatedly presented rats with a tone that consistently preceded the illumination of a light. As neither the tone nor the light elicited any significant change in behaviour, at this stage there was no evidence of learning. However, the subsequent introduction of a powerful US, a shock, which regularly followed the light, ensured that behaviour during the light changed. The rats came to freeze and suppress any ongoing responding in the presence of the light. The problem for an S-R theory of learning is the animals' behaviour when the tone, which had never itself been correlated with the shock, was presented. Despite no alteration in the rats' behaviour as a result of the pairings of the light and tone, which, according to behaviourism, equates to their having failed to learn, the suppression in their responding during the tone shows the rats to be frightened of it.

A cognitive account of learning treats changes in behaviour not as learning itself, but as an index of learning. As a result of exposing an animal to a contingent relationship between two events, or between its behaviour and an outcome, a novel mental structure is formed which reflects those relationships. Changes in behaviour indicate learning, but are not themselves learning. By forging a distinction between learning and performance in this way, cognitive learning theory can encompass behaviourally silent learning. The absence of behaviour change is not synonymous with the absence of learning.

A cognitive understanding of Pavlovian conditioning would suggest that through exposure to a contingent relationship between a CS and a US (an S-S association), the CS comes to elicit some central representation of the US. The activation of this US representation elicits the response. A cognitive account of instrumental conditioning proposes that what is represented is the relationship between a response, and an outcome which is contingent upon that response (an R-O association) (Dickinson, 1980; Mackintosh, 1983).

1.2.2 A cognitive social learning theory

Heyes (1994) showed that the phenomena of social learning can be subsumed within the categorisation scheme used for individual learning. Types of asocial learning are individuated according to the conditions which foster learning (Rescorla, 1988). Thus, for a social learning process to be an analogue of an asocial type, it must, according to this principle of classification, occur under similar conditions. Because the mechanisms of learning are inferred from the conditions of learning, the fact that social and asocial learning phenomena resemble each other in their conditions of occurrence, suggests that the same mechanisms are operating in the social and asocial cases. Hence, because the mechanisms of asocial learning are psychological, cognitivism is introduced into social learning theory.

In particular, Heyes suggested that observational learning is a subset of instrumental learning, where the observer learns about the demonstrator's behaviour and its consequences. In observational conditioning, the social counterpart of Pavlovian conditioning, the demonstrator's behaviour plays some part in exposing the observer to an S-S relationship.

1.3 Implications of a cognitive account of learning for learning theory and social learning research

The reappraisal of learning as a cognitive process has had many implications for learning theory. This section explores some of those implications, and their consequences for the analysis of social learning. It will be suggested that conceiving of learning as a process of information acquisition provides a means of categorising social learning, such that examples of each category can be identified empirically. These arguments do not, of course, obviate the need for empirical study to validate a contemporary learning theoretic analysis of social learning. But if the arguments in this chapter are valid, and contemporary learning theory can inform a methodology to demonstrate the effects of imitation, its utility will have been established.

1.3.1 The distinction between learning and performance and the importance of Pavlovian conditioning

a) Consequences for learning theory

When Skinner (1937) made the distinction between Pavlovian and instrumental conditioning, he did not think they were equally important. Instrumental conditioning had an obvious adaptive function; an animal would only repeat actions with favourable outcomes. Like his contemporaries, Skinner thought that Pavlovian conditioning could not confer the same kind of behavioural flexibility as instrumental conditioning. Conditioning according to a principle of contiguity is restricted to responses that are automatically and reliably elicited by a US. Temporal contiguity ensures that a CS comes to elicit the response which was initially a UR to a US. Thus, an animal learns to salivate in response to a light that has been followed by a US such as food, for which salivation is the UR.

From a cognitive perspective, salivation that occurs in response to a light that signals food evidences learning, but is not learning per se. Any systematic change in behaviour that results from exposure to a contingent relationship between events is indicative of learning, and may be described as a CR.

Two studies by Brown and Jenkins (1968) and Hearst and Jenkins (1974) demonstrated autoshaping, and, thereby confirmed the cognitivist expectation that exposure to stimulus relationships would result in CRs in addition to those which resemble the form of the original US. Brown and Jenkins (1968) showed that key-pecking by pigeons, which until this point had been assumed to be a definitively instrumental response, could, in fact, be established by a contingent relationship between the illumination of a key-light and food. Pavlovian conditioning was encroaching on territory traditionally occupied by instrumental conditioning. Hearst and Jenkins (1974) showed that the pigeon's key-peck response would develop in response to key-light and food pairings, even when the site of food delivery and key-light were separated by three feet. Through pairings with an appetitive food event, the key-light CS came to control the birds' approach behaviour. These data suggest that Pavlovian conditioning can control approach and avoidance behaviour to stimuli, dependent on whether they signal favourable or harmful outcomes. Thereby, the phenomenon of autoshaping established Pavlovian conditioning as a process with pervasive and adaptive influence.

b) Implications for the study of social learning

Social learning research has had as an almost exclusive goal the demonstration of an imitative ability in animals (Galef, 1988; Heyes, 1994; Zentall, 1996). Although many social learning phenomena may be construed as observational conditioning (see Chapter 2, section 2.2.3), the role of this social analogue of Pavlovian conditioning has been investigated explicitly only with reference to the social learning of fear in monkeys (Mineka and Cook, 1988). Acknowledging the behavioural flexibility which a capacity for Pavlovian conditioning confers would suggest that observational conditioning is a functionally significant category of social learning, and, therefore, deserving of more thorough empirical investigation.

Furthermore, the pervasive influence of Pavlovian conditioning would suggest caution in interpreting as imitative, any example of socially learned behaviour for which the effects of observational conditioning have not been controlled. For example, Palameta and Lefebvre (1985) showed that pigeons exposed to a conspecific piercing a red spot on a covered food cup to gain access to grain, will, when presented with an intact cover, pierce the food cover faster than pigeons who have seen a conspecific pierce but not eat, or eat but not pierce. Palameta and Lefebvre suggested that the facilitated learning shown by the piercing and eating observers was the result of imitation. That is, that the observers acquired the piercing behaviour through observation of the models exhibiting that behaviour. However, in addition to the relationship between key-pecking and food, observers of pecking and eating demonstrators were exposed to a purely Pavlovian relationship between the red spot and the grain. Therefore, it is possible that Palameta and Lefebrve observed a social form of autoshaping; that it was the Pavlovian relationship which was responsible for the observers' matching behaviour.

Finally, if, as the cognitive hypothesis suggests, an animal learns about event relationships, then social learning, like individual learning, might be expected to result in changes in behaviour across many response systems. In this case, it might be profitable to regard matching behaviour as one possible index of social learning, not as definitive of social learning.

1.3.2. The distinction between what the animal learns and what the experimenter arranges

a) Consequences for learning theory

Procedurally, Pavlovian and instrumental conditioning involve distinct reinforcement contingencies. In the former case, the experimenter arranges for an outcome to correlate with the occurrence of a preceding stimulus. In an instrumental procedure, the experimenter delivers a reinforcer every time an animal makes a designated response. Theoretically, if a change in behaviour is the consequence of learning about the correlation between events, then it is the result of Pavlovian conditioning. Instrumentally conditioned behaviour relies on learning about the relationship between a response and its outcome (Dickinson, 1980; Mackintosh, 1983).

The phenomenon of autoshaping (Brown and Jenkins, 1968) gave cause to question whether the contingencies operationalised by the experimenter were necessarily those responsible for the resulting conditioned behaviour. Subsequent experiments have confirmed that the conditioned behaviour generated by some instrumental procedures is, in fact, due to the contingency between stimuli. Thus, procedural definitions of conditioning do not automatically map on to their theoretical counterparts. For example, Moore (1973) demonstrated that a pigeon's key-peck response, generated when key-peck behaviour is reinforced, develops because of the contingency between the key-light and food, rather than the contingency between key-pecking and food. Similarly, Bolles, Holtz, Dunn and Hill (1980) found that rats' reluctance to press a lever following response contingent shocks could be accounted for in terms of what the animals' had learned about the lever, rather than about the response performed on that lever. The rats avoided the place where shocks had been delivered, and consequently there was a decrement in responding to the lever in that vicinity.

Cases in which an instrumental procedure gives rise to classical conditioning (exemplified by Moore (1973) and Bolles et al (1980)) are unlikely to be rare. It had become apparent that every instrumental contingency has embedded within it a classical relationship between stimuli, and therefore in no circumstance is it possible simply to assume that procedural definitions of conditioning match the causally effective contingency. Instead, it is necessary to use experimental manipulations such as Grindley's bidirectional control procedure to distinguish Pavlovian and instrumental conditioning empirically (Grindley, 1932). Grindley trained harnessed guinea pigs to turn their heads either to the left, or the right when a buzzer sounded. The experiment was procedurally instrumental: head turns in the correct direction earned the guinea pigs a bite of carrot. However, because head turning was contiguous with the sound of the buzzer, it was possible that the behaviour of the guinea pigs was in fact controlled by this Pavlovian contingency. To establish that, in this case, the procedural and theoretical distinctions coincided, Grindley reversed the instrumental contingency while the Pavlovian relationship between the buzzer and food was maintained. Animals that had originally been rewarded for head turns to the left were now rewarded only if they turned to the right during the buzzer, and vice versa for those originally rewarded for right turns. The guinea pigs *did* reverse the direction of their head turning, suggesting that they had learned about the consequences of their behaviour, rather than the buzzer.

b) Implications for the study of social learning

It has been pointed out that the principal aim of research on social learning has been to provide an unambiguous demonstration of imitation. Yet, despite 100 years of research attempting to do just that, the methodologies of all but two paradigms have proved to be flawed (Galef, 1988; Heyes, 1994). A cognitive perspective suggests that this is because the experimental methodologies that have been used have lacked the power to distinguish S-S from R-O effects. Thus, for example, it is illegitimate to conclude that because its demonstrator had responded to a procedure that was ostensibly instrumental, an observer's matching behaviour must be imitative. An observer that saw, for example, a demonstrator earning food by lever-pressing (R-O), also saw that food was contingent on a moving lever (S-S). In addition, because a cognitive social learning theory raises the possibility that, like Pavlovian conditioning, observational conditioning is a pervasive process, it is likely that the embedded S-S relationships in observational instrumental procedures have supported many of the observed matching behaviours, whether or not the matching behaviours have resembled a UR.

Therefore, to individuate empirically types of social learning, a strategy like that exemplified by the bidirectional control procedure (Grindley, 1932) is required. In the particular cases of observational conditioning and observational learning, they must be differentiated according to whether they affect behaviour through stimulus-outcome, or response-outcome associations.

Heyes, Dawson and Nokes (1992) used a bidirectional control procedure to investigate whether rats could observationally learn. They attempted to isolate observational learning by considering how an observational learning process, as opposed to other social learning processes, affects behaviour. Specifically they sought evidence to suggest that, of the relationships embedded in the observational experience of a conspecific responding for reward, the contingency between the observed response and outcome can govern a rat's behaviour.

A Skinner box was divided into two compartments by wire mesh. A demonstrator and an observer were placed facing each other in the separate compartments. The demonstrator pushed a joystick suspended from the ceiling either to its left (i.e., to the observer's right), or to its right (the observer's left). For each of fifty pushes in the specified direction a food pellet was delivered to the demonstrator.

When observers were given access to the joystick and rewarded for pushes in either direction, observers of left pushing demonstrators made a greater proportion of left pushes than did observers of right pushing demonstrators. On test, the joystick hung in front of the side wall of the demonstration compartment, rather than in front of the wire mesh partition where it had been during observation. Thus, anything that the observers had learned about the joystick's movement relative to features of the apparatus was irrelevant to responding to the joystick in its new position. The directional bias in the observers' responding could, therefore, be attributed to the remaining contingency; that between behaviour and reward.

In summary, in this case, appreciation of the developments in contemporary learning theory led to the development of a procedure which could disambiguate the effects of imitation (but see Byrne and Tomasello, 1995, for an attempt to provide an explanation of the joystick effect in terms of local enhancement)

1.3.3. Inhibitory Conditioning

a) Consequences for learning theory.

The thesis that during conditioning animals learn about event relationships, rather than acquiring S-R habits, highlights the possibility that relationships other than event pairing may support learning (Mackintosh, 1983). A CS may, for example, be negatively correlated with, or provide no information about, the occurrence of a second event.

The typical behavioural effect of a negative correlation between a CS and an outcome is that an animal suppresses a response that it would otherwise have made. As Mackintosh (1983) pointed out, it is not obvious how conditioned suppression in responding is to be explained if conditioning is thought of as the strengthening of responses. Consequently, the processes of inhibitory conditioning began to receive appropriate empirical and theoretical scrutiny only when learning began to be viewed as a cognitive process.

It is now known that animals can learn about inhibitory relationships involving both responses and stimuli. An animal can learn that its behaviour causes an otherwise expected outcome to be omitted (e.g., Holland, 1979), and, in situations where a reinforcer is expected, an animal can learn that a particular stimulus signals that the reinforcer will not be delivered (Rescorla, 1969).

Unlike excitatory conditioning, inhibitory learning often has no direct behavioural consequences. For instance, pairings of light and food may cause an animal to salivate, but it is not obvious what behaviour to expect from a non-salivating animal that is presented with a stimulus associated with the absence of food. Two techniques, the summation and retardation tests have been developed to reveal inhibitory learning. The summation test works by making the animal respond. A conditioned excitor is trained, and, therefore, in its presence the animal responds. If a putative conditioned inhibitor does have inhibitory properties, then an animal should respond to the excitor less when it is presented together with the inhibitor than when it is presented alone. The retardation test assumes that, in comparison with a stimulus that has no history of reinforcement, an inhibitory stimulus should take longer to acquire excitatory properties when it is paired with a US.

b) Consequences for social learning

Socially learned analogues of inhibitory learning have not been empirically identified or given theoretical consideration, and this may be because matching behaviour is the only recognised outcome of social learning (Heyes, 1994). Learning that a demonstrator's lever-press response leads to the cancellation of a food delivery, for example, is unlikely to lead to the production of that response by an observer. Therefore, while social learning is identified with matching behaviour, this sort of phenomenon is unlikely to be sought or, if found, recognised as a form of social learning.

Generally, if social learning researchers were to conceive of learning as the acquisition of information about event correlations rather than as the acquisition of behaviour, the potential significance of social inhibitory learning would be highlighted.

1.4 Summary

Conceiving of learning as the acquisition of information has many theoretical and empirical implications. For social learning, three seem particularly important. First, acknowledgement that the ability to learn about stimuli confers considerable behavioural flexibility, suggests that observational conditioning is an important social learning process, and that social learning is likely to result in CRs other than matching behaviour. Second, a rationale is provided for experiments the aim of which is to demonstrate the unconfounded influence of a particular social learning process; the necessary and sufficient conditions for a particular learning type cannot be isolated, and, therefore, to be successful, a procedure must operationalise theoretical distinctions which individuate learning types according to the way they have their effects on behaviour. Third, because learning about relationships other than event pairing is possible, a cognitive social learning theory would highlight the possible existence of socially mediated inhibitory learning.

Chapter 2

Socially Mediated Associative Learning: A Review and Research Proposal

2 Introduction: Conditions of Associative Learning

Chapter 1 argued that a sensitivity to the issues made pertinent by cognitivism would be useful for social learning research. It was suggested that the kind of cognitivism evident in contemporary learning theory reformulates questions, which have been intractable, such that they become subject to empirical analysis. By searching for data commensurate with a cognitive learning theory, this chapter attempts to show that in addition to being useful, an associative social learning theory has empirical support.

The contention is that social learning is a generic term for examples of associative learning that are in some way dependent on their social context. There would be preliminary support for this hypothesis if it could be shown that social and individual learning were similarly selective. That is, finding that the conditions which foster social learning mirror those of individual learning would suggest that the same, associative mechanisms were operative in the two learning domains.

Chapter 2 discusses the conditions that are characteristic of associative learning and searches for evidence that social learning is dependent on similar conditions. In particular, data are sought which suggest that social learning is 1) contingency dependent, 2) subject to blocking and overshadowing, 3) sensitive to both S-S and R-O relationships, and 4) subject to the effects of stimulus pre-exposure. In recognition of the limitations of this *post hoc* analysis, an experiment was designed to test each predicted parallel. The rationale for each of the procedures used is described in this chapter. The experimental findings are reported in the subsequent empirical chapters.

Associative learning is selective, i.e., not every event is associated with every other event. According to the most complete formal model of associative learning, the Rescorla-Wagner model (Rescorla and Wagner, 1972), learning about stimuli or responses occurs when there is a discrepancy between the actual and expected outcome of a conditioning trial. Excitatory conditioning will occur if a CS provides information about the occurrence of a US. A CS will become a conditioned inhibitor if it signals the absence of an expected reinforcer.

The account of learning offered by the Rescorla-Wagner model is derived from the conditions which have been shown empirically to be effective in producing learning. Therefore, analyzing that description of learning will identify those conditions which, if they could be found in social learning, would be diagnostic of an associative mechanism.

First, let us take excitatory conditioning as an example. If, as the Rescorla-Wagner model asserts, a CS must be informative about the occurrence of a US for associative learning to occur, then the occurrence of associative learning is implied when an animal's behaviour changes as a result of the contingency between a CS and US.

Second, the requirement that a discrepancy between expected and actual outcome exist if learning is to occur, acts as a caveat to the contingency requirement above. Contingency is a necessary but not a sufficient condition for learning. A contingent relationship between a CS and a US will be learned only if the CS offers new information about the US.

Third, according to contemporary learning theory, an animal will learn about consequences that are contingent upon either the occurrence of environmental events, or its own performance of a response.

Finally, the Rescorla-Wagner model does not provide an exhaustive account of the laws of association. The model focuses on the current relationship between a CS and a reinforcer. However, there is evidence which implicates a CS's past history of reinforcement in the determination of learning. For example, a CS that is repeatedly presented in the absence of reinforcement will be slower to condition when it is subsequently paired with a US (Lubow, 1973). Latent inhibition, as this pre-exposure effect on learning is known, suggests that the associability of a stimulus declines with repeated nonreinforced exposure.

These four conditions of associative learning show that the claim that social learning is associative would be substantiated if there were evidence that :1) social learning is dependent on a contingent relationship between events; 2) in the absence of a discrepancy between the actual and expected probability of reinforcement, social learning will not occur; 3) observers can learn S-S and R-O relationships; and 4) pre-exposure to a to-be-learned CS retards social learning about that stimulus.

2.1. Contingency dependence

According to Rescorla (1967), whether learning depends on contingency can be assessed most reliably using a truly random control procedure. To show, for example, that a rat came to approach a light because food delivery was contingent on the light's illumination, it must be demonstrated that another rat, exposed to the uncorrelated presentation of the same number of lights and food pellets, did not develop approach behaviour.

There are many reported examples of social learning that could be contingency based, but the controls necessary to establish this fact have seldom been applied. As Biederman and Vanayan (1988) put it, "few [social learning] studies have attempted to identify the nature of the information extracted during observation"

For example, Lore, Blanc and Suedfeld (1971) found that rats exposed to a demonstrator learning to avoid a candle flame (CS-US group), required fewer flame contacts to acquire the passive avoidance response, than rats exposed to a demonstrator that could not reach the flame (CS alone group). Lore et al reported that the sharp withdrawal response exhibited by the demonstrators when they touched the flame, elicited a startle response from the observers. Descriptively, this sequence of events accords with the definition of observational conditioning. In the experimental group, the demonstrator's withdrawal behaviour acts as a US for the observer's startle response (UR). Through social exposure, the observer learns that the flame (CS) is associated with unpleasant consequences (US). As a consequence of learning about this CS- aversive US contingency, the observer avoids the flame. Therefore, the observer makes fewer flame contacts than a rat in the CS alone group whose demonstrator, because it was denied access to the flame, did not make any withdrawal responses.

However, Lore et al's data cannot be attributed firmly to observational conditioning because their experiment did not include a control group in which the CS and US were presented uncorrelated with one another. Consequently, it could be, for example, that habituation to the candle CS is affected by whether or not the candle is presented in the same context as a US (Rescorla, 1967). According to this, non-associative interpretation, an observer from the CS-US group does not make fewer flame contacts than a CS alone observer because it has learned from the contingent presentations of CS and US that the candle has aversive consequences, but because its initial CS exploratory responses have habituated to a greater extent.

Better evidence for the importance of the contingency between a CS and a US in some social learning situations comes from the work of Mineka and her colleagues (see Mineka and Cook, 1988 for a review). Cook, Mineka, Wolkenstein and Laitsch (1985) showed that rhesus monkeys that were initially unafraid of snakes, acquired a snake fear through observation of a fearful conspecific. According to Mineka and her colleagues, the fear response of the conspecific demonstrator to the snake stimuli acted as a US eliciting an unconditioned fear response from the observer. A contingent relationship therefore existed between the sight of the snake and the demonstrator's fear, allowing the snake to be established as a CS for the observer's fear.

Although this experiment did not contain a truly random control group, as a discriminative observational conditioning procedure, its design was better suited to the inference of associative learning than that of Lore, Blanc and Suedfeld. Thus, in addition to a demonstrator responding fearfully in the presence of snakes, observers were exposed to the demonstrator responding non-fearfully in the presence of non-snake stimuli, e.g. coloured wooden blocks. That is, the US did not occur in the presence of non-snake stimuli, and, as an observational conditioning account would anticipate, the observers did not become fearful of the non-snake stimuli. Unlike Lore et al's findings, this stimulus specific responding cannot be accounted for in terms of differential rates of habituation to each stimulus type, because both the snake and non-snake stimuli were presented in the same context as the US.

Unfortunately, however, there is another obstacle to the interpretation of Mineka's discrimination data as evidence of observational conditioning. Because the observers showed less fear of the snake stimuli than the demonstrators at pretest (as indexed by the amount of time spent in a compartment of the cage which contained the snake), they were classified as fearless. However, at pretest the observers spent less time in the compartment containing the snake than in the compartments containing neutral stimuli, implying that they experienced some fear of snakes at that stage, and raising the possibility that, rather than leading to observational conditioning, exposure to the demonstrator's fear behaviour simply sensitised the observers' fear responses to the snake stimuli.

Although sensitisation effects are thought to be transient (Hall, 1991), persistence of the observer monkey's fear of snakes six months after demonstrator exposure (Mineka and Cook, 1986) does not rule out a sensitisation account. The test session, when the observers were isolated, provided the opportunity for conditioning the observers' sensitised arousal to the snake.

An experiment by Vanayan, Robertson and Biederman (1985) investigated social discrimination learning in the pigeon, and, because the discriminative stimuli did not differ in terms of the behaviour they elicited prior to conditioning, its procedure was better suited than Mineka et al's to establishing that social learning relies on contingency. In the discrimination group, observers were exposed to key-pecking demonstrators. Pecks to the key when an inverted triangle was illuminated, resulted in access to a grain hopper (CS+). Pecks to an erect triangle introduced a 20s delay before the 40s intertrial interval began (CS-). The demonstrator pigeons were untrained on the discrimination problem and, therefore, they distributed their pecks equally between the CS+ and CS-. In a second group, control observers were simply confined to the apparatus.

Testing revealed a social learning effect. Discrimination group observers made a greater proportion of their responses to the CS+, than did control observers. Unlike the Lore et al case, the superiority of the discrimination observers cannot be explained as the result of differential habituation to CS+ and CS-; both the positive and negative stimuli were presented in the same context. Similarly, since it is unlikely that erect and inverted triangles elicit different behaviour, the sensitisation explanation applicable to Mineka's data is also ruled out. It seems, therefore, that the Vanayan et al. experiment provides evidence of the importance of CS-US contingency. However, Vanayan et al's discrimination design does not enable us to isolate exactly which CS-US contingency or contingencies were important. The observer pigeons may have pecked the CS+ key because they had learned about the contingency between an inverted triangle and food, or because they were avoiding the CS-, having learned that an erect triangle signals the absence of food, or both.

In summary: During many social learning experiments, observers have been exposed to contingencies between stimuli (or responses) and outcomes. However, it was argued in Chapter 1 that learning processes cannot be inferred from procedures, and therefore, to implicate an associative mechanism, it must be shown that the contingency was effective in changing the observers' behaviour. To my knowledge, no social learning experiment has contained the ideal, truly random control against which to assess any contingency effects. However, careful use of a discrimination paradigm, such as that made by Vanayan et al, can rule out non-associative processes such as habituation and sensitization, and thereby implicate a contingency effect of some sort, even if it cannot pinpoint whether the positive or negative contingency is effective.

2.1.1 Experiments investigating contingency dependence

The experiments reported in Chapter 3 used a truly random control procedure to show contingency effects in social learning. In the first of these, hungry, observer rats were exposed to a demonstrator responding to either a contingent or a truly random relationship between a light (CS) and food (US). Ten such stimulus presentations occurred in each observation session. After several observation sessions the observers were exposed to the light in the absence of reinforcement, and their magazine behaviour, during and just prior to the light, was recorded.

Consider, for example, an observer who has been exposed to a demonstrator restricting the majority of its own magazine behaviour to a CS period preceding food delivery. If the observer comes to enter the food tray during the CS, it can be said to have learned an associative relationship through observation if there is no corresponding elevation in the magazine behaviour of observers in a truly random group.

2.2 Discrepancy between actual and expected reinforcement

Overshadowing and blocking are phenomena characteristic of an associative learning mechanism. These two phenomena show the selectivity of an associative learning mechanism, i.e., that what an animal learns about a CS depends on its predictive status relative to other stimuli. Learning about a stimulus will occur only if that stimulus provides information about consequences in addition to that provided by all other stimuli. In other words, learning about a stimulus will occur only if there is a discrepancy between the reinforcement actually received, and that expected on the basis of all other stimuli.

Overshadowing and blocking will be discussed in turn, and evidence for their occurrence in social learning will be described.

2.2.1 Overshadowing

Wagner (1969) found that the extent of learning about the aversive consequences (shock) of a tone that has been presented in compound with a light, is dependent on the predictive status of the light. Thus, a rat will learn less about the tone if, in addition to its compound presentations, the light is also presented alone and followed by shock. Learning about relatively good predictors of reinforcement overshadows learning about relatively poor predictors.

Beauchamp and Kacelnik (1991) found that the amount that observer zebra finches learned about the predictive status of a light depended on whether the observers were exposed to demonstrators that were 'knowledgeable' or 'non-knowledgeable' with respect to the relationship that existed between the light and food delivery. Observers pecked less during the light if they had previously been exposed to knowledgeable demonstrators that restricted their pecking behaviour to the light because they had learned that the light signalled the availability of food. Non-knowledgeable demonstrators pecked equally often in periods when the light was off and pecking did not lead to food, and during its illumination.

These data are consistent with an overshadowing account. Pecking behaviour was a better predictor of food for observers of knowledgeable demonstrators than it was for observers of non-knowledgeable demonstrators. Consistent with the operation of an associative mechanism, the provision of a relatively better predictor of food, meant that observers of knowledgeable demonstrators learned less about the light. Correct pecking behaviour overshadowed learning about the light. Biederman and Vanayan (1988) reported a similar effect in pigeons. Observers that saw demonstrators pecking an erect triangle (S+), and withholding pecks to an inverted triangle (S-) did not make the S+/S- discrimination as well as observers of non-knowledgeable demonstrators.

2.2.2 Blocking

Kamin (1969) demonstrated that, despite a contingent relationship between a stimulus, CS2, and shock, a rat will fail to learn about CS2 if it is presented in compound with a second stimulus, CS1, that has previously signalled that a shock will occur. Learning about the CS1-> shock relationship is said to block learning about the CS2-> shock relationship. The Rescorla-Wagner model understands blocking to mean that an associative learning mechanism requires there to be a mismatch between the level of reinforcement that an animal expects, and the level of reinforcement that actually occurs (see Miller and Schachtmann, 1985 for an alternative account of blocking).

Having interacted with a recently fed conspecific demonstrator, an observer rat will consume the diet eaten by its demonstrator in preference to an equally palatable, novel, diet (Galef, Kennett and

Wigmore, 1984). Galef and Durlach (1993) investigated whether this social enhancement of food preferences effect was subject to blocking, and hence, whether there is evidence that the social enhancement effect is associative. Galef and Durlach reasoned that, if it is associatively mediated, it should be possible to reduce the socially enhanced preference shown to a second diet, CS2, by presenting CS2 in compound with a diet, CS1, to which the observers have been previously exposed in a social context. They found, however, that when given a choice of the CS2 diet and another, novel diet, the proportion of CS2 eaten by observers in the blocking group was equivalent to the proportion consumed by observers exposed to CS2 alone and without previous experience of CS1. That is, there was no evidence that the opportunity to learn about CS1 prior to CS1/CS2 presentation blocked subsequent learning about CS2. As the authors themselves note, however, blocking is not always found when only a single CS1/CS2 compound is administered, and therefore this result does not necessarily indicate that social enhancement of food preferences is not subject to blocking.

It has not been possible to find data suggestive of blocking elsewhere in the social learning literature. This, however, cannot be regarded as evidence that blocking does not occur, because, aside from the Galef and Durlach experiment, no investigators have used experimental designs involving stimulus pre-exposure that are sensitive to blocking (see Chapter 1, section 1.1.2).

In summary, data have been found to suggest that in social learning the acquisition of information is selective. This selectivity, demonstrated for example by Beauchamp and Kacelnik's finding of overshadowing, (Beauchamp and Kacelnik, 1991) is consistent with the operation of an associative mechanism. Through observation, an animal will learn about a strong predictor of reinforcement to the detriment of a poor predictor.

2.2.3 Experiments on overshadowing and blocking

The experiments in Chapter 4 used an existing experimental procedure, developed by Galef and Durlach (1993) to seek evidence of overshadowing and blocking of the social enhancement of food preferences effect. Galef and Durlach failed to find a reduction in consumption of CS2 following compound exposure. However, it was considered worthwhile, in the first instance, to repeat Galef and Durlach's procedure without substantial modification because blocking and overshadowing are not highly reliable one-trial procedures (Dickinson, Nicholas and Mackintosh, 1976). Later experiments continued with the same basic procedure, but the blocking group observers were given more exposure to CS1 and efforts were made to enhance the sensitivity of the test measure in an attempt to show the effects relative validity.

2.3.3 S-S or R-S learning by observation

It was argued in Chapter 1 that no procedure is either purely Pavlovian or instrumental, and, therefore, it must be empirically established whether an animal's responding is governed by classical or instrumental relations. This has been achieved in the case of instrumental learning and observational learning by using a bidirectional control procedure which isolates the effects of R-learning (Grindley, 1932; Heyes et al, 1990; see section 1.3.2). For example, observers that stood facing a demonstrator while the latter pushed a joystick to its left (i.e., to the observers right) made more responses to their left than did observers of right pushing (Heyes, Dawson and Nokes, 1992). Observational learning, i.e., social learning about the demonstrator's behaviour, was implicated because the joystick was moved between observation and testing. Therefore, while learning about the direction in which the demonstrator pushed the joystick could result in a preference for pushes in a particular direction, social learning about the movement of the joystick relative to features of the apparatus could not.

Social learning about stimuli, because it is presumed to be a simpler process than observational learning, has become the default interpretation for those social learning phenomena where the controls have been inadequate to establish definitively the underlying mechanism. For example, uncontrolled field observations by McGrew and Rogers (1983) of chimpanzees learning how to use twigs to 'fish' for termites from watching a knowledgeable chimpanzee 'fishing', have been interpreted by Galef (1992) as the chimpanzees learning about stimuli, rather than behaviour. However, observational conditioning has been explicitly investigated only with reference to the acquisition of fear by rhesus monkeys (Mineka and Cook, 1988). Observer monkeys developed a fear of snakes having seen a conspecific react fearfully in their presence (see Chapter 1, section 1.1.2; Mineka, Davidson, Cook and Keir, 1984). Mineka and her colleagues hypothesized that the demonstrators' fear behaviour acted as a US for fear in the observer. However, a demonstrator's behaviour, in what are ostensibly observational conditioning procedures, has correlated consequences, and it is possible that an observer learns about this R-O relationship, rather than that arranged by the experimenter to exist between stimuli. Thus, for example, the observer monkeys could have learned to perform a fear response because its execution by demonstrators had preceded the removal of the snake stimuli which prior to conditioning the observers had tended to avoid

(Chapter 2, section 2.1.1).

The aim of the experiments reported in Chapter 5 was to develop an experimental procedure allowing positive identification of observational conditioning processes, unconfounded by observational learning effects, and which could also isolate imitative behaviour. Although, unlike observational conditioning, an unambiguous demonstration of observational learning in rats would not be new (see Heyes, Dawson and Nokes, 1992), a procedure with the potential to mutually isolate both social learning processes could subsequently be used to examine the conditions favouring each. The experiments used a two lever two action paradigm that was adapted from a procedure developed by Bolles, Holtz, Dunn and Hill (1980) to isolate asocial Pavlovian conditioning.

2.3.1 Bolles' (1980) method for distinguishing Pavlovian and instrumental conditioning.

Bolles, Holtz, Dunn and Hill (1980) developed a procedure that could isolate the effects of Pavlovian conditioning. Their experiment aimed to distinguish classical and instrumental effects in punishment situations, those in which there is a positive relationship between a response, such as lever pressing, and an aversive reinforcer. While a suppression in responding under these conditions could be due directly to the contingency between lever pressing and shock, there is also the possibility that the reduction in responding could be mediated indirectly by the animal avoiding a stimulus, the lever, which was nearby when it was shocked.

The experiment by Bolles et al used a manipulandum, a lever, which could be lifted or pressed. The logic of the bidirectional control would suggest that, if a rat were trained to both lift and press this lever, and one response type was then punished, responses in the punished direction should cease if the animal had learnt about the consequences of its action. Bolles reasoned that if two, identical dual action levers were used, and the animal trained on all four possible response x stimulus configurations (i.e., left lever lift, right lever lift, left lever press, right lever press), the effects of instrumental and classical learning could be separated. If lifting the left lever were punished, and this resulted in equal suppression of lifting on both bars, it would indicate response learning. If, however, the animal avoided the left bar entirely and responded indiscriminately with lifts and presses on the right lever, the effects of S-S learning would have been isolated. The extent of each effect indicated the extent of the relevant type of learning.

2.3.2 Empirically distinguishing observational conditioning and observational learning

To distinguish observational conditioning from observational learning, four groups of observers; Groups LEFT UP, LEFT DOWN, RIGHT UP and RIGHT DOWN, were exposed to a demonstrator making one type of response, on one lever, for reward. The observers were then given access to both levers, and reinforced for any response they made. Observational conditioning would be implicated if, for example, observers of left up responses made the majority of their own responses on the left lever. To warrant the conclusion that their behaviour was solely controlled by stimulus learning, observers of left up would have to make the same proportion of lifts and presses as observers of left down responding. Observational learning would be suggested if, instead, observers of left lever lifting were to lift only, and to distribute their responding in the same way across levers as observers of right lever lifting.

In addition to isolating social learning about stimuli, a demonstration of observational conditioning must establish that, for the effect to occur, the outcome must be contingent on the CS (see Chapter 2, section 2.1.1) for an explanation of Mineka's data of the social acquisition of snake fear that does not involve contingency, and is, therefore, non-associative). In this case, to support an observational conditioning interpretation, truly random control animals that observed uncorrelated responses and reinforcers must not develop a lever bias (see section 2.1.1. for a discussion of the truly random control procedure)

2.4 Pre-exposure effects

On first presentation, many stimuli elicit a set of typical behaviours, or orienting responses. For example, on its first exposure to a light, a rat will rear on its hind legs. With repeated exposure, this orienting behaviour declines or habituates. If the light is now presented in a contingent relationship with a US, the rat's learning about that relationship will be retarded. This is known as latent inhibition (Lubow, 1973). If however, conditioning occurs in a context other than that used for pre-exposure, learning occurs at a normal rate (Hall, 1991). Thus, latent inhibition is said to be context specific. Latent inhibition shows that in addition to the present relationship between a stimulus and its outcome, associative learning is also determined by the CS's history of reinforcement.

Curio (see Curio, 1988 for a review) has shown that a redwinged blackbird will come to mob another previously innocuous bird, e.g. a honeyeater, when the blackbird has seen a conspecific direct its mobbing behaviour at a honeyeater.

By presenting the CS for mobbing behaviour (the honeyeater) to the observer before social exposure to a mobbing demonstrator, Curio has provided indirect evidence for the influence of a CS's history of reinforcement on socially learned mobbing behaviour. Observers that were pre-exposed to the honeyeater produced a much weaker mobbing response after social exposure to a mobbing demonstrator than observers that had not received pre-exposure.
Although the pre-exposed and non-pre-exposed blackbirds were tested in separate experiments, this effect provides prima facie evidence of latent inhibition. This interpretation becomes yet more plausible when one considers another of Curio's findings: For half of the blackbirds that had been pre-exposed to the honeyeater the context was changed between observation and testing. On test, the honeyeater appeared in a different part of the aviary, and a piece of grey cardboard had been introduced behind the honeyeater. Blackbirds tested in this different context performed significantly more mobbing behaviour in response to the honeyeater than observers for whom pre-exposure, conditioning and testing occurred in the same place. Numerically, pre-exposure and conditioning in a different context from testing produced almost identical amounts of mobbing behaviour as that produced previously without pre-exposure. Selective disruption of the effects of pre-exposure by a novel context is predicted by a recent account of how a CS's history of reinforcement affects behaviour (Bouton, 1993). According to Bouton, when a pre-exposed stimulus is reinforced, latent inhibition is not overwritten, rather, information about the stimulus provided by both the non-reinforced and reinforced phases is retained. Performance depends on which memory is retrieved. Latent inhibition is context specific (Hall, 1991). Therefore, in Curio's experiment, when testing occurred in a context other than that used for pre-exposure and conditioning, the honeyeater was mobbed because information about its non-reinforcement was not retrieved.

2.4.1 Experiments on socially mediated stimulus pre-exposure

The experiments in Chapter 6 used observer rats' orienting responses as an index of attention to investigate whether the effects of stimulus pre-exposure are influenced by the presence of a demonstrator. The hypothesis that the processes of social learning are the same as those of asocial learning predicts that a socially exposed stimulus will be subject to habituation and latent inhibition. Accordingly, the social context in which the stimulus is presented, if it has any effect at all, might be expected to alter the magnitude, but not the nature, of the processes typically accompanying stimulus pre-exposure.

It has commonly been assumed that one of the consequences of watching a demonstrator responding for reward is that the observer pays more attention (Thorpe, 1956), or receives more exposure (Spence, 1937) to the stimulus to which the demonstrator is responding. It is also thought that, in most cases, local enhancement or stimulus enhancement, as this phenomenon is know, is a sufficient explanation for matching behaviour generated by observational instrumental procedures (Denny, Clos and Bell, 1988; and Hogan, 1988). It has been argued that, because an observer pays more attention to a lever that it has seen pressed, it will be more likely, by chance, to emit a lever-press response and, thereby, have the opportunity to learn that lever- pressing is reinforced. This account of matching behaviour has not been empirically tested. Instead, the occurrence of local enhancement has been inferred via an appeal to parsimony; local enhancement is assumed to be a simpler process than observational learning. Eschewing this approach, the experiments in Chapter 6 attempted to provide a positive demonstration of local enhancement in the rat.

A panel light close to the roof of the operant chamber was used as a stimulus. Observers were exposed either to demonstrators who had never experienced this light before, and who, therefore, made distinctive orienting responses when the light was turned on, or to demonstrators who had seen the light often enough for their orienting responses to have habituated. Another group was exposed to the light without a demonstrator present. If the presence of a demonstrator influences the processes accompanying stimulus pre-exposure, the orienting responses of both observer groups should differ from those produced by the social isolates. The orienting of observers exposed to orienting demonstrators should differ from the social isolates if local enhancement of stimuli requires a demonstrator to respond to the stimulus.

The experiments in Chapter 6 also investigated whether a demonstrator responding to a stimulus affects the degree to which a stimulus becomes latently inhibited. The more a stimulus is processed, the more profoundly latently inhibited it will be (Hall, 1991). Thus, observers would be expected to learn an association between the panel light and food more slowly than social isolates if demonstrators increase the observers' attention/exposure to the panel light. Interestingly, if experiments confirmed this, social learning researchers could be more confident in their ascription of imitative processes to matching behaviour; the typical local enhancement effect might be to hinder learning about the positive relationship between a response and an outcome.

2.5 General Summary

There are data in the social learning literature which are consistent with the hypothesis that social learning is associative. It has been possible to find correspondence in the conditions of social and asocial learning, and, therefore, to provide prima facie evidence that they are subserved by the same mechanism. Social learning effects have been described which suggest that it is; subject to overshadowing (Beauchamp and Kacelnik, 1991), susceptible to contingency effects (Vanayan et al, 1985), sensitive to the consequences contingent upon a behaviour (the demonstrator's behaviour) (Heyes et al, 1992), and affected by stimulus pre-exposure (Curio, 1988). A *post hoc* analysis cannot establish that social learning is associative. Therefore, where social analogues of asocial effects have been found, experiments have been proposed to test whether social learning occurs under these conditions which are, descriptively, similar to the causal conditions of associative learning.

Chapter 3

An Assessment of the Effects of Contingency in Social Learning Using a Truly Random Control

3 Introduction

Observation of a conspecific that is frightened by snakes is sufficient for rhesus monkeys to acquire a fear of snakes (Mineka and Cook, 1988). Mineka has suggested that when it is observed by a conspecific, the behaviour of a frightened monkey is an unconditioned elicitor of fear (US). By virtue of Pavlovian conditioning, the observer monkey's elicited fear is associated with antecedent stimuli with which it is correlated, i.e., snakes. Social Pavlovian conditioning, or observational conditioning, is implicated because the US is a conspecific's behaviour.

It was argued in section 2.1.1 that to substantiate a claim that a given socially learned behaviour is the result of observational conditioning, or imitation when imitation is construed as a variety of instrumental learning, it must be demonstrated that the behaviour's development depends on there being a contingent relationship between the occurrences of the stimulus/response and the outcome. This is because, outside social contexts, associative learning occurs when events are contingently related. Thus, a putative example of observational conditioning must be assessed relative to a truly random control (Rescorla, 1967). Interpreted in this way, to attribute the acquisition of fear by Mineka's observers to observational conditioning, it must be shown that observers that see fear behaviour non-contingently with respect to snakes, remain unafraid (see section 2.1.1 for possible non-associative explanations of Mineka's data).
The experiments in this chapter use a truly random control procedure to investigate the associative basis of a social learning effect.

3.1 Experiment 1

The purpose of Experiment 1 was to show, using a truly random control procedure (Rescorla, 1967), that, like individual learners, observers' enhanced responding to a CS, following social exposure to a Pavlovian relationship involving that CS and an appetitive outcome, is dependent on the observation of a CS-US contingency. If so, it would imply that the mechanisms subserving this social learning effect are associative.

The basic experimental paradigm involved four groups of animals. Two groups of observers, Group COND and Group RAND, were exposed to the behaviour of one of two groups of demonstrators, Group DEMCOND and Group DEMRAND, respectively. Group DEMCOND had been trained on a simple Pavlovian contingency whereby the presentation of a light (CS) terminated in the delivery of a food pellet (US). Therefore, the rats in Group DEMCOND approached and entered the food tray during the CS. Group DEMRAND saw the same number of lights and received the same number of food pellets, but, the schedule controlling CS delivery was independent of that controlling US delivery. Hence a zero contingency existed between CS and US. Randomisation of event presentation ensured that Group DEMRAND distributed their magazine behaviour equally throughout the session. To implicate an associative mechanism, the behaviour of the two groups of rats that observed DEMCOND and DEMRAND demonstrators should differ.

Method

Subjects

Twenty-four male hooded Lister rats, obtained from Harlan Olac Ltd (Bicester, Oxon.) served as subjects. Sixteen rats were experimentally naive and served as observers. The remaining eight rats had prior instrumental experience, and acted as demonstrators in this experiment. Each demonstrator was assigned two observers. The free feeding weights ranged from 489-575g and 377-448g for demonstrators and observers, respectively. The animals were maintained at 90% of their free feeding body weights. Throughout the experiment, observers and demonstrators were housed separately in groups of four. Water was freely available in the home cage. The animals were fed at the end of their daily experimental sessions.

Apparatus

All training and testing occurred in four identical operant chambers measuring 50 x 25 x 21 cm. The interior walls of each box were of sheet metal painted black. The ceiling was made of translucent Perspex, and the floor consisted of parallel metal rods.

Each chamber was divided into two compartments of equal size by a wire-mesh partition. One compartment was used for demonstration and testing. In the centre of the side wall of this demonstration compartment, opposite the wire-mesh partition, there was a recessed food tray, 6 cm high x 5 cm wide, in to which 45mg sucrose pellets could be delivered. If a subject entered the food tray, a photocell beam was broken and a response was recorded. The corresponding side wall of the observation compartment was blank.

Two stimuli were used: a 24 v light, 1 cm from the top of the side panel in the demonstration compartment was used as the house light, and another 24 v light, again situated in the side panel of the demonstration compartment, but only 2 cm above the food tray, was used as the CS. Intermediate between these two lights was a speaker 3 cm in diameter.

Procedure

Demonstrator training. On each day of training, the demonstrators received two, 30 minute sessions. For half the demonstrators (Group DEMCOND) these sessions consisted of ten, 30s presentations of the light CS, with each presentation followed immediately by the delivery of a sucrose pellet. The mean intertrial interval (ITI) was three minutes, governed by a random time (RT) schedule. The remaining demonstrators (Group DEMRAND) received the same number of CS and US presentations, but the arrival of the US was random with respect to CS presentation; CS and US presentations were determined by independent RT 3 min schedules. Training continued for 12 days, until demonstrators in Group DEMCOND showed an elevation ratio of .8 or more. (The formula for calculating the elevation ratio is A/(A+B), where A is responding during the CS and B is responding during the 30s pre-CS period.) At the end of training, the elevation ratios of demonstrators in Group DEMRAND did not differ from .5. Thus, on average, the magazine behaviour of demonstrators in Group DEMRAND was unaffected by the onset of the CS. If, in the course of observer training, the elevation ratio of a demonstrator in Group DEMRAND departed significantly from .5, additional training was given to the demonstrator. All US deliveries were cancelled in the supplementary training of demonstrators whose elevation ratios exceeded .5. If their elevation ratios fell below .5, demonstrators were exposed in supplementary training to pairings of the light and food.

Observer training. All observers received four daily sessions of magazine training in the demonstration compartment. Thirty food pellets were delivered on a RT 60s schedule in each session.

During each observation training session, observers were placed in the observation compartment and exposed to the performance of a trained demonstrator. Observers in Group COND were exposed to a demonstrator from group DEMCOND. For this group, the majority of magazine responding by demonstrators occurred during the 30s CS which preceded food delivery. To be included in Group COND, observers must have been exposed to a demonstrator that, during the course of their observational training, produced a cumulative elevation ratio of .75 or above. Observers in Group RAND were exposed to a demonstrator responding on an entirely random ? light/food schedule. To ensure that Group RAND observed magazine behaviour that was uninfluenced by the light, observers were included in the group only if the cumulative elevation ratio of their demonstrators' magazine behaviour fell between .45 and .55.

Observer testing. All of the test sessions immediately followed a demonstration session. At the end of a demonstration session the house light was extinguished and the demonstrator removed. The observer was then transferred to the demonstration compartment and exposed to 10 presentations of the light CS with a mean ITI of three minutes.

In all there were four test sessions in Experiment 1; three acquisition tests and one extinction test. In acquisition tests, the light was presented 10 times, and on each occasion followed by the delivery of a food pellet. In the extinction test, the light was presented 10 times with no programmed consequences. In all cases, the behavioural measure was magazine entry during the 30s CS, and during the 30s period immediately prior to CS presentation.

The first acquisition test was given after one demonstration session. Acquisition tests two and three followed a total of five and six more demonstration sessions, respectively. A further five demonstration sessions intervened before the extinction test.

Results and Discussion

Elevation ratios for the observers' magazine behaviour during each test session were calculated. A score of less than .5 indicated that fewer entries were made during the CS compared to the pre-CS period; a score of .5 meant that responding inside and outside the CS period was equal; and a score greater than .5 meant that more responses were made during the CS. If the observer restricted its responding to the CS period, a score of 1 was given. A score of 0 was assigned if responding occurred only in the 30s prior to CS onset, and no responding in either period was assigned a score of .5.

The requirement that the animals in Group COND be exposed to a cumulative elevation ratio greater than .75, while those in Group RAND were exposed to cumulative elevation ratios between .45 and .55, ensured that these groups saw different distributions of magazine behaviour throughout the observation sessions. However, a ratio measure does not establish that, except for the influence of the light on its distribution, the demonstrators' magazine behaviour was comparable, i.e., that equal numbers of tray entries were made. This pattern of responding would be suggested if, in addition to satisfying the criteria for elevation ratios, there were no differences in the number of magazine responses made by groups DEMCOND and DEMRAND during the final observation session. The total magazine response data are presented in Figure 3.1. Analysis of variance revealed that Group DEMCOND made a greater number of magazine entries than Group DEMRAND ($F(1,14) = 6$, $p< .05$). The potential importance of this variable for interpreting the observers' behaviour is discussed below.

The left hand panel of Figure 3.2 shows the mean elevation ratios for each observer group for the three acquisition tests. A split plot analysis of variance of these data, with type of observational experience (COND or RAND) as a between subjects factor, and test number (1 to 3) as a within subject factor, failed to find any reliable effects (Fs< 1).

The mean elevation ratios for all 10 CSs presented during the extinction test are presented in the right hand panel of Figure 3.2. Surprisingly, given that the expected outcome of a social learning experiment is matching behaviour (see chapter 1, sections 1.1.2 and 1.3.1), in comparison with Group RAND, Group COND suppressed their magazine entries during the light, ($F(1,14) = 4.69$, $p< .05$). That is, when they had seen a demonstrator making the majority of its magazine responses during a light, observers withheld their magazine responses when the light was on relative to observers that had seen a demonstrator whose magazine behaviour was unaffected by the light.

The behaviour of Group COND following exposure to a CS-> US contingency could have been the result of learning about one of two relationships: 1) an excitatory relationship between the light and an aversive US (thus, when the light was turned on the observer came to expect an aversive outcome, and withdrew from the vicinity of the light and food magazine); 2) an inhibitory appetitive relationship, where the light signals to the observer that an expected, appetitive

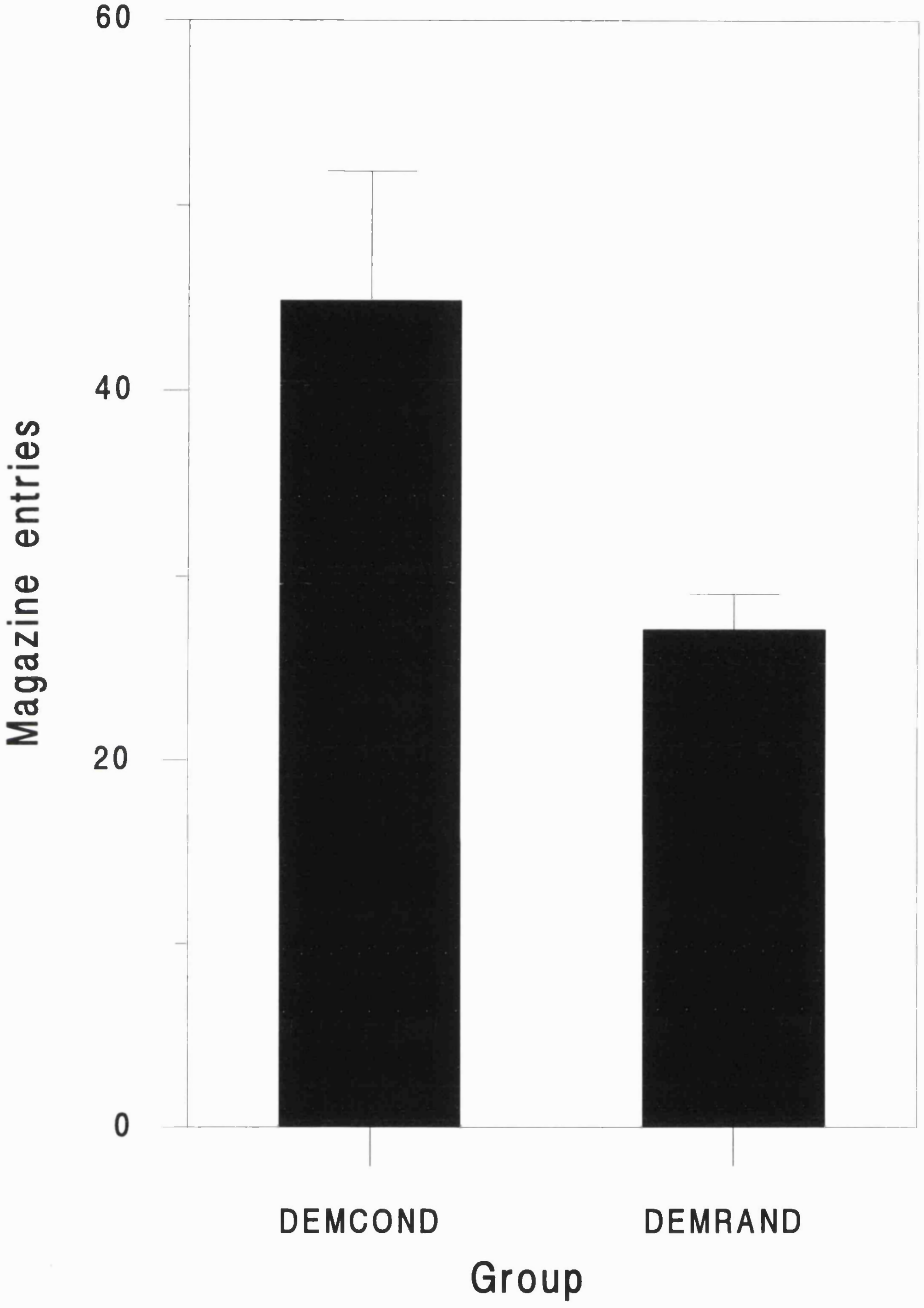

Figure 3.1. Total number of magazine entries made by the demonstrators during the final observation session in Experiment 1. Error bars indicate SEMs.

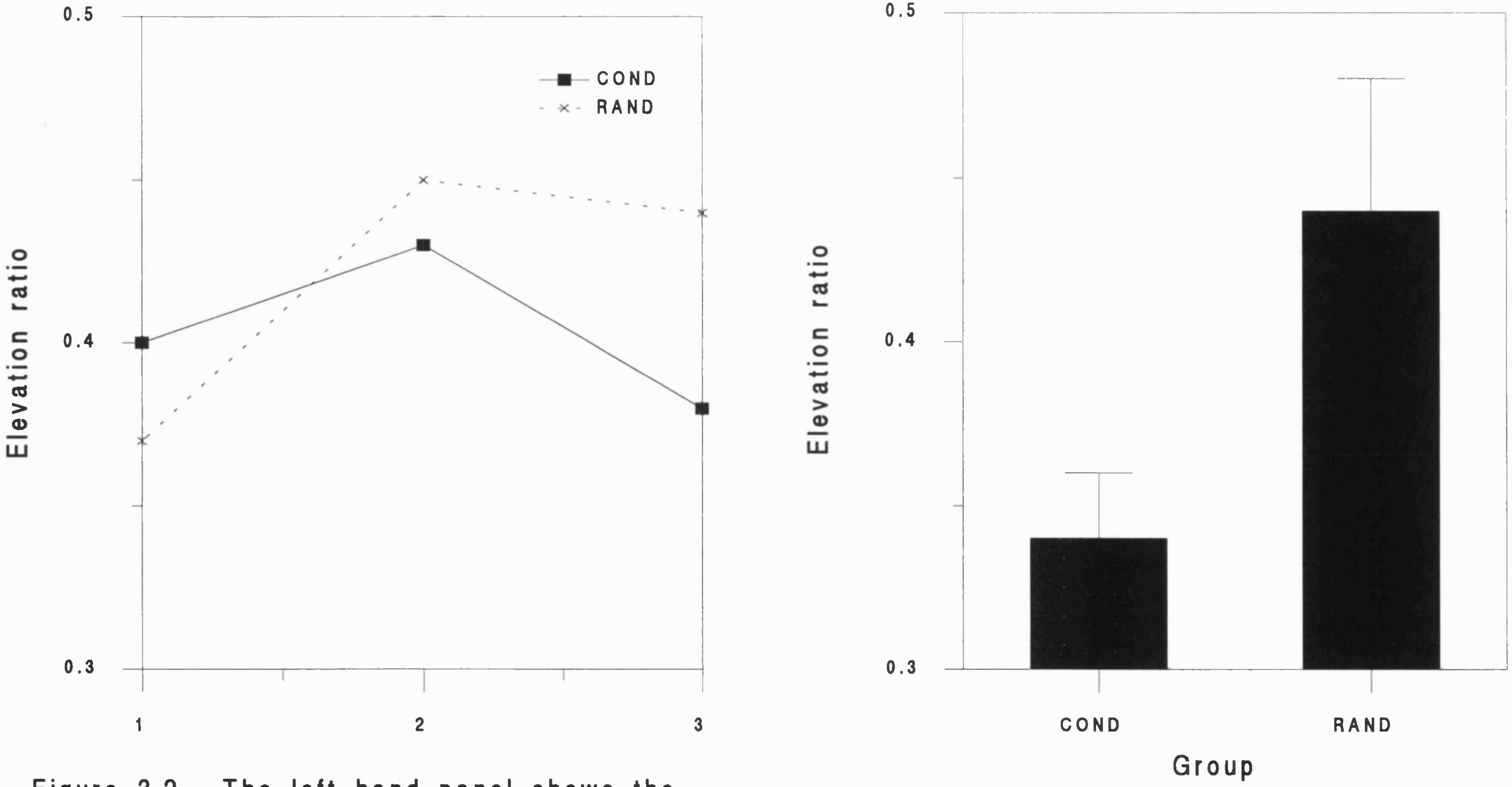

Figure 3.2. The left hand panel shows the mean elevation ratios of observer magazine behaviour to the light in three acquisition tests in Experiment 1.
One observation session preceded Test 1. Tests 2 and 3 occurred after a further five and six observation sessions respectively.

The right hand panel shows the mean elevation ratios of observer magazine behaviour to ten presentations of the light in extinction in Experiment 1. Error bars indicate SEMs.

reinforcer is to be omitted, inhibiting the animal's ongoing magazine behaviour.

It seems implausible that an observer should learn an excitatory-aversive relationship from this observational experience. The candidate associates of the light, the operation of the food magazine which has previously been paired with food, the sight of a feeding conspecific, and a demonstrator's magazine approach behaviour, are unlikely to be aversive. There are data, for example, which show that animals will approach a conspecific that is eating (Galef, 1971), indicating that it is an appetitive stimulus. Thus, the remainder of the experiments in this chapter explore the second possibility, i.e., that the observers' learning is inhibitory.

Suppression of responding to the light in Group COND following extended training may account for the failure to find reliable effects in the acquisition tests. Earlier inhibitory performance may have been masked by the conflicting appetitive contingency between the light and food.

Group COND saw a contingent relation between the light and a demonstrator's food-related magazine behaviour, and, relative to Group RAND, observers in Group COND came to avoid the magazine when the light was on. Although Group RAND observed the same number of events, because the lights and food presented to their demonstrators were scheduled independently, they were not exposed to a contingency between food arrival, its influence on the demonstrator's magazine behaviour, and the light. However, interpretation of these suppression data as evidence for the activity of contingency sensitive, or associative processes, in social learning is not straightforward. First, the experiment did not establish that the suppression of magazine behaviour by Group COND is a social learning effect. An opportunity for the stimuli associated with the operation of the food magazine to acquire conditioned reinforcing properties was provided by the observers' magazine training, i.e., their occurrence was followed by food (Rescorla, 1980). Thus, during observation when no food was delivered to the observers, Group COND could have learned that a negative contingency existed between the light and the arrival of food which the operation X of the food magazine predicted. To exclude this possibility, in the remaining experiments the observers were not magazine trained. In order to repudiate all varieties of asocial mediation, ? Experiment 3 included two additional groups. Group ASOC RAND saw random presentations of the light and inaccessible food without a demonstrator present, and, again in the absence of a demonstrator, Group ASOC COND were exposed to pairings of the light and the delivery of inaccessible food. Comparable magazine behaviour by these two asocial groups would suggest that the suppression in magazine behaviour shown by Group COND in the present experiment was dependent on a demonstrator, i.e., it would implicate social learning.

The second reason for questioning whether, despite the use of a truly random control group, social associative learning was responsible for the suppression shown by Group COND concerns the nature of the outcome of one of the two contingencies not experienced by Group RAND. Group COND were exposed to two contingent relationships, one between the light and the demonstrator receiving a food pellet, and a second between the light and the demonstrator's magazine entries. In itself, the existence of two contingencies is unproblematic for an associative interpretation of learning; a difference relative to a truly random control would establish that one of the contingencies was necessary for learning. It is the demonstrator's magazine behaviour that undermines the associative inference, because it seems plausible that this behaviour had non-associative effects on the way in which the light was processed. For instance, it is reasonable to assume that a conspecific that makes magazine entry responses is more salient than a conspecific that does not. One consequence of attending to their demonstrators might be that Group COND observers attended less to the light than Group RAND. According to this interpretation, the two observer groups differed in their opportunity to habituate to the light. Therefore, rather than reflecting inhibitory associative learning, competition between responses might account for the Group COND's magazine behaviour being suppressed during the light: they did not enter the magazine because they were orienting to the non-habituated light. Given the parameters of the observational experience of the light prior to testing, i.e., eleven sessions in which the light was illuminated for 30s on ten occasions, an explanation relying on differential habituation may seem implausible. For example, Kaye and Pearce (1987) investigated habituation of orienting to a 10s light that was presented on six occasions during a session. It is apparent from their data that very little habituation occurred after the first six sessions. However, other varieties of stimulus processing account, discussed in subsequent experiments, are possible. Experiments 2 and 3 used summation and retardation tests (Rescorla, 1969) to establish that the light was a conditioned inhibitor, and, therefore, sought empirical confirmation that Group COND's behaviour was the result of associative learning.

Finally, in order to infer that Group COND learned associatively, all variables other than stimulus contingency must be constant across groups. However, not only did Group DEMCOND make more magazine entries during the light than Group DEM RAND, the data presented earlier suggested that they made more magazine entries in general. Thus, the significance of the light might have been the same for both Group COND and Group RAND, but because Group RAND saw less magazine behaviour in general, their baseline magazine entry responding may have been too low to see a suppression in the entries made during the light. However, this, or any other account which denies that different magazine behaviour was due to differences in learning (of whatever kind) about the light specifically, can be ruled out by analyzing the magazine responses that occurred during the pre-CS period. Figure 3.3 shows the observers' pre-CS behaviour. Analysis of variance failed to find a reliable difference in the number of magazine entries that each group made (F(1,14) = 2.97, ns) suggesting that, when the light was out, Group COND and Group RAND were making similar numbers of magazine entries. This suggests that it was the observers' behaviour during the light which was responsible for the different elevation ratios produced.

3.2 Experiment 2

Experiment 1 established that, if an observer is given the opportunity to respond to a stimulus which has previously signalled the delivery of food to a knowledgeable demonstrator, and if this observational experience is extensive, then the observer will suppress magazine behaviour in an extinction test. Experiments 2 and 3 investigated the possibility that this suppression effect was the result of the light becoming a conditioned inhibitor.

It was argued in the discussion of Experiment 1 that the activity of a conspecific during a CS might affect the degree to which that CS is processed, and, therefore, despite the comparison with a truly random control, the suppression in Group COND's responding may not have been due to inhibitory associative learning. Experiments 2 and 3 used procedures, retardation and summation tests (Rescorla, 1969), originally designed to unmask inhibitory learning, but which, in combination, confirm a stimulus' status as a conditioned inhibitor.

Although an inhibitory stimulus may have no direct behavioural effects, if it is subsequently reinforced, it will acquire excitatory properties slowly (Rescorla, 1969). This provides the rationale for the retardation test used in Experiment 2. If the light was a conditioned inhibitor of Group COND's magazine behaviour, it should, if paired with food, acquire excitation more slowly for Group COND than Group RAND. Thus, after fewer light-> food trials, Group RAND should make a greater proportion of magazine entries than Group COND when the light is on.

In addition, Experiment 2 sought to demonstrate that observers which had no direct experience of the light-> food relationship prior to the extinction test, and had not been magazine trained, would

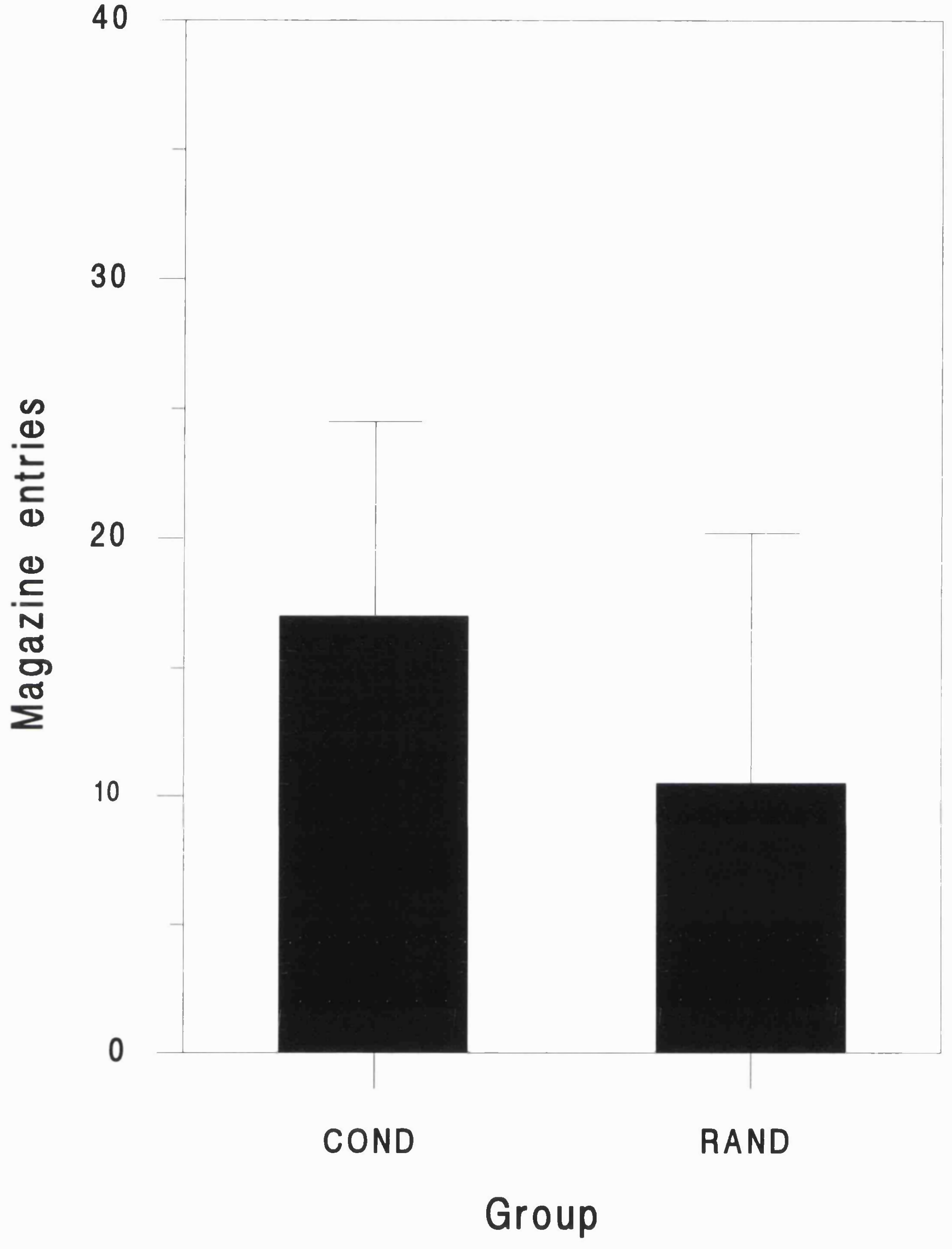

Figure 3.3. Total number of magazine entries made by the observers during the pre-CS period in Experiment 1. Error bars indicate SEMs.

suppress their tray entries when the light was on. This was to rule out the possibility, discussed in Experiment 1, that the conditioned reinforcing properties of asocial stimuli were responsible for the behaviour of the experimental group.

Procedurally, Experiment 2 was very similar to Experiment 1. Two groups of observers, Groups COND and RAND, this time without prior magazine training, were exposed to the corresponding groups of demonstrators used in the preceding experiment (Group DEMCOND or Group DEMRAND). Following extensive observational experience uninterrupted by acquisition tests, and an extinction test assessing the observers' magazine behaviour during the light, sessions were administered in which illumination of the light was paired with food.

Method

The method employed in Experiment 2 differed from that of Experiment 1 in the following respects.

Subjects

The animal's free feeding weights ranged from 492-568g and 416-495g for the eight demonstrators and 16 observers respectively.

Procedure

Demonstrator training. The demonstrators used in Experiment 1 received further training until the magazine behaviour of Group DEMCOND consistently produced elevation ratios of .75 or above, and those of Group DEMRAND ranged between .45 and .55.

Observer training and testing. Rather than magazine training, the observers received four daily 30 minute sessions of context exposure in the demonstration compartment with the house light on.

No acquisition tests were given in this experiment. Following 13 observation sessions, the observers were transferred to the demonstration compartment and responding to the light was tested in extinction. The demonstrators were removed from the experiment at this point.

On each of four days following the extinction test, the observers were given a 30 minute session in which the panel light was illuminated for 30s on 10 occasions, and followed immediately by the delivery of a food pellet. The mean ITI was three minutes, governed by an RT schedule. The observers' magazine behaviour was recorded during the light and the 30s period preceding its illumination. These sessions constituted the retardation test.

Results and Discussion

The requirement that Group COND were exposed to a cumulative elevation ratio greater than .75, while Group RAND were exposed to cumulative elevation ratios between .45 and .55, ensured that these groups saw different distributions of magazine behaviour throughout the observation sessions. Unfortunately, the demonstrator's data have since been lost, and, therefore, it has not been possible to assess the comparability of their total number of magazine entries. However, as suggested in the discussion of Experiment 1, even if there were a difference in the gross magazine activity observed by Group COND and RAND, a difference in the observer groups' baseline responding would be required in order to make it plausible that the amount, rather than the distribution, of observed magazine behaviour was responsible for the relative suppression of Group COND's responding. Analysis of the observers' pre-CS behaviour did not reveal such a difference in baseline responding (F(1,13) = 2, ns). These data are presented in Figure 3.4.

One animal from Group RAND was excluded from the analysis because it failed to make any magazine entries on test. Analysis of variance of the extinction test data failed to reveal a difference in the elevation ratios produced by Group COND and Group RAND in response to all 10 presentations of the light (F< 1). These data are shown in the left hand panel of Figure 3.5.

The right hand panel of Figure 3.5 shows the mean elevation ratios for the two observer groups during the extinction test when only the first five CS presentations were considered. Analysis of variance revealed a marginal effect of observed contingency, i.e., relative to the random control, Group COND's magazine behaviour was suppressed during the light, (F(1,13) = 4, p< .07). These observers had not been magazine trained and had not had direct experience of the light-> food relationship. This finding is consistent with hypothesis that the suppression was socially learned. As the suppression effect did not depend on the conditioned reinforcing properties of the most obvious contingent asocial event, the operation of the food magazine, it suggests that the effect was in some way reliant on Group DEMCOND.

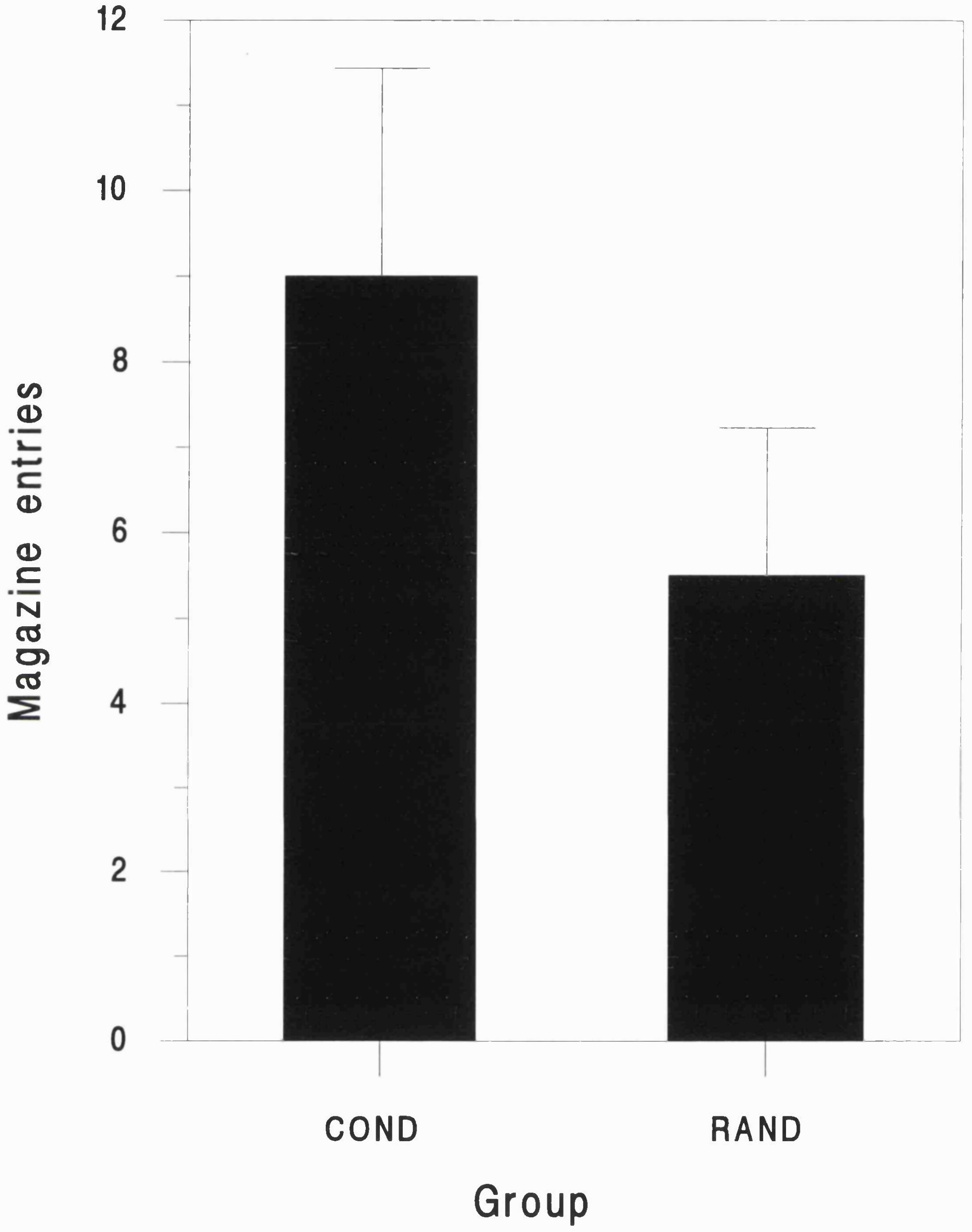

Figure 3.4. Total number of magazine entries made by the observers during the first five pre-CS periods in Experiment 2. Error bars indicate SEMs.

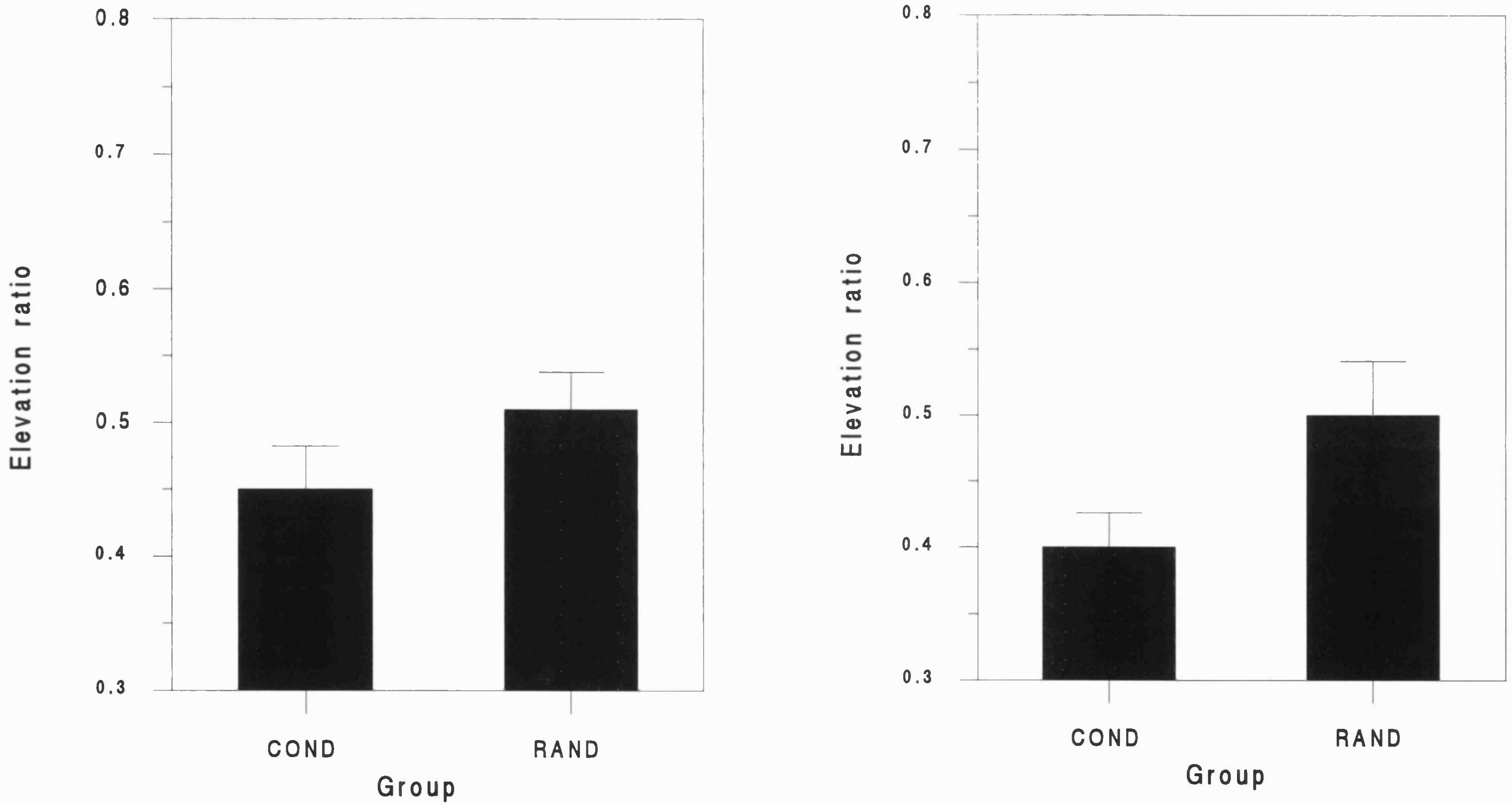

Figure 3.5. The left hand panel shows the observers' mean elevation ratios in response to ten presentations of the light in extinction in Experiment 2. Error bars indicate SEMs.

The right hand panel shows the observers' mean elevation ratios in response to the first five presentations of the light in extinction in Experiment 2. Error bars indicate SEMs.

Inhibition does not extinguish, rather a CS in extinction acquires inhibition (Mackintosh, 1983). Therefore, the disappearance of the group difference in magazine responding when behaviour during all 10 CSs was analysed might be considered inconsistent with the idea that the light is a conditioned inhibitor. In fact, however, it is likely that as the session progressed the inhibition was no longer expressed in behaviour. According to this account, the extinction procedure abolished the baseline of conditioned responding, previously maintained by some excitatory associative relationship. A response that is not emitted cannot show suppression. The results of the retardation test make the latter explanation plausible.

Figure 3.6 shows the mean elevation ratios produced by the experimental and random control groups in response to the light when it was paired with food during the retardation tests. Analysis of variance revealed a marginal group difference and confirmed that Group COND made fewer magazine responses to the light than Group RAND ($F(1,13) = 3.35$ p, <.09). There was a significant effect of test ($F(3,39) = 6.31$, $p < .001$), suggesting that both groups showed some learning over the course of the tests, and there was no reliable interaction effect, ($F < 1$).

Thus, the proposal that the suppression effect, observed for the second time in Experiment 2, is due to inhibitory learning gained preliminary support. Those observers who had reduced their magazine behaviour to the light early in the extinction test learned, in a subsequent phase, an excitatory association between the light and food more slowly than random control observers. This means that, were the light subsequently to pass a summation test, its ability to do so cannot be attributed to external inhibition (Pavlov, 1927). It could not be, that is, that Group COND were continuing to orient to a stimulus which, because their attention had been distracted from it by a demonstrator making magazine entries, had not received sufficient processing to allow habituation.

3.3 Experiment 3

An inhibitory stimulus will acquire excitation slowly. However, a stimulus which passes the retardation test is not necessarily a conditioned inhibitor (Rescorla, 1969). A stimulus that is no longer attended to, or is latently inhibited (Lubow, 1973), is also slow to condition. Therefore, to qualify as a conditioned inhibitor, a stimulus that is slow to condition must pass a summation test (Rescorla, 1969), i.e., when presented in compound with an excitor, it must reduce the level of responding governed by the excitor alone.

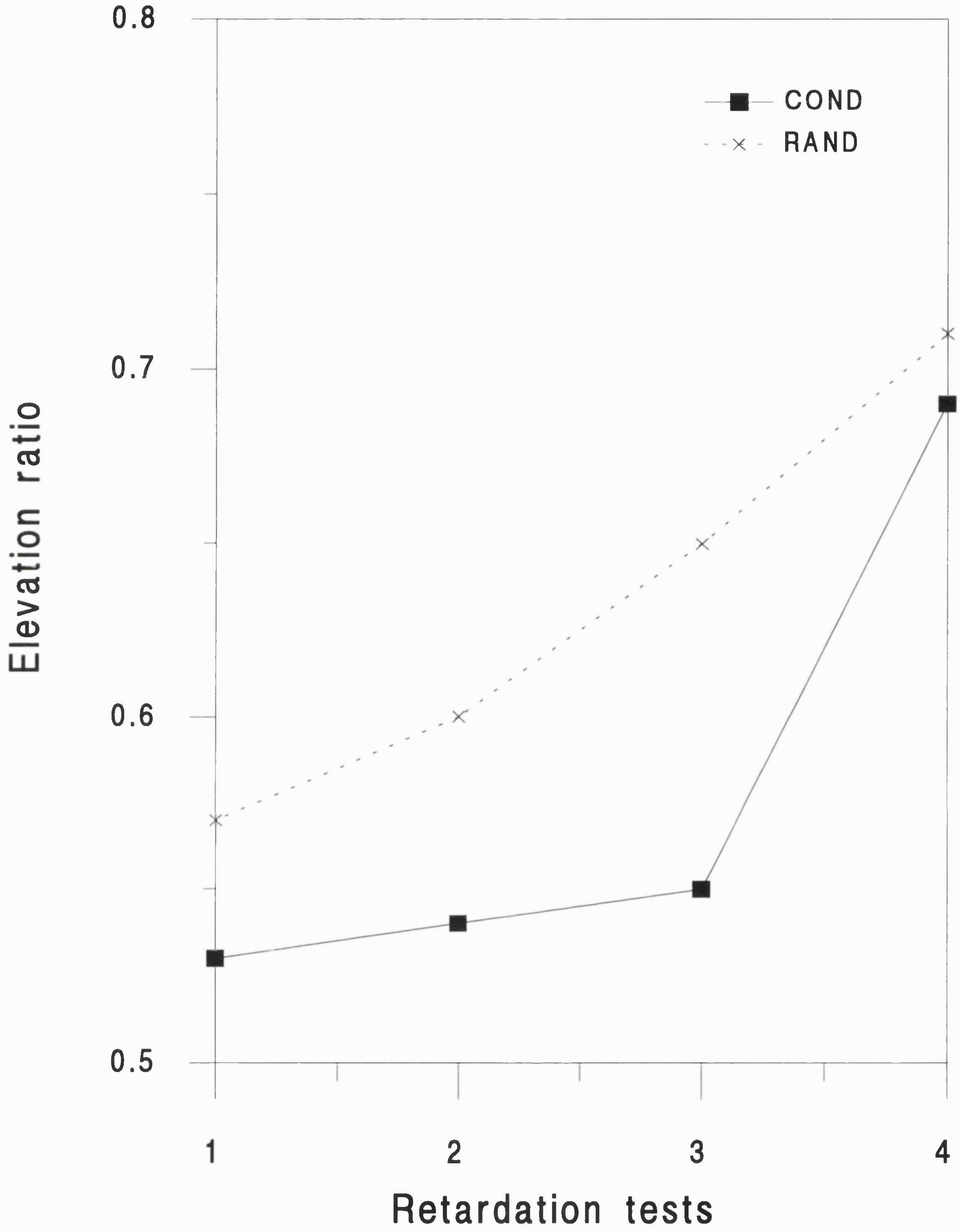

Figure 3.6. The observers' mean elevation ratios in response to the reinforced light presented in the retardation tests in Experiment 2. Error bars indicate SEMs.

Experiment 2 investigated the possibility that processing of the light was disrupted in Group COND. However, as the previous paragraph suggests, if stimulus processing were enhanced in some way, this also might account for the suppression effect. For example, if a demonstrator that orients in the vicinity of a stimulus attracts attention to the stimulus, the effects of stimulus processing, i,e., habituation of orienting, and (the acquisition of) latent inhibition, should be more profound (Hall, 1991). According to this account, during the extinction test Group COND made fewer magazine entries when the light was on because habituation of general exploratory responses to a novel stimulus, in this case a light, was more complete in this group. A relative enhancement of latent inhibition explains their retarded conditioning to the light. However, if, in a summation test, the light were to reduce the behaviour produced in response to a trained excitor, Group COND's behaviour could not be explained in terms of enhanced latent inhibition. A stimulus that is not attended to should not influence behaviour. Therefore, in combination with the successful retardation test, if the light were to summate with an excitor to reduce responding, it would suggest that the light was an inhibitory stimulus.

Thus, in Experiment 3 following observational experience of the light similar to that of the previous experiments, a second auditory, stimulus was conditioned, i.e., food was delivered to the observers when a quiet 30s clicker terminated. (Previous experiments using a loud tone, the volume of which could not be manipulated because of faults in the apparatus, failed to demonstrate inhibition. This may have been because the excitor was sufficiently salient to overshadow any inhibitory effects of the light). During the summation test session, trials of the clicker alone were intermixed with trials on which the light and clicker were presented in compound, and magazine behaviour during each trial type was recorded. It was thought that measuring the baseline of responding to the excitor and responding to the compound of the excitor and putative inhibitor within the same session would maximise the sensitivity of the summation test to the light's inhibitory properties. (Previous experiments comparing magazine behaviour during the compound with magazine behaviour during the clicker on the final day of excitatory training were unsuccessful in yielding evidence of inhibition).

Experiment 3 had a second purpose. In combination, the arguments advanced so far suggest that if suppression were a) found in non-magazine trained animals and, b) established as the result of inhibitory learning, a variety of social associative learning would be implicated. Its inhibitory nature, because it would have been diagnosed by two tests which together rule out stimulus processing explanations, would establish the necessity of a reinforcer, or associate. The fact of the effect's existence in the absence of prior individual magazine training would rule out the influence of the most obvious asocial source of reinforcement, the conditioned reinforcing properties of the stimuli associated with the operation of the food magazine. Experiment 3 tested the social learning hypothesis directly. In addition to replicating Groups COND and RAND from the previous experiment, Experiment 3 included two further groups of observers, ASOC COND and ASOC RAND. Except that there was no demonstrator present in their training sessions, the observational experience of Groups ASOC COND and ASOC RAND matched that of their social counterparts. The ASOC observer groups were run in order to test empirically whether Group COND's suppression was learned socially. The social learning hypothesis requires that suppression is not generated when the light and food have been experienced without a demonstrator being present.

To summarise the procedure: Following extensive observational experience, the magazine behaviour of four groups of observers in the presence of a light was examined: Group COND, Group RAND, Group ASOC COND and Group ASOC RAND. A second stimulus was then conditioned with food in order that the light's influence on its CR could be assessed.

Method

The method differed from that used in Experiment 1 in the following respects.

Subjects

Forty male hooded Lister rats, obtained from Harlan Olac Ltd (Bicester, Oxon.) served as subjects. The eight demonstrators had been subjects in previous instrumental experiments. Their free feeding body weights ranged between 382- 492g. The remaining 32 animals were experimentally naive and served as observers. They were randomly assigned to one of four groups; COND, RAND, ASOC COND, ASOC RAND. The observers' free feeding body weights ranged between 352- 492g.

Apparatus

A 30s, 30 dcb clicker provided the second stimulus. The clicker was delivered from the speakers situated on the side wall of the demonstration compartment between the houselight and the CS.

Observer training and testing. The observers were not magazine trained. They each received 10 sessions of observational training. There were no demonstrators present during the training sessions of the ASOC observers. In all other respects their observational experience was identical to that given to their social counterparts, Groups COND and RAND, in the Experiments 1-3.

Following the extinction session in which the observers' magazine behaviour towards the light was tested, the observers received three daily sessions of excitor training. For these, and in the subsequent test sessions, the observers were placed in the demonstration compartment. A session consisted of 10 30s clicker presentations which terminated in the delivery of a food pellet. The mean ITI was three minutes, governed by an RT schedule. In addition to the total number of magazine entries made in each session, the observers magazine entries during the clicker and the 30s period which preceded its presentation were recorded.

The summation test session was given the day after the final session of conditioning to the clicker. The session, which was given in extinction, consisted of five presentations of the clicker randomly intermixed with five compound trials when the clicker and light were presented together. The mean ITI was three minutes. Magazine entry data was recorded during the 30s trials and the 30s pre-CS periods.

Results and Discussion

Elevation ratios of the observers' magazine behaviour during each test session were calculated.

For their observers to be included in the experiment, animals in Group DEMCOND were required to have cumulative elevation ratios of greater than .75, the criterion for Group DEMRAND animals was a ratio that fell between .45 and .55. Figure 3.7 shows the mean number of magazine entries made by the demonstrators during the final session of observational training. Analysis of variance failed to find a difference between the two demonstrator groups on this measure (F(1,14) = 1.1, ns), suggesting that Group COND and Group RAND were exposed to equivalent absolute levels of magazine behaviour, but that that behaviour was distributed differently across CS and pre-CS periods within the session.

Two-way analysis of variance of the observers' extinction test data failed to reveal a difference in the elevation ratios produced by the different groups in response to the light when all 10 light

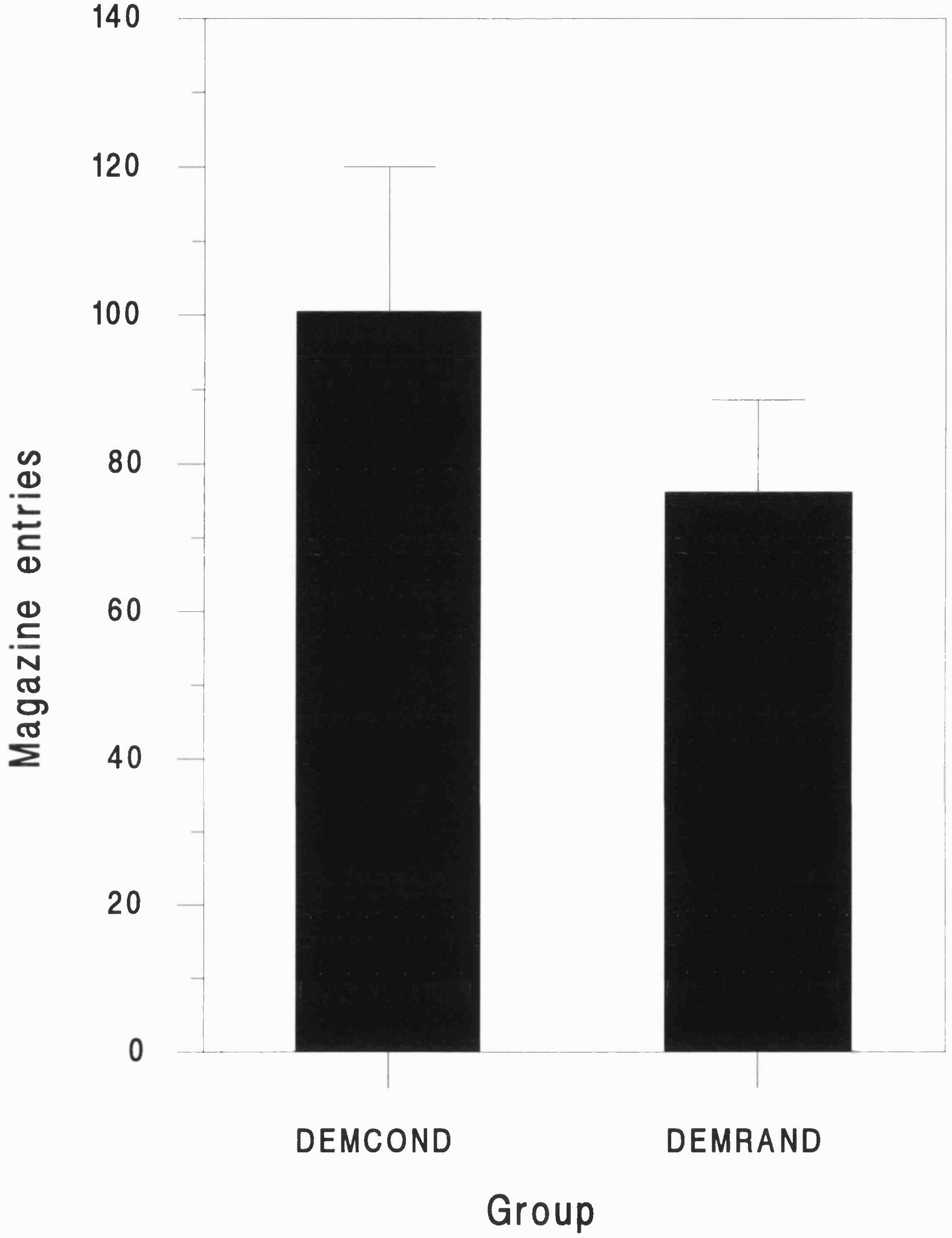

Figure 3.7. Total number of magazine entries made by the demonstrators in the final observation training session in Experiment 3. Error bars indicate SEMs.

presentations were considered. These data are presented in the left hand panel of Figure 3.8. There was no evidence of an effect of the contingency between light and food ($F < 1$). The presence of a demonstrator had no influence on the elevation ratios that the observers produced ($F(1,28) = 1$, ns). The interaction of these two variables was also not reliable ($F < 1$).

The right hand panel of 3.8 shows the observers' mean elevation ratios when only the first five CSs of the extinction test were considered. The data from one animal in Group COND, a statistical outlier whose responding fell more than two standard deviations from the group mean, were removed from the analysis (Tukey, 1977). A two way analysis of variance failed to find a main effect of the presence of a demonstrator ($F(1,27) = 2.89$, ns). However, the magazine responding during the light of the two observer groups that saw a contingent relationship between the light and food (Group COND and Group ASOC COND) was suppressed relative to the two random control groups ($F(1,27) = 6.05$, $p < .02$). Although there was no reliable interaction between the nature of the observed contingency and the presence of a demonstrator ($F < 1$), simple effects analysis of variance showed that while Group COND's magazine behaviour was significantly suppressed relative to that of Group RAND ($F(1,27) = 8.4$, $p < .05$), responding by Group ASOC COND did not differ from that of Group ASOC RAND ($F(1,27) = 1.53$, ns) (see Howell 1987, p. 376 for justification of simple main effects ANOVA without a reliable interaction). It would seem, therefore, that in order for an observer to suppress their magazine behaviour in response to a light that has been paired repeatedly with inaccessible food, a demonstrator must be present. Thus, the suppression effect documented in Experiments 1-3 is the result of social learning.

Figure 3.9 shows the mean elevation ratios of magazine behaviour produced by the four observer groups during the summation test session. The filled bars show responding that occurred when the clicker, a conditioned excitor, was presented alone. Responding during the simultaneous presentations of the clicker and the light is represented by the open bars. The data were analysed using a three way mixed model ANOVA. The between subject factors of the analysis were the presence or absence of a demonstrator, and whether a contingency existed between the presentations of light and food. Whether the observer was responding to the excitor presented alone or to the excitor/inhibitor compound was the within subject variable. This analysis failed to find any reliable main effects ($Fs < 1$). The interaction effect between trial type and whether or not a demonstrator was present was reliable, ($F(1,27) = 4.95$, $p < .05$). A marginally significant three way interaction effect was also found ($F(1,27) = 3.69$, $p < .06$). Subsequent simple

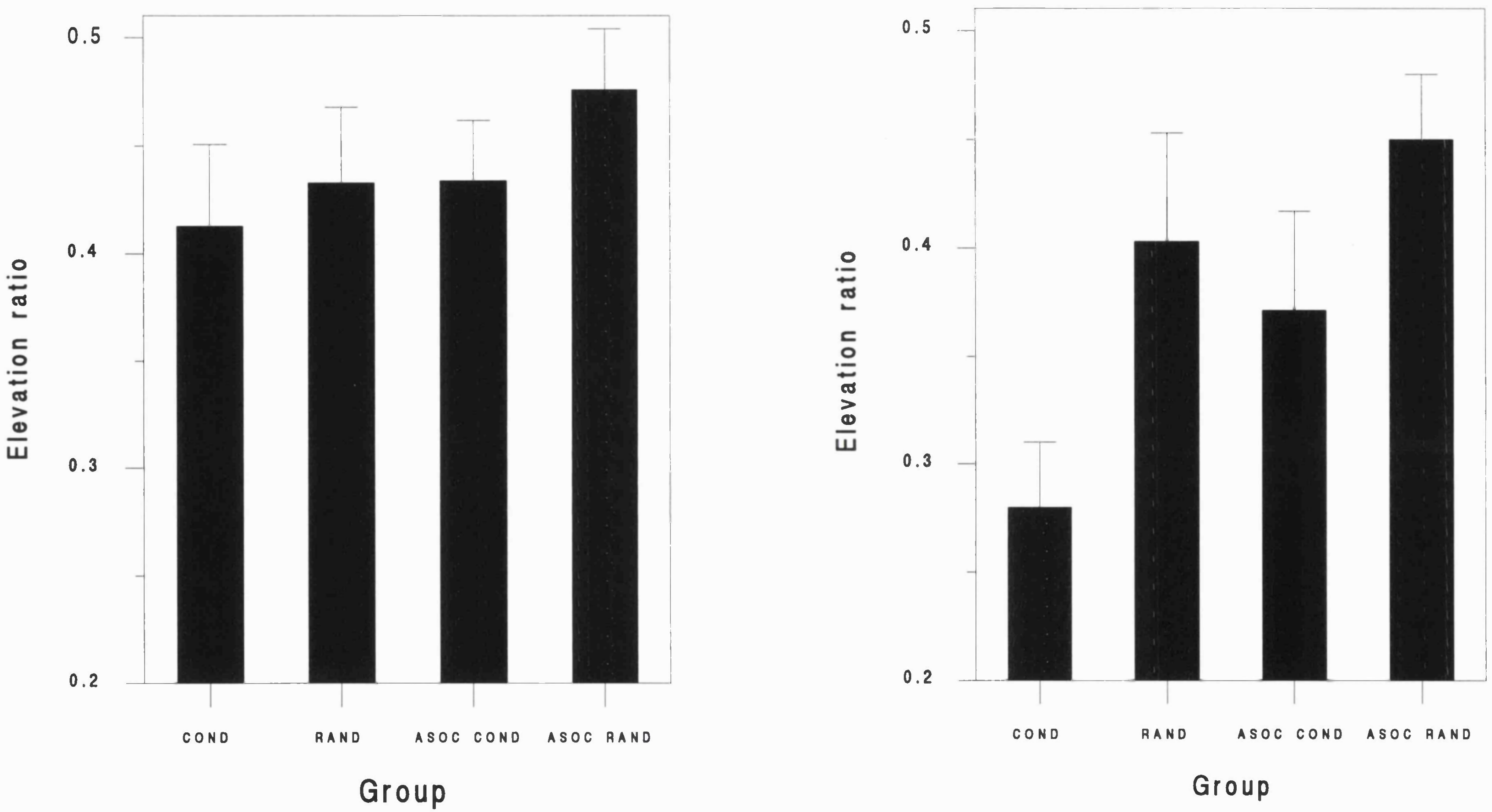

Figure 3.8. The left hand panel shows the observers' mean elevation ratios in response to all ten presentations of the light in extinction in Experiment 3. Error bars indicate SEMs.

The right hand panel shows the observers' mean elevation ratios in response to the first five presentations of the light in extinction in Experiment 3. Error bars indicate SEMs.

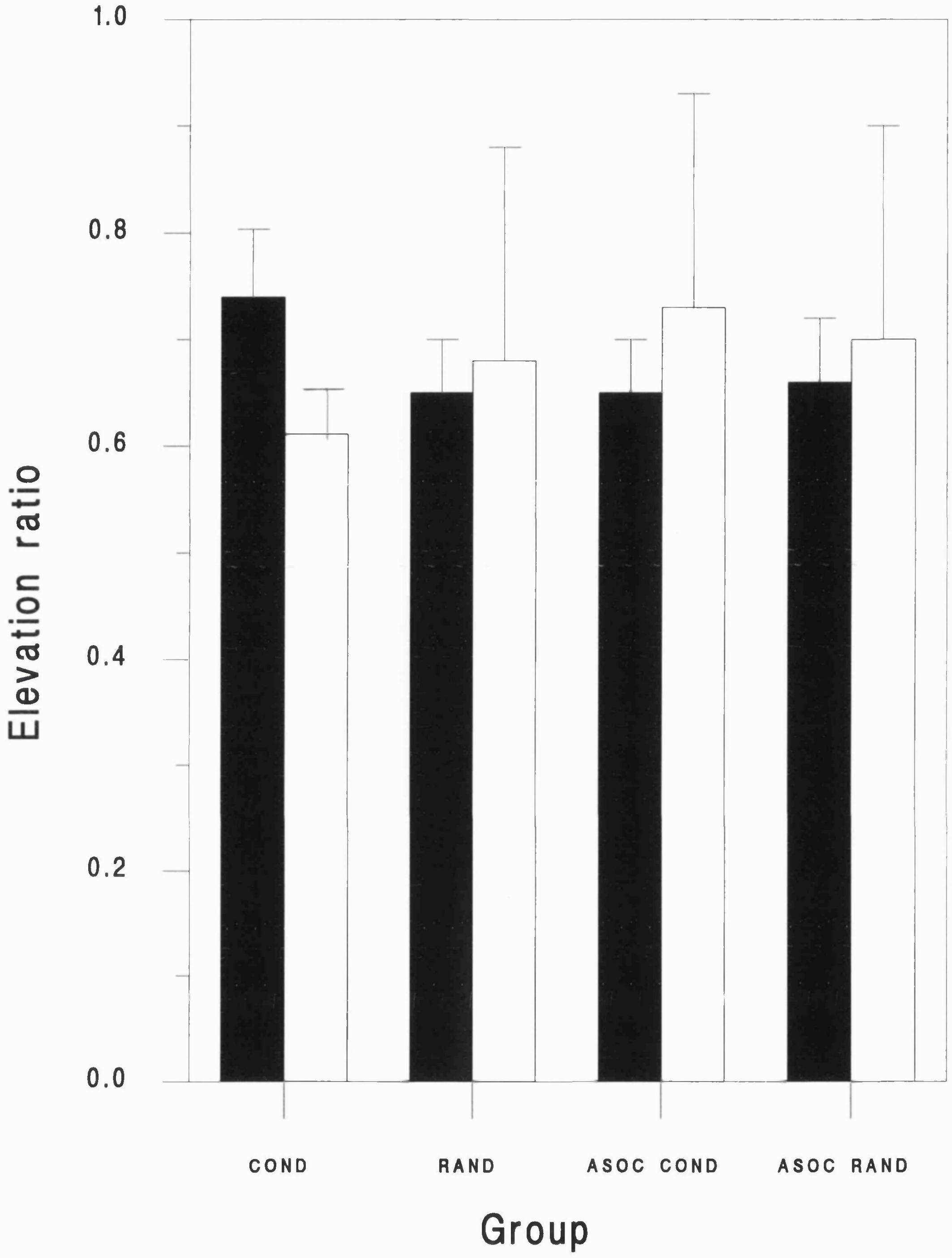

Figure 3.9. The observers' mean elevation ratios in response to the clicker alone (filled bars), and to the light/clicker compound (open bars) presented in the summation test in Experiment 3. Error bars indicate SEMs.

interaction effects analysis of the within subject factor revealed that the light inhibited excitatory responding in Group COND (F(1,27) = 6.6, p< .05). The remaining three groups produced comparable elevation ratios to the light and light/clicker compound; Group ASOC COND (F(1,27) = 2.3, ns), and Groups RAND and ASOC RAND (Fs< 1).

Thus, it would seem that the light, if it has been experienced socially in combination with a demonstrator for whom it signalled the arrival of food, inhibited behaviour maintained by an excitatory appetitive stimulus. In combination with the data from Experiment 2 which showed that Group COND were slow to learn an excitatory relationship involving a light that had been paired with food, the success of this summation test confirms that, for these observers, the light was a conditioned inhibitor. Additionally, taken together, the results of the summation and retardation tests rule out stimulus processing explanations of the suppression effect: A stimulus that is not attended to should not summate with an excitor to cause suppression, and, conversely, conditioning of a stimulus subject to enhanced attention should not be slow. Thus, Experiment 3 not only identifies the specific, inhibitory, nature of Group COND's conditioning, it confirms that the learning by Group COND was associative. In this particular case, the truly random control did not provide such confirmation.

In general terms then, the nature of Group COND's learning has been identified: it is social, it is associative and it is inhibitory. However, the question of exactly what the observers learned has not been addressed. To expand, it seems reasonable to suppose that eating a food pellet and approaching the magazine during the light, are the two most salient features which distinguish a demonstrator that expects food to be delivered following the illumination of a light, and a demonstrator for whom light and food are unrelated. It is not clear which of these features is influential in producing Group COND's suppression, or how. Either aspect of the behaviour of Group DEMCOND could serve to potentiate learning about an inhibitory relationship between asocial stimuli, or function as an event involved in the inhibitory relationship. Contingent eating would be implicated if observers that had seen an untrained demonstrator, one that distributes its responding throughout the session irrespective of light presentations, were, like Group COND, to show suppression. If the relevant aspect of the demonstrator is itself learned about, rather than potentiating, suppression should be apparent in observers that have received the same observational experience as Group COND but following a phase in which the inaccessible food has been delivered repeatedly. During this initial phase, any conditioned reinforcing properties that the sight and smell of a food pellet might have should extinguish. This result would make the hypothesis that the reinforcer responsible for inhibition is asocial yet more implausible (see Experiment 2). The data from Experiments 5 and 6, which used a modified version of the procedure established in Experiment 4, address to these issues.

3.4 Experiment 4

Although procedurally very similar to Experiments 1 to 3, the rationale for Experiment 4 was somewhat different. The experiment, which was begun when it was proving difficult to diagnose inhibition using the summation and retardation tests, sought evidence of inhibitory learning in Group COND by an alternative, indirect manipulation; by attempting to establish that, with fewer observational sessions, observers in Group COND would show an elevation in responding to the light.

The procedure used to generate inhibition is similar to the procedure for second-order conditioning, yet the outcomes are very different; a reduction in responding in the case of inhibition, and an increase in responding in the case of second order conditioning (Rescorla, 1980). Taking an appetitive paradigm as the example, both the procedures involve two separate event relationships, a pairing of one CS, CS1, with a positive outcome such as food, and a second CS, CS2, that is followed by CS1. Typically these two trial types are interspersed in the case of inhibition training, and blocked for second-order conditioning, CS1-> food trials preceding CS2-> CS1 trials. The critical factor in determining the type of association found is the number of CS2-> CS1 trials; inhibitory associations require more extensive training (Yin, Barnet and Miller, 1994).

Without needing to identify which event functions as CS1, we can surmise that if the suppression of responding by Group COND observers after many observation sessions is indeed due to inhibition, if tested after fewer sessions, their responding to the light should be enhanced relative to truly random control animals.

Method

The method differed from that of Experiment 1 in the following respects.

Subjects

Sixteen naive, male hooded Lister rats were observers. Their free feeding weights ranged between 380-497g. The eight demonstrators from the previous experiment served again (free feeding body weights, 382-492g).

Procedure

Observer training and testing. The observers were not magazine trained. The observers were tested for their responding to the light in extinction following four observation sessions.

Results and Discussion

Figure 3.10 shows that the mean elevation ratios of magazine behaviour produced by Groups COND and RAND were identical ($F< 1$). This suggests that, when only four observation sessions were administered, the nature of the observational experience received, i.e., whether the demonstrator's food related activity was observed to be contingent on the light, was irrelevant to the light's influence on the observers' behaviour.

It is possible that, with a different amount of observational exposure one could isolate the peak in Group COND's magazine behaviour predicted by a second order conditioning account. However, rather than varying the amount of observational experience, Experiments 5 and 6 sought evidence of second order conditioning using behavioural indices other than magazine entry.

3.5 Experiment 5

For ease of exposition, in the subsequent discussions of the rationale for Experiments 5 and 6 it is assumed that Group COND have learned something about their demonstrators. Thus, it is supposed that, rather than facilitating an association between asocial stimuli, some aspect of the demonstrator's light contingent behaviour was associated with the light. However, the hypotheses investigated in the remaining experiments could be applied to the former, and as we have seen, less plausible, social potentiation account. These hypotheses concern the failure to demonstrate second order conditioning in Experiment 4.

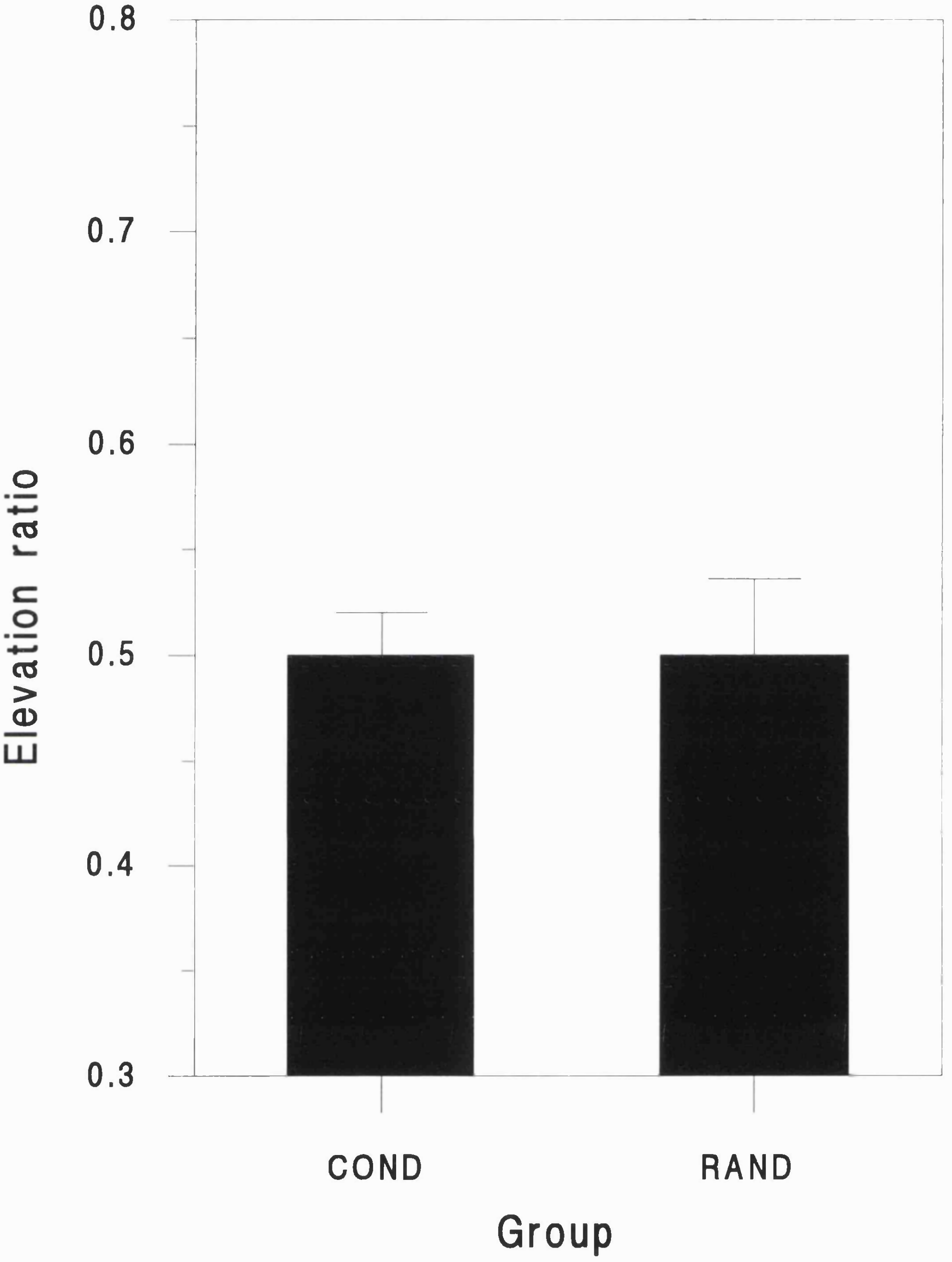

Figure 3.10. The observers' mean elevation ratios in response to the light in extinction in Experiment 4. Error bars indicate SEMs.

If the parameters used in Experiment 4 were not inappropriate to show second order conditioning effects, then perhaps the wrong CR was measured. To expand, Experiments 1-3 found reliable effects of whether or not observational experience involved a contingency between events on magazine behaviour, and, therefore, it has been assumed that what was learned by Group COND affected their magazine behaviour directly. The veracity of this assumption is crucial if the summation and retardation tests are to confirm that inhibition was responsible for Group COND's behaviour. Ordinarily, when summation and retardation tests are used to diagnose inhibition, because the reinforcer used to establish inhibition is the same as the reinforcer used to condition the excitor, opposing effects on the same CR are conditioned to different stimuli. However, the potential scenario we are considering is one where different reinforcers are involved in the putatively inhibitory, and in the excitatory relationship, and consequently the "inhibitor" affects a CR dissimilar from that affected by the excitor. In this case, it is possible that, rather than inhibiting the ongoing excitatory behaviour, a stimulus that summates with an excitor to reduce the magnitude of the excitatory response may do so by providing a competing excitatory CR. A CR that competes with magazine behaviour may also explain the original suppression shown by Group COND in response to the light.

In Experiment 3, the clicker used in the summation test had been conditioned with food, and, therefore, elicited tray entries. What, however, is the source of CS1 during observational exposure? In the discussion of Experiment 3 two aspects of the Group DEMCOND's behaviour were outlined as possible associates of the light: the demonstrator's magazine behaviour during the light, and their consumption of a food pellet. In fact, because there are two potential effects of the demonstrator's magazine behaviour, there are three possible associates. Firstly, according to an S-R hypothesis, the demonstrator's magazine approach behaviour is itself acquired and associated with the light. It might seem prima facie unlikely the observers acquire a response that they do not perform. However, this consideration is not decisive because Heyes and her associates (e.g., Heyes and Dawson, 1990; Heyes, Dawson and Nokes, 1992) have shown that rats can learn an instrumental response by observation. Secondly, the demonstrator's responses may function as a consequent stimulus that becomes associated with the light. Finally, the light may become associated with the sight of an eating demonstrator. In the latter two cases, the relevant aspect of the demonstrator may be acting as a conditioned reinforcer, a CS1. It is not possible to determine from these rather loose characterisations of potentially effective CS1s whether to expect conditioned reinforcing effects to be manifest in a CR other than magazine entry. Therefore, the remaining two experiments take seriously the idea that, in this case, the summation and retardation tests, while confirming that the light is involved in an associative relationship, may be insufficient to establish its inhibitory properties. Two alternative associative explanations for suppression are explored.

Holland (1977) showed that, in the course of second order conditioning of a light by a CS1 that had reinforcing properties endowed by its prior association with food, orienting to the light developed at the expense of magazine behaviour. Therefore, had it been measured in the previous experiment, orienting behaviour may have revealed second order conditioning, i.e., Group COND may have oriented more than Group RAND. This account could then explain the suppression in Group COND's magazine behaviour after extended training as inhibition, but not necessarily of their magazine behaviour. Rather, it was the fortuitous result of the light's position above the magazine. By inhibiting orienting to the light, or associating the region around the illuminated light with an aversive motivational state (see Mackintosh, 1983, for various accounts of the associative structure underlying inhibition) the observers came to withdraw from that area which happened also to house the magazine. This hypothesis, tested in Experiment 6, would be consistent with more orienting by Group COND than Group RAND after limited, but not extensive, observational experience.

Second, it is possible that excitatory second order conditioning to the light was directly responsible for the suppression in magazine behaviour shown when the light was illuminated. According to this account, a CR, such as orienting, the performance of which is incompatible with the magazine approach, develops slowly. This explanation, which was tested in Experiment 5, would be supported if Group COND were found to orient more than Group RAND with the parameters previously associated with the inhibition of magazine responding.

Thus, Experiment 5 used a modified version of the existing procedure. Observers were tested for their responding to the light after 10 observation sessions. In addition to recording their magazine behaviour, the sessions were videotaped so that the observers' orienting behaviour could be assessed.

Method

The procedure used in Experiment 5 differed from that of Experiment 1 in the following respects.

Subjects

Sixteen experimentally naive hooded Lister rats served as observers and were randomly assigned to Group COND or Group RAND. Their free feeding body weights ranged between 354- 476g.

Apparatus

A square, 5 x 6.5 cm, was marked on the perspex ceiling surrounding the panel light used as the CS in previous experiments. One side of the square was flush with the chamber wall which contained the panel light. If an animal's nose entered the area of the square, an orienting response was recorded.

Responding by the subjects to the light was recorded by video cameras (Sanyo, model no. VW-D3P and JVC, model no. G2-S3) suspended 27 cm above the ceiling of the chamber. From this position, the entire demonstration compartment was visible.

Procedure

Observer training and testing. The observers were not magazine trained. The test session was given after 10 observation sessions run on consecutive days. In addition to measuring their magazine behaviour, the observers' orienting to the light was recorded on video.

Results and Discussion

Figure 3.11 shows the mean number of magazine entries made by the demonstrator groups in the last observation session. Analysis of variance showed that Group DEMCOND made a greater number of magazine entries than Group DEMRAND ($F(1,14) = 6.9$, $p < .02$).

The left and right hand panels of Figure 3.12 show the observers' elevation ratios of magazine behaviour in response to all 10, and the first five, CSs, respectively. Analysis of variance failed to find an effect of the type of observational experience on the magazine behaviour produced when the light was illuminated ($Fs < 1$).

Despite the failure to replicate the suppression effect, analyzing the orienting responses seemed

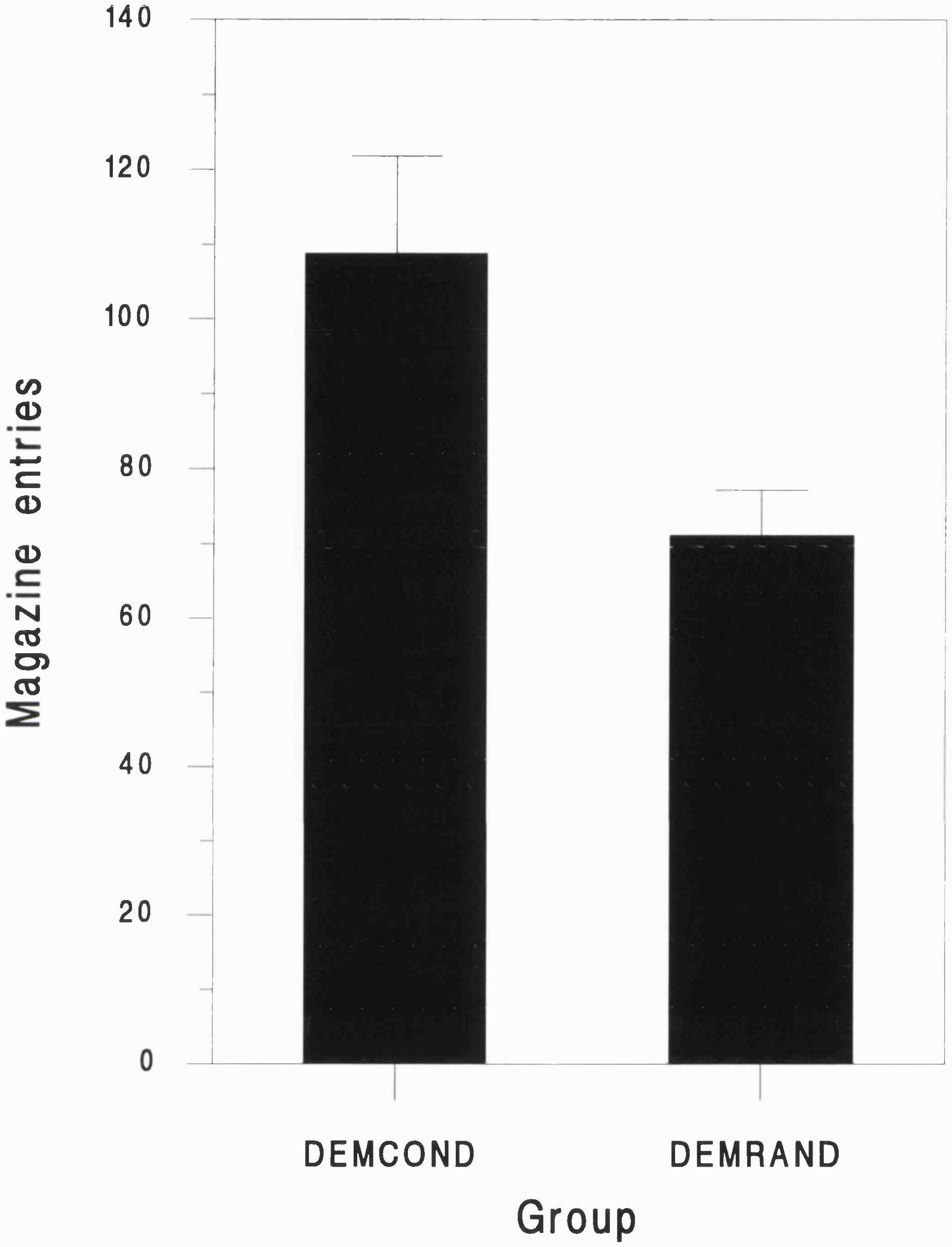

Figure 3.11. Total number of magazine entries made by the demonstrators in the final observation session in Experiment 5. Error bars indicate SEMs.

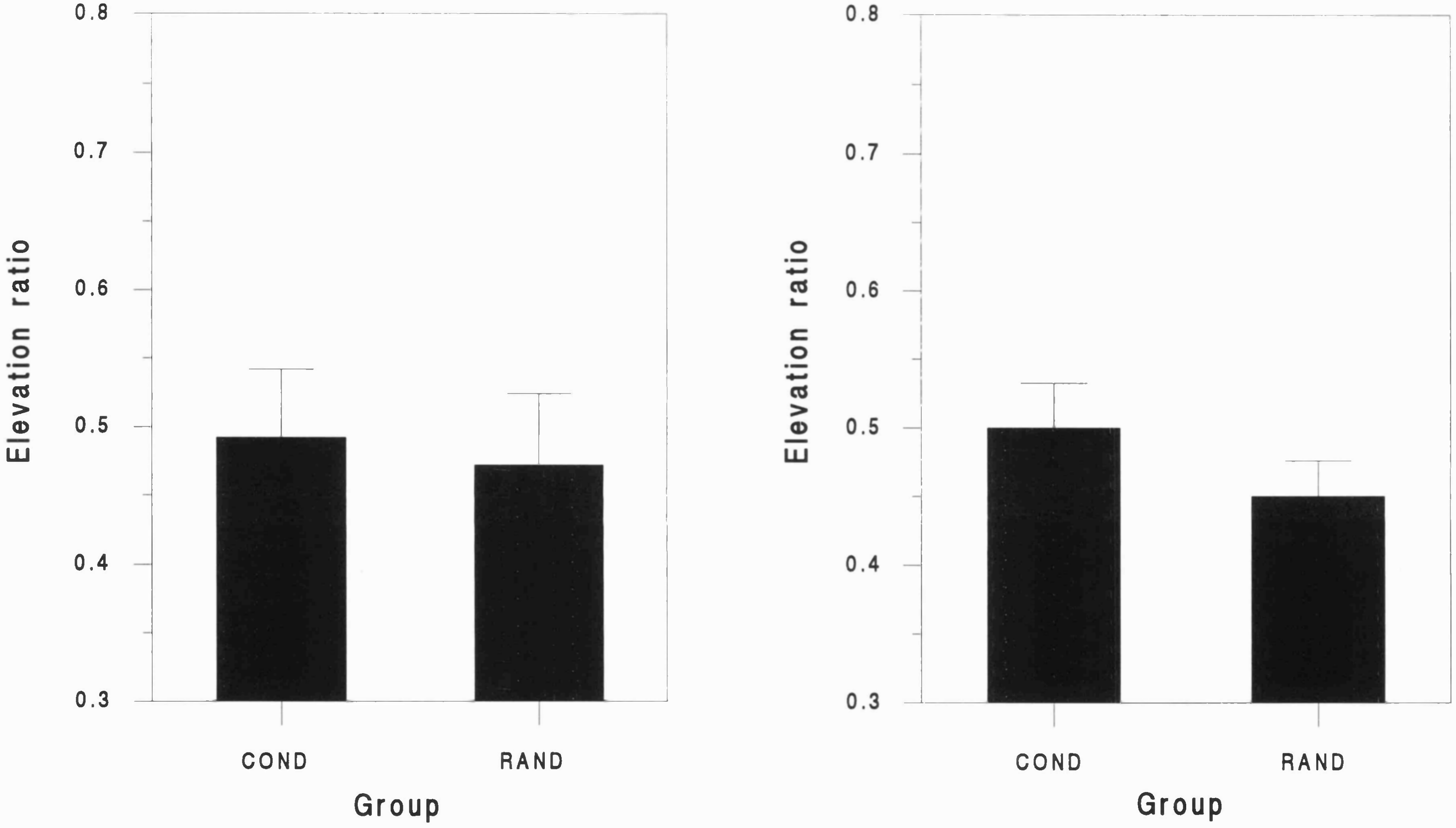

Figure 3.12. The left hand panel shows the observers' mean elevation ratios in response to ten presentations of the light in extinction in Experiment 5.

The right hand panel shows the observers' mean elevation ratios in response to the first five presentations of the light in extinction in Experiment 5. Error bars indicate SEMs.

worthwhile. If, in accordance with the hypothesis that the experiment aimed to test, Group COND made fewer magazine responses during the light in previous experiments because a greater proportion of their time was spent orienting in front of it, then measuring the CR itself could provide a more sensitive test of whether group differences existed. Of course, to do more than merely suggest that orienting behaviour was responsible for the previously found suppression, it would have been necessary to demonstrate both effects in the same experiment.

The orienting data from one animal of each group were lost when the video failed to record. Analysis of variance failed to find any difference in the number of times an observer oriented according to the observational experience it had received whether all 10 CSs were considered (F< 1), or the first five CSs (F(1,12) = 2.4, ns). The left and right hand panels of Figure 3.13 show the 10 CS and five CS data, respectively. In the context of the failure to find the suppression expected with these parameters, the null orienting data are uninterpretable; the hypothesis that orienting may account for the suppression remains to be tested. However, because of the similarity, discussed previously, of the procedures used to establish second order conditioning and inhibition, if a difference in orienting could be shown after limited observational training, a comparable difference following repeated trials is not likely.

3.6 Experiment 6

Despite the failure in the previous experiment to find a reliable effect of suppression against which to assess the effects of orienting when 10 observation sessions had been administered, it was considered worthwhile to test the observers' orienting responses to the light after only limited observational ~~significance~~ experience. An effect of second order conditioning would be suggested if Group COND were to orient more to the light than Group RAND. In turn, this result would suggest that the most plausible explanation of the suppression in magazine behaviour previously demonstrated in Experiments 1-3 with extensive observational experience is that it was mediated indirectly, i.e., because the observers withdrew from the light, they could not enter the magazine beneath it.

Thus, Experiment 6 replicated the procedure used in the previous experiment in all respects except for the amount of observational experience given to the observers before they were tested. There were four, as opposed to 10, observation sessions.

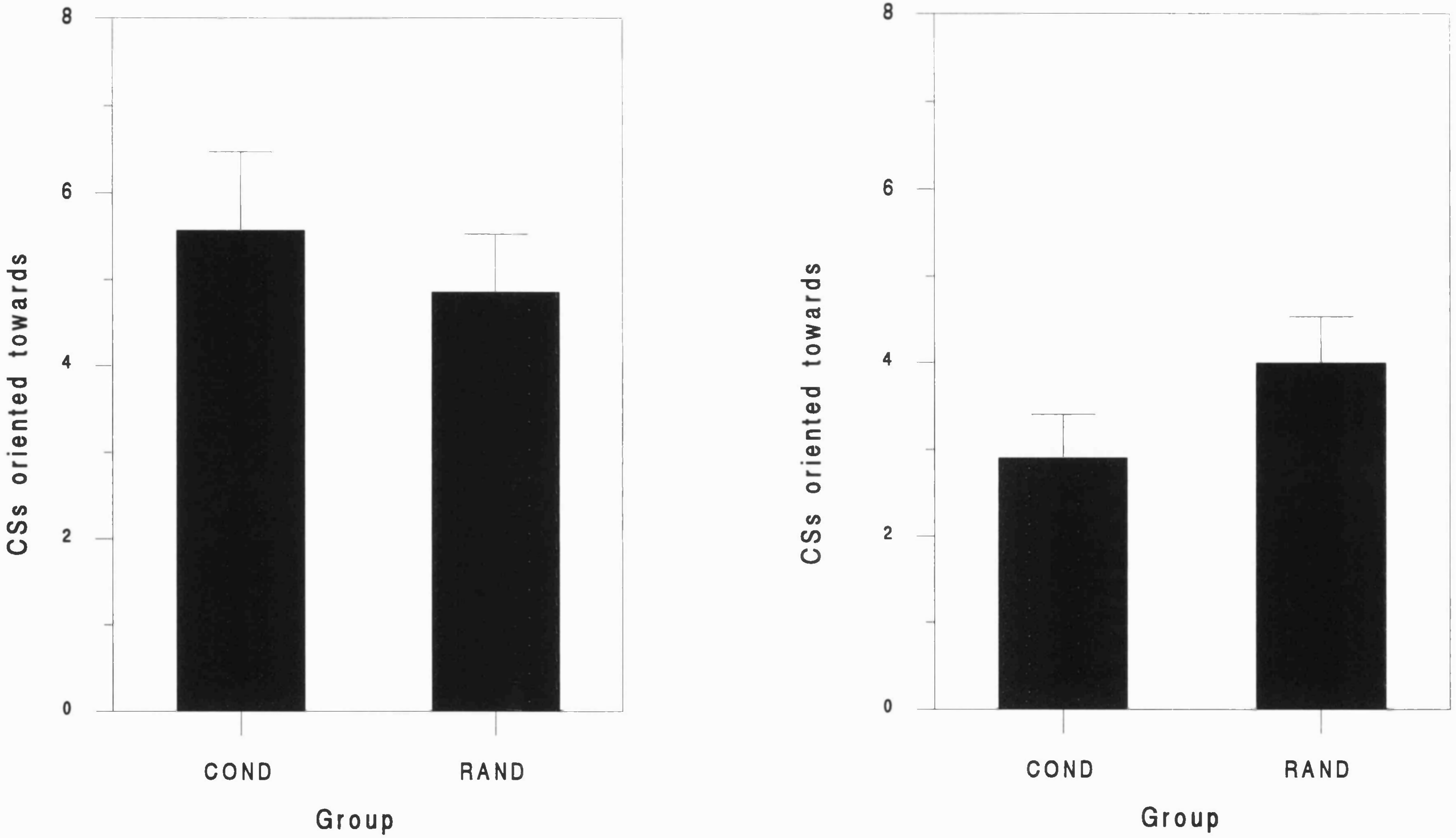

Figure 3.13. The left-hand panel shows the mean number of the ten light presentations to which the observers made an orienting response in Experiment 5.

The right hand panel shows the mean number of the first five light presentations to which the observers made an orienting response in Experiment 5. Error bars indicate SEMs.

Method

The method used differed from that of Experiment 5 in the following respects.

Subjects

Sixteen experimentally naive hooded Lister rats served as observers and were randomly assigned to Group COND or Group RAND. Their free feeding body weights ranged between 370- 520g. The eight demonstrators had been used as demonstrators in previous experiments in this series.

Procedure

Observer training and testing. The observers were tested for their responding to the light in extinction after four observation sessions.

Results and Discussion

Figure 3.14 shows the mean number of magazine entries made by the two demonstrator groups during the final observation session. Analysis of variance failed to find a difference between groups DEMCOND and DEMRAND on this measure (F< 1). In combination with the requirement that Group DEMCOND produced a cumulative elevation ratio of greater than .75, and group DEMRAND should not deviate from between .45 and .55, this suggests that, as intended, the distribution of responding did, but the overall amount of magazine behaviour did not, differ between groups.

The mean elevation ratios of magazine behaviour produced by the observers in response to all 10 and the first five unreinforced light presentations are shown in the left and right hand panels of Figure 3.15, respectively. As Experiment 4 had lead us to expect, analysis of variance did not reveal an effect of type of observational experience on magazine responding (Fs< 1).

Two animals were lost from the analysis of orienting behaviour because the video failed to record during their test session. A variety of measures of orienting were taken and analysed: the number of CSs in which the snout entered the box; if the snout entered the box, the total number of times the observer made contact with the light and the number of occasions on which the observer

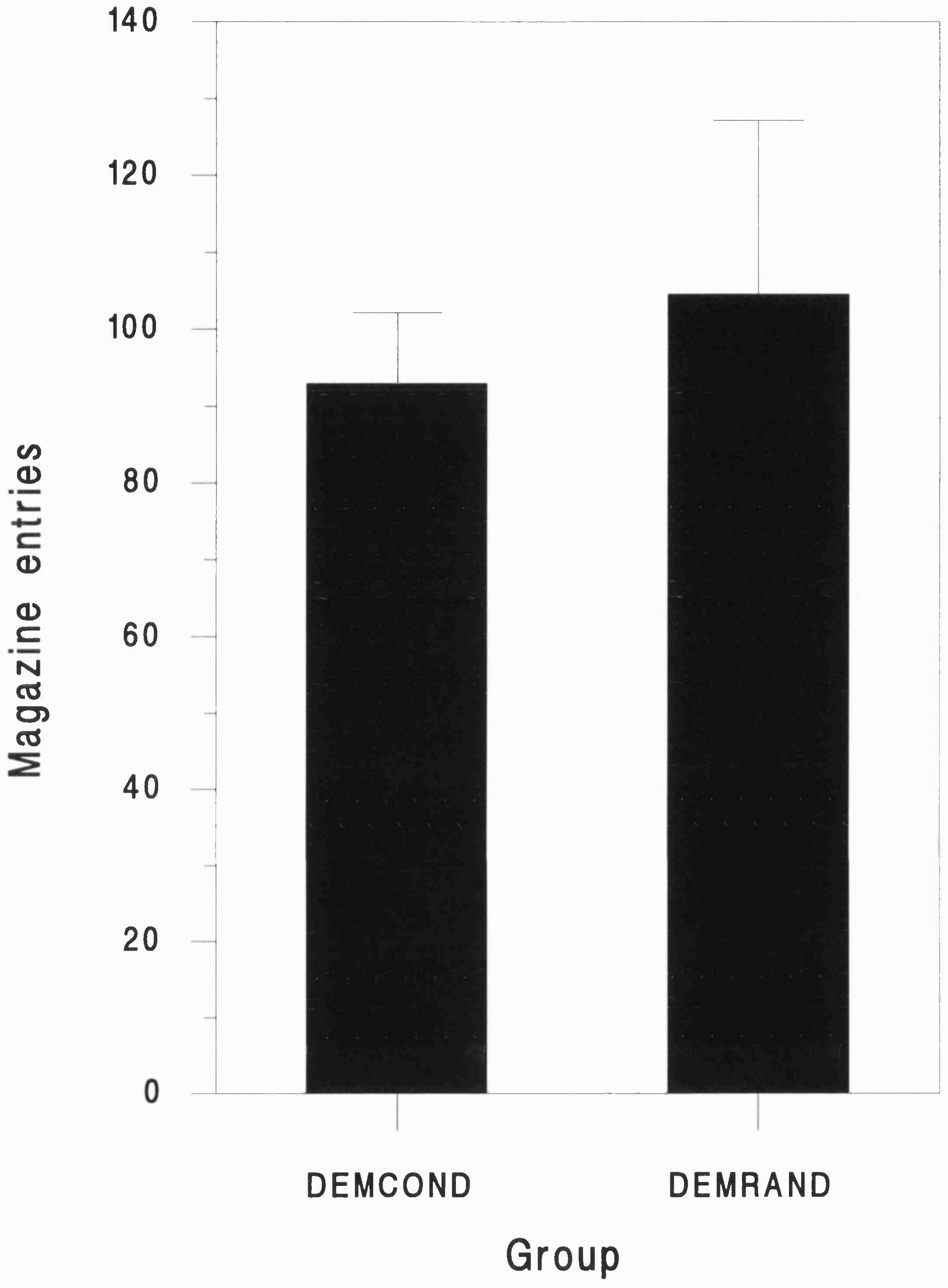

Figure 3.14. Total number of magazine entries made by the demonstrators during the final observation session in Experiment 6. Error bars indicate SEMs.

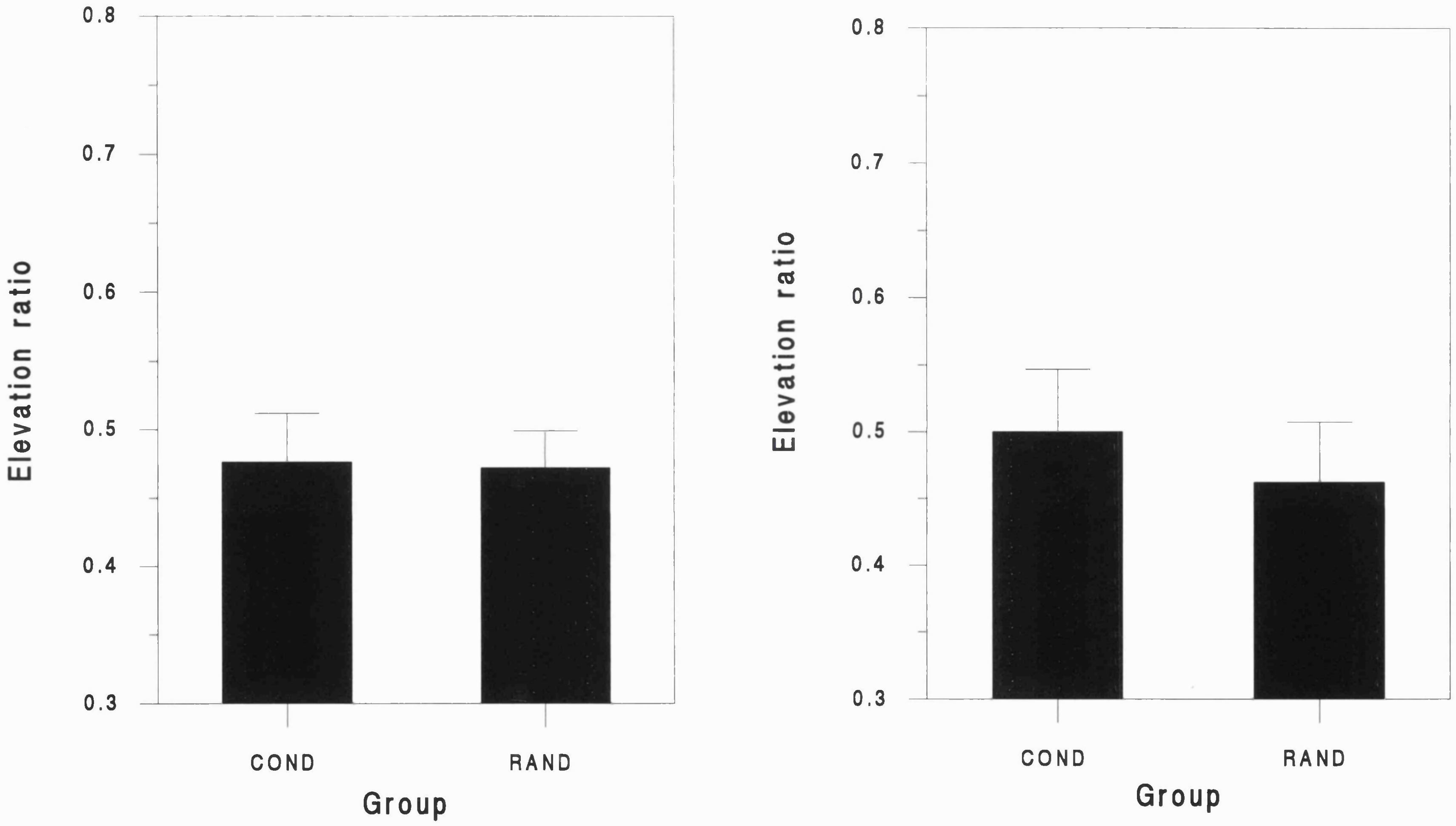

Figure 3.15. The left hand panel shows the observers' mean elevation ratios in reponse to ten presentations of the light in extinction in Experiment 6.

The right hand panel shows the observers' mean elevation ratios in response to the first five presentations of the light in Experiment 6. Error bars indicate SEMs.

reared; the proportion of the CSs during which the snout entered the box; and the proportion of the latter CSs in which the observer either reared or contacted the light. Although on the majority of measures Group COND observers had higher mean scores, separate analyses of variance revealed that, in comparison with Group RAND, they responded significantly more on only one measure: Group COND contacted the light and made rearing responses to a greater proportion of the CSs on which their snout entered the box, ($F(1,12) = 3.97$, $p< .05$). Figure 3.16 represents the groups' behaviour measured in this way.

In combination with the suppression of magazine behaviour found in Experiments 1-3 after extensive observational experience, a difference in Group COND's and Group RAND's orienting behaviour after only a few observational sessions is consistent with a second order conditioning account of their orienting, followed, after further observation experience, by inhibition. A limited number of pairings of the light and CS1 ensured that the light was a conditioned excitor capable of eliciting orienting. These conditioned excitatory properties ensured, in turn, that when the light was illuminated, the observers expected a reinforcer. This expectation continued to be violated, because the reinforcers were delivered to the demonstrators. Therefore, with an increasing number of trials, the light came to signal the absence of the reinforcer expected on the basis of CS1, i.e., the light became a conditioned inhibitor. Withdrawal from the inhibitory light meant that the observers were less likely to enter the magazine which was in the vicinity of the light.

Acceptance of this account of Group COND's behaviour should be tentative however. This was a preliminary experiment that analysed various measures of orienting only one of which showed group differences. The significant effect of the type of observational experience on this particular measure needs replication. However, because of the arrangement of the apparatus, it is possible to argue that the isolated significance of this one measure is less arbitrary than it at first appears. The positions of the panel light used as the CS, and the magazine were not ideal for measuring orienting to the light. The panel light was above the food magazine, and therefore, responses to the magazine took the observers into the critical area marked around the CS that was used as the basic measure of orienting. It seems reasonable to suppose that the responses that this measure confounds, ie., orienting to the light and tray entries, could be distinguished by a more sensitive measure of the observers' behaviour once they had entered the critical area. Recording behaviour that was specific to the light, i.e., rearing to, and making contact with, the light, was an attempt to achieve this.

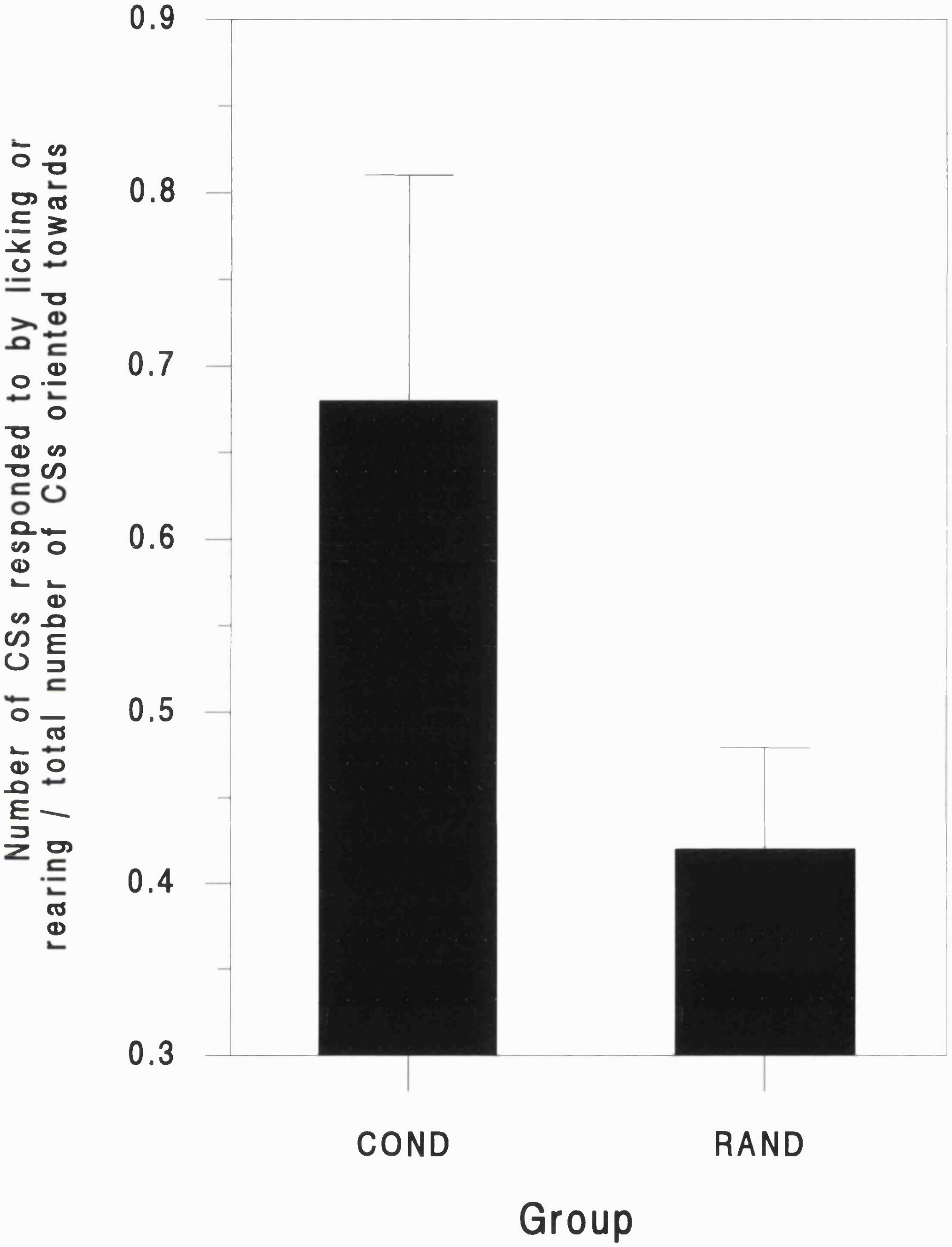

Figure 3.16. The proportion of ten CSs on which an orienting response was scored, to which, in addition, the observers either reared to or licked the light in Experiment 6. Error bars indicate SEMs

If for the time being we accept the effect as genuine, how is its interpretation, and that of the suppression effect it is meant to explain, affected by the null data from Experiment 5? Without a demonstration that further training resulted in the light suppressing the magazine behaviour produced by Group COND but had no influence on their orienting, it is possible that, when suppression has been found, it has been in animals that continued to orient to the light. However, there are two reasons for preferring the account outlined in the previous paragraph that conceives of a light that has been extensively socially exposed as inhibitory. First, there was no obvious primary reinforcer the occurrence of which correlated with the light. However, if, instead, orienting were established because of a contingent conditioned reinforcer, it would not be expected to persist irrespective of an increase in the number of light-> CS1 pairings. It was on this basis that Experiments 4 and 6 were expected to show an elevation with fewer trials of a behaviour that is suppressed after repeated trials (Yin et al, 1994). Second, assuming that the light becomes a conditioned inhibitor more readily explains why the suppression effect often disappeared when all 10 test presentations of the CS in extinction have been considered. If the CS were inhibitory, the extinction of excitation conditioned to the context would abolish baseline magazine responding when the light was off, and, therefore, there would be no opportunity for the light's inhibitory effects to be expressed in behaviour (Mackintosh, 1983). If the CS were excitatory, the differential excitation to the context and the light responsible for an elevation in light elicited orienting, should have been maintained.

The final point I want to make about this experiment concerns the specific nature of Group COND's learning. The finding that orienting, but not magazine behaviour, that occurred when the light was on, was affected by exposure to a demonstrator that approached a magazine and ate a food pellet, cannot be explained by an S-R account. The magazine approach behaviour of the demonstrator was not itself acquired.

3.7 General Discussion

Together, the data from the experiments reported in this chapter characterise the learning which results from exposure to a demonstrator responding to a light-> food contingency on which it has previously been trained, as social associative inhibitory conditioning. Convergent evidence has been provided for each component of that characterisation. Thus, finding that the magazine behaviour produced in response to the light by experimental group observers was suppressed relative to a truly random control, while in this particular case not definitive of the effect's dependence on a stimulus- stimulus contingency, and, therefore its associative nature, was at least suggestive of associative learning (Experiment 1). The retardation test (Experiment 2) and summation test (Experiment 3) data, because they could not be interpreted in terms of stimulus processing, confirmed that the learning was associative. Usually, finding that a stimulus is slow to condition and summates with an excitor to reduce responding is sufficient to indicate that it has conditioned inhibitory properties (Rescorla, 1969). In this case, additional confirmation of the light's inhibitory status using a different, orienting measure was required. Group COND were shown to orient more than Group RAND after four observational sessions (Experiment 6). No primary reinforcing event was delivered to the observers, encouraging the passibility that their orienting was generated by second order conditioning. Inhibition develops as trials, that initially result in second order conditioning, are repeated (Rescorla, 1980). Therefore, an early elevation in Group COND's orienting is consistent with the light subsequently acquiring inhibitory properties and causing, indirectly, a suppression in magazine entries. Finally, the social nature of Group COND's learning was suggested by the light's ability to suppress magazine responding in animals that had not been magazine trained, and that had, therefore, been denied the most obvious asocial conditioned reinforcer, i.e., cues arising from the operation of the food magazine (Experiments 2-6). Establishing that a demonstrator was required during training if an observer were subsequently to show suppression confirmed that Group COND had learned socially (Experiment 3).

Except for the finding of suppression, the effects reported here have yet to be replicated. One each of the experiments that reported orienting data have been conducted. The remaining effects were found in experiments that used procedures modified from those which had failed to produce the expected data. In the case of suppression, one of the occasions on which it has been demonstrated required that all 10 test presentations of the light be considered (Experiment 1), other times suppression has been apparent only if the behaviour during the final five CSs has been discarded (Experiments 2 and 3). It is hard to assess the degree of caution that this difficulty in establishing these effects should introduce into accepting the interpretations of the data that have been offered. Social learning experiments are imperfectly controlled precisely because they rely on social mediation. The behaviour of a conspecific demonstrator, however well trained, is not perfectly predictable and, therefore, noise, not a feature of asocial experiments, is introduced into the delivery of independent variables. Hence, one might expect even "real" social learning effects to be difficult to replicate.

However, if, for the present, we tentatively accept the characterisation of Group COND's learning that has been offered, then we have established how learning occurred (associatively), the nature of the learned relationship (inhibitory), and whether it was an example of social learning (yes). The most obvious remaining question concerns the identity of the contingent event that was the light's associate. Experiment 6 excluded the possibility that an S-R habit was acquired observationally. When the observers were given the opportunity of responding after four observation sessions, the particular behaviour that they had seen performed during the light, i.e., magazine approach, was uninfluenced by the light. However, an elevation in Group COND's orienting revealed that learning involving the light had occurred. The possibility that the light's associate is an asocial stimulus, and therefore that the effect of the demonstrator is to potentiate learning, has been deemed implausible because of the difficulty in identifying any potentially reinforcing asocial event in non-magazine trained observers. Two sources of a CS1 remain plausible: 1) the demonstrator's eating behaviour, and 2) the demonstrator's magazine approach behaviour.

Closer examination of what is required for a CS1 to have conditioned behavioural effects makes the former source more likely. Any two stimuli can be associated (see Rizley and Rescorla (1972) for an example of associative learning involving neutral events), but in many cases where a stimulus predicts the occurrence of a neutral event, there is no discernible CR. Learning about the stimulus has to be unmasked against a baseline of responding maintained by a motivationally significant event. Although the demonstrator's magazine behaviour is a consequence of the light's presentation, it is not obvious that it can be construed as a reinforcing event. Observed magazine approach is not a primary reinforcer, and its uniqueness to the experimental setting makes its prior acquisition of conditioned reinforcing properties unlikely. The effects of its association would, therefore, be expected to remain behaviourally silent unless some other motivation for responding were provided. However, the effect of watching a demonstrator approach and eat from a magazine when a light is illuminated is directly manifest in behaviour; depending on the amount of observation given and the behavioural measure taken, the light elicits orienting or inhibits magazine approach.

In the case of the second potential associate, seeing a demonstrator eating a food pellet, it is possible to construct a plausible story to explain its development and maintenance as a conditioned reinforcer. The rats were housed in groups, and fed at the same time on a food deprivation regime. Therefore, the sight of a conspecific approaching and feeding from a food source will have regularly preceded ingestion of food by the observer. Consequently, an opportunity has been provided for this 'feeding conspecific' stimulus to become a second-order conditioned reinforcer, a CS1. According to this account, through initial pairings of the light, CS2, with the feeding conspecific stimulus, CS1, the light acquired excitatory strength in Group COND. The conditioned reinforcing properties that CS1 gained by virtue of its prior pairing with a motivationally significant event, ensured that a CR developed, i.e., learning was expressed as orienting. The subsequent development of inhibition required that the excitatory strength of CS1 be maintained. If CS1 no longer predicted food, the presentation of the light in combination with CS1 without reinforcement would no longer violate an expectancy (Mackintosh, 1983). The expectation of food associated with an eating demonstrator could have been maintained because the animals were fed in groups. Thus, intermixed with the trials in which CS1/ CS2 predicted the absence of food for the observer, were 'trials' in which CS1 preceded food.

From the pattern of excitation and inhibition observed in Group COND's behaviour, second order conditioning has been assumed, and now, in addition, a source of that reinforcement is being suggested. An experiment which was to include a group that had never experienced the putative CS1, the sight of an eating conspecific, in tandem with the US, or for whom the CS1-> US relationship had been extinguished prior to the standard observational experience of the experimental group, would have the potential to confirm both accounts (Rescorla, 1980). If the test performance of these animals matched that of Group RAND, despite their observational experience of the CS2-> CS1 contingency, this would suggest that for the sight of an feeding demonstrator to function as a reinforcer, it must first have been followed by food.

In summary, an associative social learning effect has been demonstrated by the experiments in this series, but by a more circuitous route than had been anticipated. In comparison with truly random control animals, observers that saw a demonstrator performing food related behaviours during the light came to avoid entering the food magazine when the light was on. Summation and retardation tests confirmed that the light's contingent relationship with an outcome, tentatively characterised as a 'feeding conspecific', was essential for learning.

A Skinner box based, Pavlovian appetitive paradigm using rat subjects was chosen because it seemed to be easier to implement, in combination with a truly random control, than, for example, the aversive discrimination paradigm used by Mineka to explore how fear is socially acquired by monkeys. However, it is apparent from the discussions of the individual experiments and the

General Discussion that, unlike Mineka's paradigm, which involved an obvious outcome (the demonstrator's fear behaviour), it was not possible to identify the light's associate using the present paradigm. Therefore, interpretation of the data has not been straightforward. For example, it was argued in the discussion of Experiment 1, that exposure to a demonstrator restricting its magazine behaviour to periods when the light was on, may have affected the extent to which the light was processed. Therefore, the suppression in Group COND's magazine behaviour during the light could not be attributed to associative learning, despite the comparison with a truly random control.

Chapter 4

Overshadowing and Blocking in the Social Enhancement of Food Preferences

4 Introduction

Galef and his colleagues have found that social interaction between a naive, observer rat and a conspecific demonstrator that has recently consumed a novel diet, results in the observer showing a preference for the diet eaten by the demonstrator when compared with a completely novel diet (Galef and Stein, 1985). They have also shown that asocial presentation of a novel diet, in a food dish rather than via social interaction, does not have an equivalent effect on food preferences (Galef and Whiskin, 1992), and that the cues identifying the diet consumed by the demonstrator, and the cues rendering that diet attractive, are carried on the demonstrator rat's breath (Galef and Wigmore, 1993). In connection with the latter, Galef, Mason, Preti and Bean (1988) found that if the volatile compound carbon disulphide, which is present in significant quantities in rat breath, is added to a novel diet, and if this novel diet is then presented asocially in a food dish to an observer, that observer will develop a preference for that diet which is equivalent in magnitude to a standard social enhancement effect.

A recent experiment by Galef and Durlach (1993) investigated the possibility that the social enhancement of food preferences effect is mediated by Pavlovian associative mechanisms. Thus, they conceived of the interaction between demonstrator and observer as providing the opportunity for the observer to learn a stimulus-stimulus relationship between the odour of the demonstrator's diet, the CS, and some aspect of the demonstrator, perhaps a component of its breath, the US. Galef and Durlach argued that if an associative analysis were valid, then the enhancement effect should be susceptible to disruption by established Pavlovian compound conditioning procedures, for example, overshadowing (Mackintosh, 1976) and blocking (Kamin, 1969). That is, if the putative CS (CS1) is presented in compound with a second CS (CS2, another diet odour present on the demonstrator's breath) then less associative strength should accrue to CS2, indexed by a reduction in the level of conditioned responding to CS2. CS1 is said to overshadow CS2 if the two cues are presented simultaneously. CS1 is said to block CS2 if CS1 is presented on separate reinforced trials.

In a four group experiment, Galef and Durlach (1993) exposed observer rats to either: 1) a demonstrator who had recently eaten CS1 (conditioning group); 2) a demonstrator who had recently eaten a mixture of CS1 and CS2 (overshadowing group); 3) a demonstrator on two distinct occasions, once after it had eaten CS1, and on the following day after the demonstrator had eaten a mixture of CS1 and CS2 (blocking group); 4) a demonstrator who had recently eaten an irrelevant diet, i.e., one not present on test (control group). Having interacted with a demonstrator for half an hour, observers were immediately given a twenty-two hour preference test in which they were offered the CS2 diet and a completely novel diet to eat. For an associative interpretation to be supported, consumption of CS2 should have been reduced in the overshadowing and blocking groups relative to the conditioning group. However, Galef and Durlach found that, while all three experimental groups showed a preference for the target diet when compared with the control group, the experimental groups did not differ from one another in target diet consumption. Thus, there was evidence of the social induction of food preferences, but the effect was not found to be sensitive to compound exposure of CSs.

4.1 Experiment 1

Experiment 1 replicated the experiment by Galef and Durlach described above. Blocking and overshadowing are not highly reliable one trial phenomena, even when stimulus presentation is under the direct control of the experimenter, rather than being mediated by social interaction between animals (Dickinson, Nicholas and Mackintosh, 1983; Mackintosh, 1976). Therefore, it was considered worthwhile in the first instance to repeat Galef and Durlach's procedure without modification.

Method

Subjects

Ninety-six male hooded Lister rats, obtained from Harlan Olac Ltd. (Bicester, Oxon) served as subjects. Their weights ranged between 327-478g. The rats had previously received instrumental training in independent experiments, but had not been exposed to flavours other than their normal laboratory diet. Forty-eight rats were randomly assigned the role of demonstrators, and the remaining forty-eight were observers. Twelve observers and 12 demonstrators were then assigned to each of the four groups; conditioning (COND), blocking (BLOCK), overshadowing (OS) and control (CONT).

Apparatus and Diets

For the duration of the experiment all animals were housed individually in plastic hanging cages (20 x 24 x 40 cm). The observers' cages had metal grid floors, and those of the demonstrators had solid plastic floors. Prior to the beginning of the experiment, rats were housed in observer/demonstrator pairs for two days to allow familiarisation.

Two metal dishes (9 cm in diameter), placed 6 cms apart rim to rim, were screwed to the bottom of the observers cages throughout the experiment. Diets were presented to observers in glass jars (4.5 cm in diameter, 5 cm high), placed in the metal dishes. Demonstrators were maintained on a 23 hour food deprivation schedule for the duration of the experiment. Observers were allowed ad lib access to food until Day Two when they were also put on a 23 hour food deprivation schedule. Water was constantly available in all cages.

The diets were made using equivalent weights of flavour to powdered diet as in the Galef and Durlach experiment. Ingredients were added to 100g powdered Harlan Teklad 22/5 rodent diet to make four flavours which, according to Galef and Durlach, are discriminable and equipalatable: Diet Cin was made using 1g of Safeway ground cinnamon; Diet Mar was made using 2g of Safeway marjoram; Diet Cin/Mar was made using 1g Safeway ground cinnamon and 2g Safeway marjoram; Diet Coc was made using 2g of Hershey's pure cocoa.

Procedure

The procedure undergone by the observers is summarised in Table 1.

Day 1

All animals were rehoused individually. Food was removed from the demonstrators' cages and they were placed on a 23 hour food deprivation schedule.

Day 2

The demonstrators were taken to a separate room and fed powdered laboratory maintenance diet for one hour in their home cages. Food was removed from the observers' cages and they too were placed on a 23 hour deprivation schedule.

TABLE 1: PROCEDURE UNDERGONE BY OBSERVERS IN EXPERIMENT 1

DAY GROUP	3	4	TEST
CONDITIONING		CIN CS1	CIN/COC CS1
		MAR CS1	MAR/COC CS1
OVERSHADOW		CIN/MAR CS2/CS1	CIN/COC CS2
		CIN/MAR CS1/CS2	MAR/COC CS2
BLOCKING	CIN CS1	CIN/MAR CS1/CS2	MAR/COC CS2
	MAR CS1	CIN/MAR CS2/CS1	CIN/COC CS2
CONTROL		CIN CS1	MAR/COC
		MAR CS1	CIN/COC

Day 3

The demonstrators in the conditioning, overshadowing and control groups were fed in the same manner as on Day 2. The demonstrators for the blocking group were also removed to the feeding room and fed for an hour, but instead of powdered maintenance diet, half of the demonstrators received Diet Cin, and half Diet Mar. All demonstrators were returned to the holding room, those in the blocking group were put in the cages of their respective observers and left to interact. After 30 minutes, the blocking group demonstrators were removed and returned to their holding cages. Immediately after the removal of the blocking group demonstrators all observers were allowed one hour free access to their normal laboratory maintenance diet.

Day 4

All demonstrators were removed to the feeding room and fed flavoured powdered diet for one hour. Demonstrators in the overshadowing and blocking groups were given Diet Cin/Mar. For the remaining two groups, conditioning and control, half the animals were given Diet Cin and half were given Diet Mar. All demonstrators were then returned to the holding room and placed in the cages of their respective observers and left to interact. After half an hour, the demonstrators were removed from the cages of the observers and from the experiment.

Two food jars of approximately equal weight were then placed in the cages of each observer. One of these food jars contained the non-exposed comparison flavour, Diet Coc, and the second contained the target diet, either Diet Cin or Diet Mar. The left-right positioning of the target and other diet, was counterbalanced. Observers in the conditioning group received as the target diet the diet to which they had been exposed via their demonstrator. For example, if their demonstrator had eaten Diet Cin, observers were given a Diet Cin, Diet Coc choice. Observers in the control group, by contrast, received as a target diet the diet which had not been eaten by the demonstrator, i.e., an irrelevant non-exposed target diet. Thus, if control group demonstrators had eaten Diet Cin their respective observer received Diet Mar. For observers of the overshadowing group, half were given Diet Cin and half Diet Mar as their target diet. For observers in the blocking group, the target diet was the diet to which they had been exposed only in compound with CS1. Thus, an observer whose demonstrator had eaten Diet Cin prior to the first interaction, and Diet Cin/Mar prior to the second interaction, received a Diet Mar target diet.

After 22 hours, the two food jars were removed from each cage and reweighed.

Results and Discussion

The percentage of the total weight of food consumed over twenty-two hours accounted for by the target diet was calculated for each animal. Each group's mean consumption of target diet is shown in Figure 4.1. The data were squared in an attempt to equate the variance across groups. The data from one observer in Group OS and one observer in Group CONT were statistical outliers; their mean consumption of target diet fell more than two standard deviations from their group mean. Therefore, these data were excluded from the analysis (Tukey, 1977). One-way analysis of variance revealed a reliable effect of treatment condition on observer food choice ($F(3,42) = 5.24$, $p< .004$). Post hoc tests confirmed that the social enhancement effect had been replicated: Group COND consumed more of the target diet than Group CONT (Tukey's test. $p< .05$). Relative to the control animals, the blocking group observers also preferred the target diet (Tukey's test. $p< .05$). No other group differences were reliable.

Galef and Durlach's social enhancement effect was replicated. However, the prediction that overshadowing observers would eat a smaller proportion of the target diet, and blocking observers would eat less still, was not supported.

Overshadowing is not uniquely predicted by an associative mechanism; it could, for example, result from generalisation decrement (Pearce, 1987). According to a stimulus generalisation account of the overshadowing procedure, less responding to CS2 follows exposure to CS2 in compound with CS1 than after exposure to CS2 alone, because CS2 is not recognised when presented in isolation from CS1 on test. Thus, whatever was learned about the compound is irrelevant to the responding controlled by a stimulus perceived as novel. Although the proportion of CS2 eaten by the overshadowing observers in this experiment was not reliably less when compared with Group COND, it could be argued that the large numerical difference between the groups on this measure, combined with the absence of a blocking effect, encourages by default a variety of non-associative explanation. According to associative learning theory, overshadowing and blocking are mediated by a common mechanism, and should, therefore, occur in response to similar parameters. We found no evidence for blocking, despite the expectation from associative learning that of the two effects, blocking should be the more profound. However, certain experiments (e.g. Dickinson, Nicholas and Mackintosh, 1983) that have used a blocking procedure have revealed an elevation, rather than a reduction, in the level of responding governed by CS2. This result is explained with reference to higher order conditioning to CS2 by virtue of between-

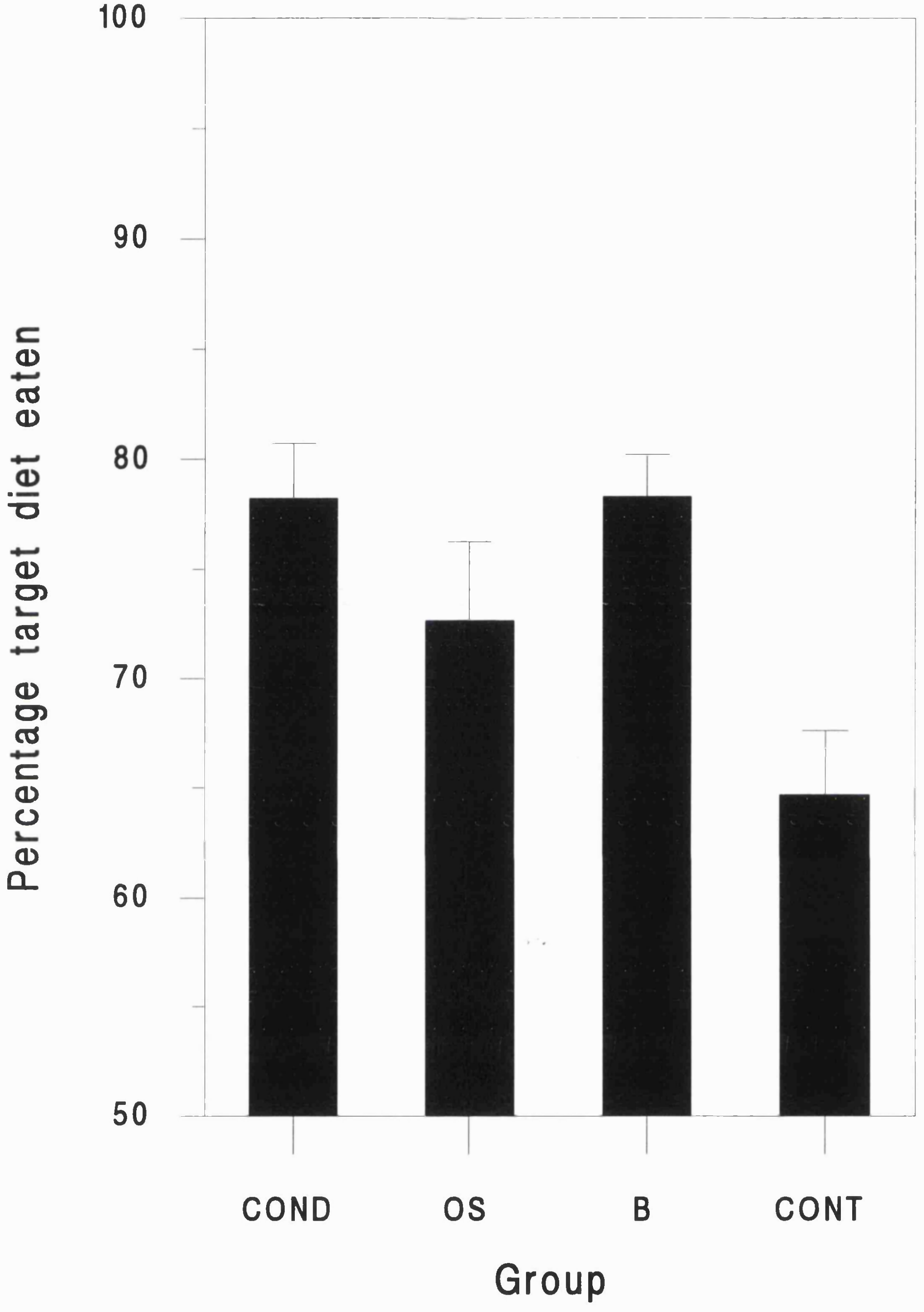

Figure 4.1. Mean percentage target diet consumption in Experiment 1. (The figure represents the values calculated prior to transformation). Error bars indicate SEMs

CS associations that may occur on the compound conditioning trial. Thus, a dissociation between overshadowing and blocking type effects can be accommodated by an associative account of learning.

Experiment 2 attempted to increase the sensitivity of the test measure to show a reliable effect of overshadowing. In addition, the number of CS1 pre-training trials received by the blocking observers was increased in a further attempt to find evidence of blocking.

4.2 Experiment 2

As Galef and Durlach (1993) acknowledged, the failure to find blocking with their procedure was not a surprising result, because blocking is not always found in one trial procedures (Mackintosh, 1975). Following Galef and Durlach, in Experiment 1 blocking observers were given a single CS1-> US pre-training trial prior to their one compound conditioning trial. This variable is potentially important because stimuli acquire associative strength incrementally with each US pairing (Rescorla and Wagner, 1972). It is conceivable, therefore, that with more extensive pre-training, CS1 could accrue sufficient associative strength to disrupt conditioning to CS2 when they are presented in compound, thereby showing an effect of one-trial blocking.

The second purpose of Experiment 2 was to investigate whether collecting the diet that the observers spilled from their food jars would enhance the sensitivity of the dependent measure to group differences in target diet consumption enough to demonstrate a reliable overshadowing effect.

The design of Experiment 2 was identical to that of Experiment 1 except that the control group was replaced by an enhanced blocking group (EBLOCK) in which observers received five pre-training trials with CS1. The control group was considered unnecessary because the basic social enhancement effect was found in Experiment 1, and has been shown by Galef and his associates to be robust (Galef et al 1985; Galef et al 1983; and Galef and Durlach 1993).

Method

Subjects

Sixty-four male hooded Lister rats, with weights ranging between 320- 465g served as subjects. Thirty-two of these, those assigned the role of observers, had previously received instrumental training in independent experiments, but had not been exposed to flavours other than their normal laboratory diet. The remaining 32 acted as demonstrators and had served as observers in the previous experiment. Eight observers and eight demonstrators were randomly assigned to each of four groups; conditioning, blocking, enhanced blocking and overshadowing.

Apparatus and Diets

The apparatus and diets were identical to those of Experiment 1.

Procedure

The procedure undergone by the observers is summarised in Table 2.

Until Day 4, the procedure for this experiment was identical to that of Experiment 1. After this point, instead of one exposure to CS1 on the breath of a demonstrator, observers in the enhanced blocking group interacted with their demonstrators on five separate occasions prior to compound conditioning.

Days 4 to 6

All demonstrators were removed to the feeding room and, to equate diet familiarity, all were fed flavoured diets irrespective of whether they were to interact with their observers. After feeding for an hour, the demonstrators were returned to the holding room and the enhanced blocking group demonstrators were placed in the cages of their respective observers and left to interact for 30 minutes.

Day 7

The procedure for Day 7 was identical to the previous days for all except the blocking group. Having been fed, the demonstrators in the blocking group interacted with their observers for 30 minutes. This was the single pre-training trial with CS1 for the observers in the blocking group.

TABLE 2: PROCEDURE UNDERGONE BY OBSERVERS IN EXPERIMENT 2

GROUP	3 - 5	6	7	TEST
CONDITIONING			CIN CS1	CIN/COC CS1
			MAR CS1	MAR/COC CS1
OVERSHADOW			CIN/MAR CS2/CS1	CIN/COC CS2
			CIN/MAR CS1/CS2	MAR/COC CS2
BLOCKING		CIN CS1	CIN/MAR CS1/CS2	MAR/COC CS2
		MAR CS1	CIN/MAR CS2/CS1	CIN/COC CS2
ENHANCED BLOCKING	CIN CS1	CIN CS1	CIN/MAR CS1/CS2	MAR/COC CS2
	MAR CS1	MAR CS1	CIN/MAR CS2/CS1	CIN/COC CS2

Day 8

The procedures on Day 8, the test day, were the same manner as those on Day 4 in the first experiment. Treatment of animals in both the blocking and enhanced blocking groups was identical to that of the blocking group in Experiment 1. At the end of the twenty-two hour test period, the metal bowls were removed and as well as the bowl contents, the spilled food was collected and weighed.

Results and Discussion

The percentage of the total amount consumed on test accounted for by target diet, including spillage data, was calculated for each animal. The data from one animal in the conditioning group and one animal in the enhanced blocking group were excluded because their percentage consumption of the target diet was more than two standard deviations from the means for their groups (Tukey, 1977). Another animal was lost from the conditioning group because it tipped over its food bowl during the test. The data are presented in Figure 4.2. The data were squared to equate within-group variance.

Analysis of variance revealed a main effect of treatment condition [$F(3,25) = 4.16$, $p< .006$]. Post hoc tests were used to investigate the group differences responsible for this treatment effect. They confirmed that, as the associative account predicted, the conditioning group consumed a significantly greater percentage of the target diet than did either the enhanced blocking [Tukey's test, $p< .01$] or overshadowing groups [Tukey's tests, $p< .05$]. However, there were no differences in target diet consumption between the conditioning and blocking groups, or the overshadowing and enhanced blocking groups. The suppression in CS2 consumption by the enhanced blocking group when compared with the blocking group was marginally significant [Tukey's test, $p< .09$]

In summary, Experiment 2, which took spillage data into account, demonstrated overshadowing; observers that were exposed to a CS1/CS2 compound, subsequently ate less CS2 than conditioning group observers that had previously experienced CS2 in isolation. Some evidence for a reduction in learning about CS2 when observers were given five pre-training trials with CS1 was also found. This reduction in learning was relative to animals in the conditioning and blocking groups, not the overshadowing group. The significance of the comparison between the blocking and enhanced blocking groups for an associative explanation

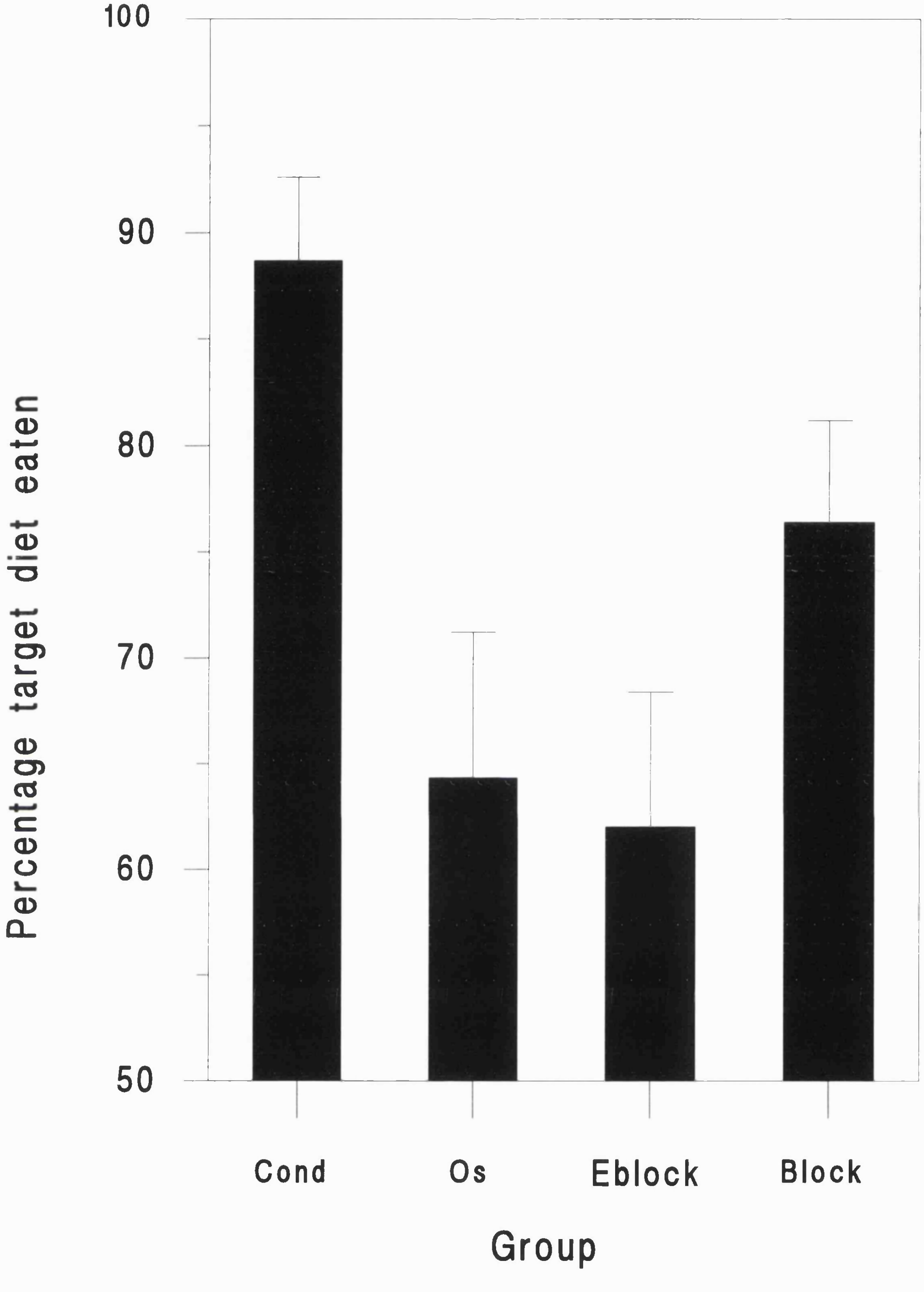

Figure 4.2. Mean percentage target diet consumption, including spillage, in Experiment 2. (The figure represents values calculated before transformation.) Error bars indicate SEMs.

of the social enhancement effect is considered below in the General Discussion.

4.3 General Discussion

In Experiment 1, blocking was not found after a single CS1- US pairing and a single compound CS-US pairing. However, in Experiment 2, there was some evidence that giving multiple reinforced presentations of CS1 did reduce learning about CS2, i.e., there was a marginally significant reduction in consumption of the target diet by animals in the enhanced blocking group when compared with the blocking group.

According to Rescorla and Wagner (1972), failures to learn a CS-US association happen when the occurrence of the US is predicted. In a successful blocking procedure, the CS1-> US pre-training trials ensure that CS1 becomes a predictor of the US, and thereby that when CS2 is presented in compound with CS1, the US is unsurprising, therefore, learning about CS2 is blocked. However, for evidence that the disruption to CS2 conditioning is greater than that which would be produced by simply presenting the compound trial, the decrement in CS2 responding must be greater in a blocking group than it is in an overshadowing group.

In Experiment 2, the reduction in CS2 consumption by the enhanced blocking group observers was not significant when compared with the overshadowing group, suggesting that the explanation of the decrement should be in terms of the disruption produced by a compound conditioning trial rather than blocking. However, observers in the enhanced blocking group ate a smaller proportion of the target diet that those in the blocking group. Both blocking groups received one compound trial, and therefore, the disruptive effects of compound conditioning trials are controlled for in this comparison. This suggests that the CS1 pre-training trials were effective in reducing learning about CS2, encouraging an interpretation of that reduction as blocking.

It may be that a potential difference in the responding of enhanced blocking and overshadowing groups is being masked by procedural difficulties. Theoretically, a preference could result in 100% consumption of the target diet. In practice, however, it seems that when a choice of two diets is available both diets will be sampled, even in cases, such as the conditioning group in these experiments, of a strong preference for one of the diets. In these experiments, the target diet constituted roughly 80% of the conditioning group's consumption.

For the control group, both the flavoured diets presented on test were novel, and hence, equivalent amounts of each should have been eaten. However, 60% of the control group's consumption was of the target diet, suggesting that the diets were not equipalatable. These departures from the ideals of preference and no preference restricted the available window in which to find potential reductions in responding due to blocking and overshadowing effects.

The blocking data from these experiments are suggestive, but not definitive, of associative learning. Therefore, it is worthwhile to consider alternative, non-associative accounts of the overshadowing demonstrated in Experiment 2.

Kaye, Gambini and Mackintosh (1988) found that the presentation of a distractor flavour in close temporal proximity to a target flavour, significantly reduced habituation of neophobia to the target flavour when assessed after four hours. At first sight, this finding seems to offer a plausible explanation for the overshadowing of socially enhanced food preferences observed in Experiment 2: Observers presented with the Diet Cin/ Mar compound ate less of Diet Cin (CS2) because the second flavour acted as a distractor and interfered with habituation of neophobia to CS2, the process responsible for social enhancement effects.

In general, habituation accounts of the social enhancement of food preferences seem unlikely for two reasons. First, unlike presentation on the breath of a demonstrator, asocial presentation of a diet in a food dish does not affect the preference shown for that diet (Galef and Whiskin, 1992). It is not obvious from a habituation account why the way in which the diet is presented should determine whether or not a preference develops. Second, habituation of neophobia is a time dependent process (Green and Parker, 1975), and yet experiments have found a social enhancement of food preferences effect when observers in a 'conditioning' group have been given a 15 minute, two diet test immediately following interaction with the demonstrator (Ray and Heyes, unpublished). This preference is also evident when testing is delayed. Thus, conditioning observers tested after 22 hours eat more of the target diet than do animals presented with the diets asocially, in trays beneath the wire-bottomed cages (Ray and Heyes, unpublished).

More particularly, overshadowing of a socially enhanced flavour preference is unlikely to be due to the disruption of habituation of neophobia because Kaye et al (1988) report that the distractor effect is found only if consumption of the target is measured four hours after the initial diet presentation. At forty-eight hours there is no difference in consumption between those animals that were presented with a distractor and those that were not. The argument for the distractor effect claims that there is little habituation at four hours because the test flavour is perceived as rather different from the initial flavour presentation (i.e., when the flavour is perceived as some configuration of target diet and distractor). This effect disappears as time passes and the precise properties of the flavour configuration are forgotten, i.e., consumption increases as generalisation decrement decreases. In the present study, the novel comparison diet and the target diet were available on test for twenty-two hours. It seems likely that continuous access to the target diet (CS2) would accelerate forgetting of the configural properties of the CS1/CS2 compound. However, interpretation, as a distractor effect, of the reduction in CS2 consumption by the overshadowing group compared to the conditioning group relies on these configural properties being remembered.

Experiments 1 and 2 have produced effects which could be explained by an associative social learning theory. The failure to show, unambiguously, effects which are diagnostic of associative learning could be because the particular experimental parameters masked such learning, or because the social enhancement of food preferences is not a Pavlovian process. However, it should be emphasised that, even if it were found that the social enhancement effect is not Pavlovian, this would not demonstrate that the mechanisms of social and asocial learning are different. To implicate distinctive social learning processes, similar conditions of learning would have to produce different social and asocial effects (Chapter 2). Yet, because there is no obvious US, it is in fact not clear what the conditions of the social enhancement of food preferences effect are.

The paradigm presents problems for investigating whether the use of different parameters might reveal the social enhancement of food preferences to be an associative effect. The animals are housed singly. If the rats have been isolated for more than a few days, the observers will fight with the demonstrators that are introduced into their cages. Under these conditions, observers do not develop a preference for the diet that their demonstrator has eaten (Galef, personal communication). Thus, the number of CS1 pre-training, and conditioning, trials that can be administered is limited. There is some reason to expect that blocking and overshadowing may be more readily demonstrated with repeated trials (see discussion of Experiment 1). For example, blocking is not a ubiquitous phenomenon when only one compound trial is administered (Dickinson, Nicholas and Mackintosh, 1983). Currently, female rats are being used as subjects in the hope that, because they are less likely to fight their demonstrators (Galef, personal communication), more conditioning trials can be given.

Chapter 5

A Demonstration of Observational Conditioning and Observational Learning Using a Two Lever/Two Action Paradigm

5 Introduction

Skinner, and others who believed that Pavlovian and instrumental conditioning were distinct types of learning (e.g. Miller and Konorski, 1928; and Rescorla and Soloman, 1976), imagined that conditioned behaviour would be divisible into two categories of CR, each amenable to modification by one principle of reinforcement. However, every attempt to specify the response systems unique to a particular type of learning have failed. Thus, according to Miller and Konorski (1928) autonomic responses are subject only to classical conditioning, but there is evidence that they can be instrumentally conditioned (Black, 1971). Similarly, the phenomenon of autoshaping, which was discussed in Chapter 1, suggests that Miller and Konorski were wrong to identify instrumental conditioning with skeletal responses. In autoshaping we find, for example, that a Pavlovian relationship between a key-light and food is sufficient to establish a key-peck response in pigeons (Brown and Jenkins, 1968). There have been no corresponding attempts to identify the domains of influence of observational conditioning and imitation with particular physiological systems.

Other attempts to forge a sharp distinction between the types of response influenced by a given variety of learning, have failed to provide an empirically meaningful criterion for establishing when an organism's behaviour will be modified by a given type of learning. Skinner (1938) argued that instrumental responses were voluntary, and classical CRs were involuntary. More recently, Tomasello and Call (1994) suggested that intentionality is a property unique to imitative behaviours. However, in neither case does the author propose an independent means of establishing whether a behaviour is voluntary or intentional, and, therefore, the proposed identifications are circular. An imitative behaviour, for example, is to be identified by its intentionality, but the only criterion we are offered for assessing whether a behaviour is intentional is to establish that it was acquired imitatively.

If, as suggested above, the type of response does not determine the process by which it is learned, it is apparent that we must be able to identify behaviour that has been modified by, for example, observational learning, before we can investigate the distinctive conditions favouring observational learning. It was hoped that the paradigm developed for the experiments reported in this chapter could be used to investigate both these issues with respect to social learning.

In Chapter 2 a two lever/two action procedure was described which, it was claimed, could isolate changes in a rat's behaviour that were the result of observational conditioning and observational learning. The two lever/ two action paradigm, a variant of a procedure used originally by Bolles, Holzt, Dunn and Hill (1980) to dissociate the effects of Pavlovian and instrumental learning, is a variety of bidirectional control procedure (Grindley, 1932; see also Chapter 1, section 1.3.2). Bidirectional control procedures identify types of learning by the way in which they modify behaviour. Pavlovian and observational conditioning affect behaviour according to the principle of stimulus substitution (Pavlov, 1927). Instrumental or observationally learned behaviour is modified by its consequences (Thorndike, 1911).

In the two lever/two action paradigm, observers were exposed to a demonstrator that was rewarded for responding on one of two levers, in one of two directions. If, when subsequently given the opportunity of responding, observers were to make the majority of their lifts and presses on the same lever as their demonstrators, it would suggest that they had learned about the relationship between the lever and food. That is, observational conditioning would be expected to generate a lever preference.

In addition, because each lever can be lifted up and pressed down in this paradigm, the effects of observational response learning, or imitation, are dissociable from other varieties of social learning. To be indicative of observational learning, i.e., to show dependence on the contingency between the observed response and its outcome, an observer of lifts, for example, must make a greater proportion of lift responses than an observer of presses. It is difficult to see how an observational conditioning process could produce a directional effect of this kind, and therefore, instrumentality, or observational learning, is implied. The observed Pavlovian relationship between the lever and food was the same irrespective of the direction of in which the demonstrators were seen to respond. Therefore, according to a principle of stimulus substitution, the same CR should develop in observers of up and down responding.

Subsequent to demonstrating observational conditioning and observational learning, the two lever/ two action paradigm was to be used to investigate the conditions determining whether a response is observationally conditioned or observationally learned. Thus, for example, it is possible that the amount of exposure to the experimental contingencies influences what is learned. In connection with the latter, in the asocial learning literature, Wahlsten and Cole (1972) reported that the development of a leg flexion response to a stimulus trained with shock on an omission schedule was established by classical conditioning, but that subsequently the behaviour was controlled by its consequences. In the case of social learning, it might therefore be expected that, with limited observational experience, an observational conditioning process would be responsible for an observer's behaviour.

5.1 Experiment 1

Prior to using the full two lever/two action procedure, pilot studies (Experiments 1 and 2) were conducted to ensure that lifts and presses were discriminable by observers. In Experiment 1, only one lever was available during observation and testing. It examined whether observers' responses to a lever were influenced by whether they saw a demonstrator that lifted it up or pressed it down. Thus, two groups of observers were exposed to a demonstrator whose responses to the lever were reinforced. Group UP were exposed to a demonstrator that lifted the lever up, while pressing responses were demonstrated to Group DOWN. If the observer groups were found to differ in the proportion of responses they made in a given direction, it would suggest that the up and down responses of the demonstrator were in some way discriminable. To be consistent with an explanation of their behaviour as observational learning, observers of down pressing demonstrators should make a greater proportion of presses than observers of up responding.

Method

Subjects

Twenty-four male hooded Lister rats, obtained from Harlan Olac Ltd. (Bicester, Oxon) served as subjects. Sixteen, that had previously received observational instrumental training to push a joystick, were observers. The remaining eight demonstrator rats had been magazine trained in an earlier experiment on the effects of stimulus pre-exposure.

Apparatus

The animals were trained and tested in four identical operant chambers. The chamber walls and ceiling were made of aluminium. Each chamber was divided into two compartments by a wire-mesh partition. The demonstration compartment measured 24 cm x 26 cm. The smaller, observation compartment was 15 cm x 26 cm, and featureless. In the centre of the ceiling of the demonstration compartment there was a 24-v, 2.8-w houselight. The grid floor was constructed of stainless steel rods spaced 1 cm apart.

There was a rectangular lever in the wall of the demonstration compartment opposite the wire-mesh partition, 3 cm to the left of the centrally placed food magazine, and 11 cm above the floor. The end of the lever (1.5 cm x 1 cm) extended 1 cm from the wall. The lever could be displaced either up or down by a maximum of 3 cm. A response was recorded if the lever was moved 2 cm in either direction. A 45mg sucrose pellet was delivered to the food magazine for each correct response (defined below).

A BBC Master computer running Spider on-line control language controlled the equipment and collected the data.

Procedure

For the duration of the experiment, all animals were maintained at 90% of their free feeding body weights. Each session began with the illumination of the houselight, and ended when the light went off. The houselight was extinguished immediately following the delivery of the fiftieth food pellet, or, if an animal failed to make 50 responses, after one hour.

Demonstrator training. Half of the demonstrators were trained to lift the lever up, and half to press it down. With each additional training session, the extent to which the lever had to be displaced to earn reinforcement was increased until a displacement of 2.5 cm was required. In all, the demonstrators received 11 daily training sessions. 'Dummy' observers were present in the observation compartment during the final two training sessions. Sugar was occasionally applied to the bottom of the lever to encourage up pushing.

Observer training and testing. Observers received three daily magazine training sessions in the demonstration compartment. A Random Time (RT) 60s schedule governed the delivery of thirty sucrose pellets. The lever, which was not retractable, remained in the compartment during magazine training.

Immediately before their test session, each observer was placed in the observation compartment while its demonstrator made 50 up responses (Group UP) or 50 down responses (Group DOWN). Each response was followed by delivery of a food pellet to the demonstrator. Any down responses made by an up pushing demonstrator were non-reinforced, and vice versa. When a demonstrator had earned fifty sucrose pellets, it was removed from the experiment. The observer was then transferred to the demonstration compartment, and responding in either direction was reinforced.

Results and Discussion

The record of the total number of UP and Down responses made by the demonstrators and observers has been lost. Using the data for the observers' first five responses, discrimination ratios were calculated by dividing the number of down responses by 5. Figure 5.1 shows these discrimination ratios. It is apparent that, irrespective of observational experience, the observers made more down responses than up responses. However, as expected, Group DOWN made a greater proportion of down responses than Group UP. An analysis of variance which did not assume equality of variance confirmed that there was a reliable difference in the observers' responding ($F(1,8) = 7.31$, $p < .02$).

This result shows that the observer rats could distinguish observed lever lifts and presses, and that at least one of the two groups tended to respond in the same direction as their demonstrators. The latter effect could have been due to observational learning (imitation) but there are other potential explanations. It could be, for example, that when observers were tested in the demonstration compartment, they were attracted to the part of the lever that, because it had been manipulated by the demonstrator, carried the demonstrators' scent. Experiment 2 examined this possibility.

5.2 Experiment 2

A demonstrator may leave its scent on the apparatus it manipulates. The scent may linger on the top of a lever that has been pressed down, and on the underside of a lever that has been lifted up. There are data showing that rats approach and contact stimuli that have been marked by another rats' scent (Galef and Beck, 1985). Thus, it is possible that scent effects are sufficient to explain the sensitivity to the direction of their demonstrators responding evidenced by the observers' matching behaviour in Experiment 1. If a rat that had observed down responses were attracted to the topside of the lever because of residual scent, it may be more likely to make fortuitous

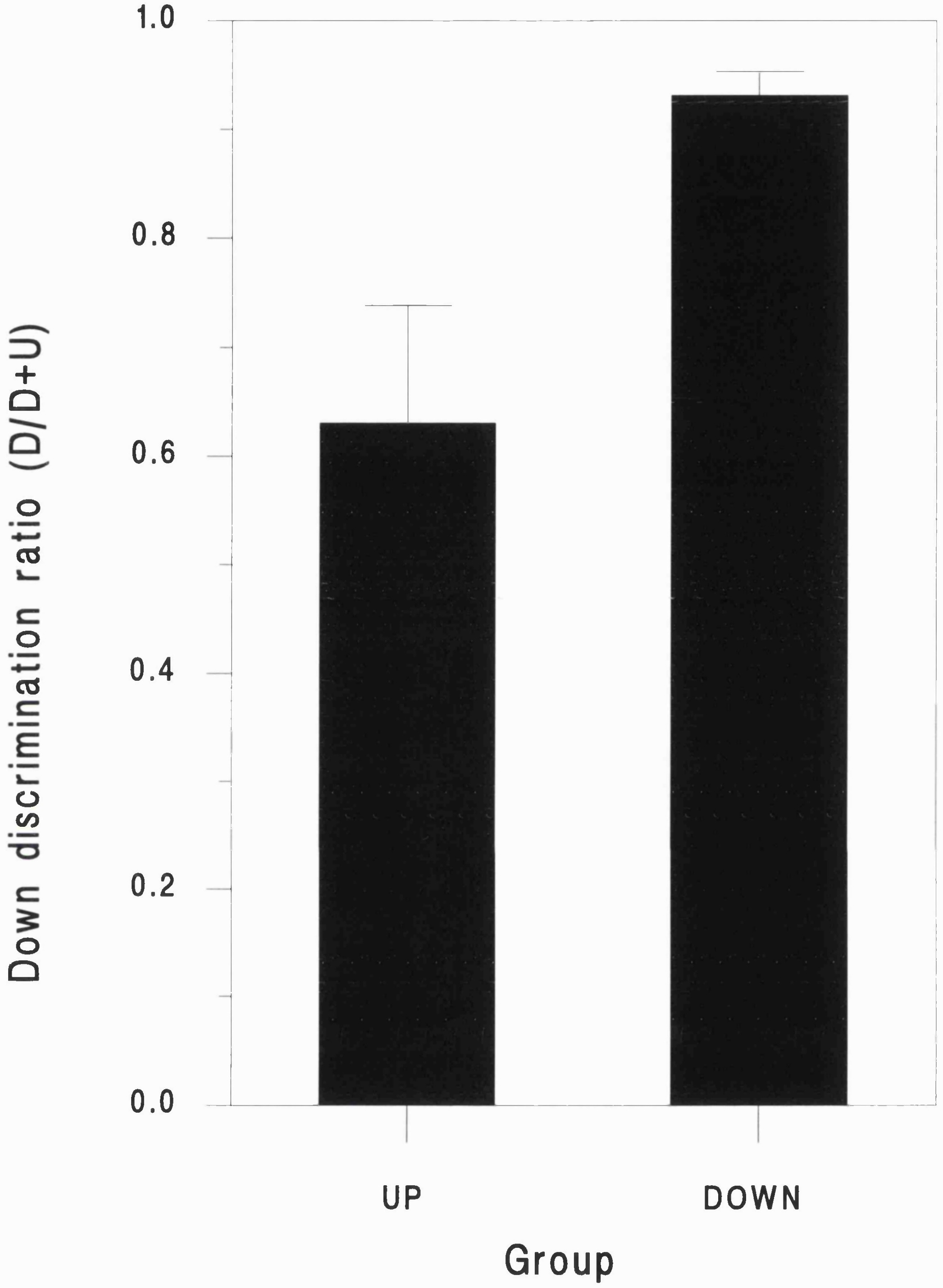

Figure 5.1. Observers' mean down discrimination ratios for the first five responses on test in Experiment 1. Error bars indicate SEMs.

down responses than an animal attracted by the scent on a lever's underside. These down responses would be reinforced, and therefore, repeated.

The scent hypothesis was tested by examining whether scent in isolation was sufficient to produce demonstrator-consistent responding. Thus, in addition to replicating Groups UP and DOWN, Experiment 2 included two further groups, Group UP SCREEN and Group DOWN SCREEN. During the observation session an opaque screen prevented observers in the SCREEN groups from seeing the responses that their demonstrators were making. If the scent hypothesis is correct, then Group DOWN SCREEN should have made a greater proportion of down responses than Group UP SCREEN. Failure to replicate the observers' response bias in the SCREEN groups would suggest that scent is an insufficient explanation for the effect observed in Experiment 1, and therefore, that observation of a demonstrator was important.

Method

The method employed in Experiment 2 differed from that of Experiment 1 in the following respects.

Subjects

Forty-eight male hooded Lister rats served as subjects. The 16 demonstrators, whose free feeding body weights ranged from 470- 567g, had demonstrated in a previous observational lever-press experiment. The 32 observers were experimentally naive. Their weights prior to scheduled feeding ranged between 413- 486g.

Apparatus

A steel screen could be attached to the wire-mesh partition to obscure the observers' view of the demonstration compartment.

Procedure

Observer training and testing. The observers were randomly assigned to one of four groups. Groups UP and DOWN replicated the procedure of Experiment 1. For observers in Group UP

SCREEN, or Group DOWN SCREEN, the opaque screen prevented their seeing the behaviour of up and down pushing demonstrators, respectively.

Results and Discussion

As in Experiment 1, using the data for the observers' first five responses, discrimination ratios were calculated by dividing the number of down responses by 5. Five animals from Group UP SCREEN and one from Group DOWN SCREEN failed to make five responses on test and were excluded from the analysis. Figure 5.2 shows for each group the mean proportion of the first five responses that were down presses. As in Experiment 1 the predominant response of all observers was pressing.

Overall, Groups DOWN and DOWN SCREEN did not make a greater proportion of down responses than the two UP groups, ($F < 1$). Nor did responding by the two SCREEN groups differ from the two standard observer groups, ($F(1,25) = 3.1$, NS). However, the interaction between the factor representing the direction of the demonstrators' responding and whether or not the observer was able to see that responding, was significant, ($F(1,25) = 6.89$, $p < .015$). Simple main effects analysis of variance confirmed that the direction in which a demonstrator responded had a marginal effect on an observer's responding when the demonstrator could be seen. Thus, when compared with Group UP, Group DOWN made a greater proportion of down responses, ($F(1,25) = 6.19$, $p < .03$). When the observers' view of the demonstrators' action was blocked by a screen, their subsequent responding was not affected by whether the demonstrator had lifted the lever up or pressed the lever down, ($F(1,25) = 1.7$, ns).

These data suggest that scent marking is not a sufficient explanation for the observers' matching behaviour shown in Experiment 1, and replicated in this experiment. Therefore, by default, it is plausible that the effect was due to observational learning. If the observation of a demonstrator's action merely attracted the observer's attention (local enhancement) to the lever, it is not clear why the observer subsequently responded in the same direction as the demonstrator. According to the simplest observational conditioning account, observers of up and down responses learned that the lever was associated with food. Plausibly, this association could have been accompanied by a lifting CR or a pressing CR. However, assuming that Groups UP and DOWN were exposed to the same classical contingency, if the observers had learned by a process of observational conditioning, Groups UP and DOWN should have performed the same CR.

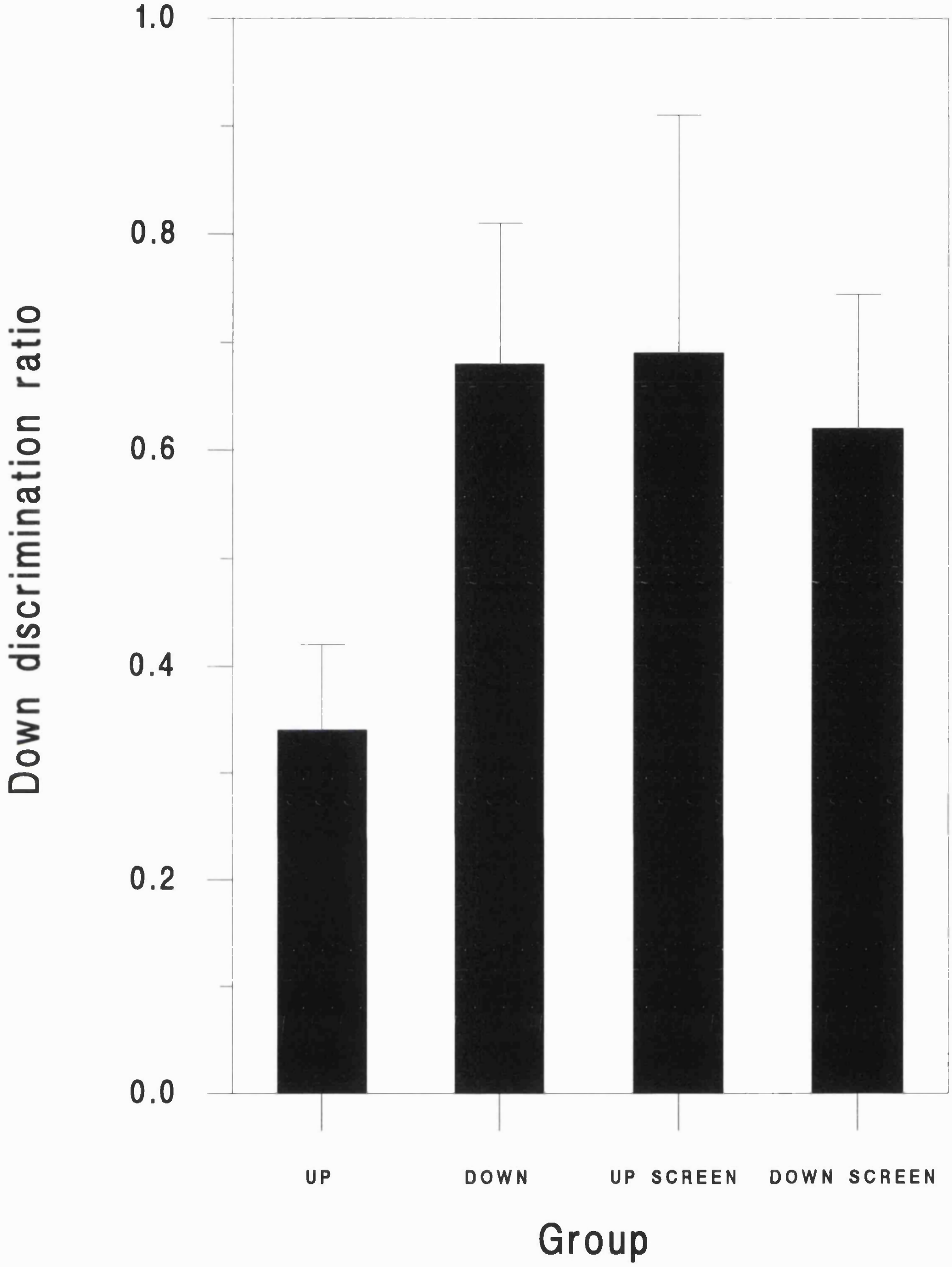

Figure 5.2. Observers' mean down discrimination ratios for the first five responses on test in Experiment 2. Error bars indicate SEMs.

5.3 Experiment 3

Experiment 3 used the complete two lever/ two action design. Four groups of observers, LU, LD, RU and RD, were exposed to demonstrators operating on the left or right levers for food reward. Group LU, for example, saw a demonstrator rewarded for lifting the left lever up. Experiments 1 and 2 established that observers who were able to see the direction in which a demonstrator manipulated a lever for reward, showed a tendency to reproduce that direction in their responses. This sensitivity to the direction of observed responding suggests that at least one of the responses was the result of observational learning. However, finding evidence of instrumentality does not exclude a role for stimulus learning, either as the sole determinant of one response type, or as a modifier of both. Rather, just as two potential responses (up and down) were required to identify observational learning, so an opportunity must be provided for identifying the unique effects of a principle of stimulus substitution. The additional lever was intended for this purpose. To the extent that the observers in the previous experiments responded to the lever because they had been exposed to a relationship between it and food, if given a choice between two levers, observers should respond preferentially to the one associated with food.

Method

The method employed in Experiment 3 differed from that of Experiment 2 in the following respects.

Subjects

Thirty-two male, hooded Lister rats served as observers. They had been observationally trained to push a joystick in an earlier experiment. Before the introduction of scheduled feeding, their weights ranged between 421- 592g. The demonstrators had demonstrated in the previous experiment.

Apparatus

The operant chamber contained two retractable levers. In their dimensions, the levers were identical to the single lever used in Experiments 1 and 2. The position of the left lever was also the same. The right lever was attached on the other side of, and equidistant from, the food magazine.

Procedure

Observer training and testing. Observers were randomly assigned to one of the following four groups: LD, LU, RD, RU. 'L' and 'R' refer to whether the demonstrators for that group responded to the left or right lever. The observed direction of responding is signified by 'U' and 'D'. Thus, Group LD, for example, were exposed to a demonstrator that pressed the left lever down.

Intervening between two sessions of magazine training, the observers were given the opportunity of habituating to the observation compartment. With the houselight on, and the demonstration compartment empty, the observers were confined to the observation compartment for thirty minutes.

Only the lever to which the demonstrator was to respond was present during observation. In the subsequent test session both levers were available to the observer. Responding in either direction, and on either of the levers, was reinforced during the test session.

Results and Discussion

Of the 32 animals tested, data from four animals were lost as a result of a computer error (all from Group LD). Of the remaining 28, two animals were omitted whose total number of UP responses were more than two standard deviations away from the mean: one from Group RU and one from Group RD (Tukey, 1977).

It was not possible to calculate legitimate discrimination ratios using these data, because each data point would contribute to the two ratios subject to analysis, a side ratio (e.g. left/left+right), and a direction ratio (e.g. up/up+down). Instead, performance was measured in terms of the number of responses of each type: left up, left down, right up, right down. Figure 5.3 shows group mean data when each observer rat had made 10 responses in total. It is apparent that, overall, there were more down responses than up responses.

The data were analysed using a three way mixed ANOVA. One between subjects factor, Side (left versus right) represented whether the demonstrator was observed responding to the left or right

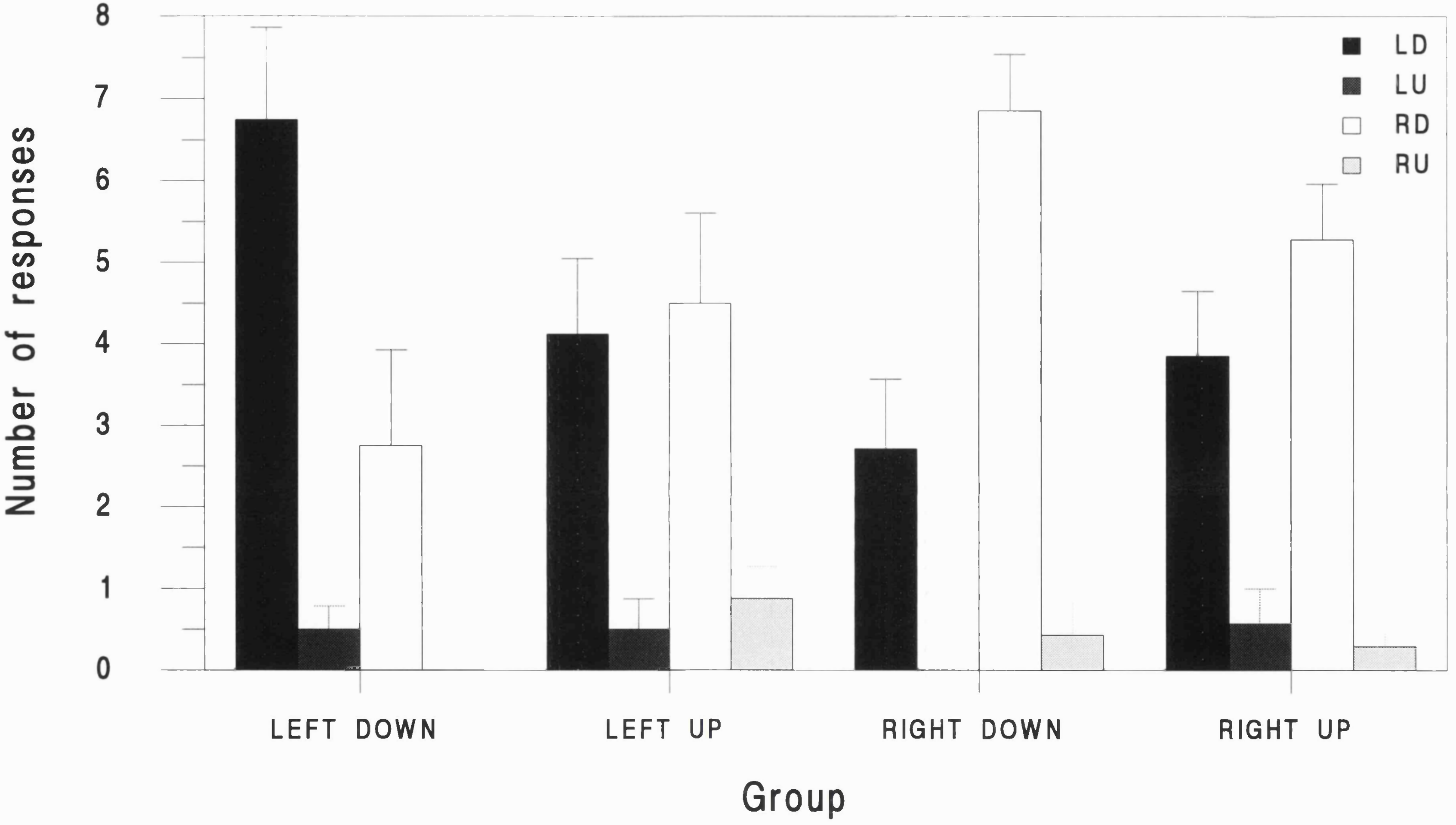

Figure 5.3. Distribution of the first ten responses, across both levers in both directions, by the observers in Experiment 3. Error bars indicate SEMs.

lever. The direction in which the demonstrator was observed responding, Direction (down versus up) was the second between subjects variable. The varieties of response available to the observer constituted the within subjects factor, Response, of which there were four levels (Left Down, Left Up, Right Down and Right Up). The groups did not differ on the between subjects factors (main effects of Side and Direction, and the interaction between Side and Direction) because each subject's total responses summed to ten. The effect of the within subjects factor, Response, was reliable (F(3,66) = 33.51, p< .0001). In addition, a significant Side by Response interaction was found (F(3,66) = 5.01, p< .003), suggesting that the lever on which the demonstrators responded influenced the overall distribution of the observers responses on test. There was no evidence of a Direction by Response interaction (F< 1). An unexpected effect of the three way interaction (Side x Direction x Response) was found (F(3,66) = 3.12, p< .03).

Further analyses were performed to identify the specific nature of the effect of Side and Direction on the distribution of observer responses.

Side. It is apparent in Figure 5.3 that the observers in Groups LU and LD made a greater proportion of their responses on the left lever than did Groups RU and RD, and vice versa for responses on the right lever. This pattern was confirmed by a pre-planned within-subjects contrast analysis. The contrast tested whether Side and Direction had an effect on the distribution of the observers' responses between the left and right levers, ignoring whether the lever was lifted or pressed (this variable is referred to as LR-Responses).

The total of left responses made by the observers was comparable to the total of right responses (F< 1). However, a significant interaction between Side and LR-Responses (F(1,22) = 5.41, p< .03) but not between Direction and LR-Responses (F< 1) suggested that the side, but not the direction, of demonstrator responding influenced the total number of left and right responses made by the observer. A three-way interaction (Side by Direction by LR-Responses) was also found (F(1,22) = 4.55, p< .05).

Direction. It is clear that the majority of responses on both levers were down responses. Although very few up responses were made overall, there is some suggestion from Figure 5.3 that observers of up responses made more up responses on test, than observers of down responses.

A second pre-planned within-subjects contrast tested whether Side and Direction had an effect on total up and total down responses, ignoring the lever on which they were made (UD-Responses). The contrast confirmed that the observers made reliably more down than up responses (F(1, 22) = 300.25, p< .0001), but, no other effects were reliable. There was no interaction between Direction and UD-Responses (F(1,22) = 1.8, ns) and no Side x UD-Responses, or Side x Direction x UD-Responses interaction (Fs< 1).

When the first five responses were considered the data showed the same pattern of responding, but the effects were not reliable.

In summary, it would appear that the proportion of left lever responses (either up or down) made by observers that saw a demonstrator operating the left lever (up or down) was greater than that of observers of a right responding demonstrator. This is consistent with observational conditioning, i.e., with the observers having learned about the relationship between the lever, irrespective of its observed direction of movement, and food. The observers also made more down responses than up responses on both levers overall. However, neither the direction nor the side of the observers' responses was affected by the direction of demonstrator responding.

5.4 Experiment 4

It is not clear why the effect of direction found in Experiments 1 and 2 was not replicated in Experiment 3. The procedure of Experiment 3 differed only in that a second lever was introduced during the test session. The procedure used in Experiment 3 was repeated in Experiment 4 in an attempt to replicate the observational conditioning effect found in Experiment 3, and to assess further the reliability of the observational learning effect found in Experiments 1 and 2, but not in Experiment 3.

Method

The method employed in Experiment 4 differed from that of Experiment 3 in the following respects.

Subjects

Thirty-two male, experimentally naive, hooded Lister rats were observers. Their free feeding body weights ranged from 403- 566g. The demonstrators from the previous experiment were used again.

Results and Discussion

Of the 32 animals tested, four (two from Group LU and two from Group RD) failed to complete 10 responses on test. Of the remaining 28, three animals (one each from Groups RU, RD and LD) were excluded from the analysis because their total numbers of up responses were more than two standard deviations from the group mean (Tukey, 1977).

As in Experiment 3, performance was measured in terms of the number of times each of the four response types was produced in the course of the first 10 responses. These data are shown in Figure 5.4. It is again apparent that the majority of the responses were down presses.

A three way mixed ANOVA, with the between subjects factors of Side (left versus right) and Direction (down versus up), and the within subjects factor of Response (Left Down, Left UP, Right Down and Right Up) confirmed that there was variation in the frequency with which different types of response were made. As in Experiment 3, the between subjects aspects of the analysis were ignored since each subject's total responses summed to ten. The effect of the within subjects factor of Response was significant ($F(3,66) = 20.93$, $p < .0001$). In addition, the Side by Response interaction was found to be reliable ($F(3,66) = 2.92$, $p < .04$), suggesting that the distribution of the observers' responses between the available response types was influenced by the lever to which they had observed a demonstrator responding. However, there was no evidence for a Direction by Response interaction ($F < 1$), or the three way (Side x Direction x Response) interaction ($F(3,66) = 1.18$, ns).

Further analyses were performed to identify the specific nature of the effect of Side and Direction on the distribution of observer responses.

Side. Figure 5.4 suggests that, as in Experiment 3, the observers of left pushing (Groups LU and LD) made a greater proportion of their responses on the left lever than did Groups RU and RD.

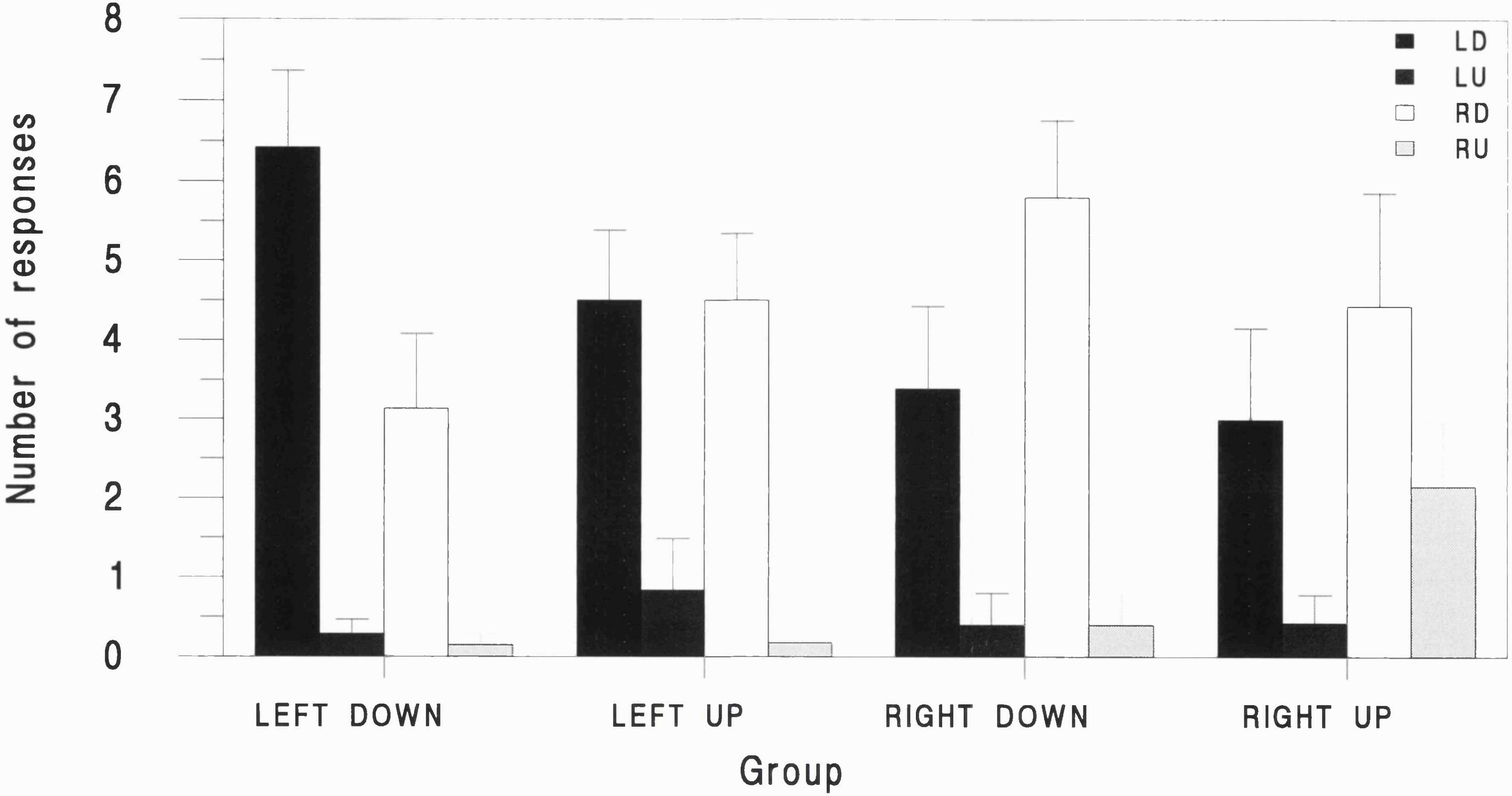

Figure 5.4. Distribution of the first ten responses, across both levers in both directions, made by the observers in Experiment 4. Error bars indicate SEMs.

This pattern was confirmed by a pre-planned within-subjects contrast that tested the effects of the between subjects variables (Side and Direction) on the two within subjects variables of total left responses, and total right responses, ignoring whether they were lifts or presses (LR-Responses).

There was no difference between the overall number of left and right responses made by the observers (F< 1). Replicating Experiment 3, a significant interaction between Side and LR-Responses (F(1,21) = 4.69, p< .05) was found. The interaction effects of Direction x LR-Responses, and Side x Direction x LR-Responses were not reliable (Fs< 1). Together, these effects suggest that the lever on which the demonstrator responded, but not the direction of those responses, influenced the total number of left and right responses made by the observer.

Direction As in Experiment 3, the majority of responses were down presses. Although very few up responses were made overall, there is some suggestion in Figure 5.4 that observers of up responses made a greater proportion of up pushes than did observers of down responding demonstrators.

A second pre-planned within-subjects contrast tested whether the factors Side and Direction affected the total up and total down responses when the lever on which the responses occurred was ignored (UD-Responses). The contrast confirmed that the observers made reliably more down than up responses (F(1, 21) = 127.72, p< .0001). In addition, the presence of a marginally reliable Direction by UD-Response interaction (F(1,21) = 3.03, p<0.05; 1-tailed), but no interaction between Direction and UD-Responses or Side, Direction and UD-Responses (Fs< 1), suggested that the total number of up and of down responses that the observers made was influenced by whether their demonstrators lifted or pressed the lever, but not by the lever on which the observed responses was made.

In summary, Experiment 4 replicated the effect found in Experiment 3 whereby observers of left responding demonstrators were shown to make a greater proportion of their responses on the left lever than those that observed demonstrators operating on the right lever (up or down). It has been argued that a lever preference could be the result of observational conditioning. Also, while observers made more down responses than up responses overall, the tendency to push up was greater in the observers that had been exposed to an up pushing demonstrator. It has been argued that this latter effect, found previously in Experiments 1 and 2 when the observers' opportunity for responding was restricted to one lever, is suggestive of observational learning.

5.5 General Discussion

In their own responding, observers have been shown to favour a lever that they have seen manipulated just prior to the delivery of food to a conspecific. This, it has been argued, is consistent with observational conditioning. The tendency to match the direction of the observed response has been interpreted as requiring a capacity for observational learning. The evidence for observational conditioning and observational learning will be examined in more detail, and suggestions for improving the experiments will be made.

In the case of the lever preference, its interpretation as an observational conditioning effect is difficult for three reasons. First, rather than representing a learned preference, the bias towards responding on the same lever as their demonstrators may have been caused by a neophobic reluctance, on the part of observers, to approach the comparison lever that was introduced for the test. However, more recent experiments which have found a lever preference when both levers were present in the experimental chamber during the observation sessions, suggest that this is not the case (Mitchell and Heyes, unpublished, Campbell and Heyes, unpublished). Second, the observers' preference may be for the lever that has been daubed by the demonstrator's scent. However, experiments have been conducted, using two levers that can be pressed down, in which half the observers were prevented from seeing the lever to which the demonstrators were responding. These observers distributed their responding equally between levers, suggesting that a lever preference represented more than an effect of scent (Heyes, Mitchell and Nokes, unpublished). Finally, and this is also relevant to the evidence for observational learning, it is apparent from Chapter 4 (see also Chapter 2, section 2.1) that, in addition to evidence that it involves learning about stimuli, a demonstration of observational conditioning requires confirmation that effect is one of associative learning. That is, it must be shown that the lever preference develops because of the relationship between the lever and food. If the lever preference were established relative to truly random control animals, i.e., observers for which lever-pressing and reward were uncorrelated, it would imply that the lever-> food contingency was responsible for observers manipulating the same lever as their demonstrators.

With respect to the evidence for observational learning, on closer examination, it is not clear that the two lever/ two action paradigm controlled for all potential stimulus learning about direction. Therefore, the influence of direction may not identify an observational learning process. For example, because food was delivered contiguously with the completion of the response, learning about the stimuli associated with the terminal position of the lever was possible. Thus, if an up observer were to make an up response on test, these reward correlated stimuli might constitute a source of reinforcement not available to an observer for whom reward had been observed correlated with the stimuli associated with the position of the lever following a down response. Heyes, Dawson and Nokes (1992) in their bidirectional control procedure (see Chapter 1, section 1.3.2) anticipated that the effect of the direction of the demonstrator's response, in this case whether they pushed a joystick to the left or right, would be confounded by reward correlated stimuli. The author's solution was to move the position of the joystick between observation and test, thereby ensuring that anything that the observers had learned about the joysticks movement relative to features of the apparatus was irrelevant to responding to the joystick in its new position. The directional bias in the observers' responding could, therefore, be attributed to the remaining contingency; that between behaviour and reward. In the case of the paradigm used here, there is no obvious analogous transfer test. Short of inverting the experimental apparatus, some stimulus features associated with an up response, e.g. the chamber's ceiling, are invariant whether or not the lever is moved between observational training and testing.

In the course of considering how to control for reward correlated stimuli in this particular paradigm it became apparent that, even if such control could be implemented, social learning procedures are importantly different from those where animals learn in isolation. It is suggested that, therefore, the bidirectional control procedure requires modification in its application to social learning.

In a social bidirectional control procedure, separate groups of observers are exposed to a demonstrator that, for example, lifts or presses a lever for reward. Assuming for the moment that we have managed to exclude the possibility for encoding the direction of the lever's movement relative to features of the apparatus, if observers of down pressing pressed the lever more than observers of lifting, would this establish that an observational learning process was responsible for at least one of the observers' responses? According to the rationale of the bidirectional control, the answer is yes in those cases where the Pavlovian relationships experienced by Group UP are identical to those experienced by Group DOWN. Although the associated outcome is assuredly the same for Group UP and DOWN, i.e., the delivery of a food pellet to the demonstrator, because the response required of the demonstrators is different in the two cases, their positions relative to the antecedent stimulus, the lever, are also likely to be different. A demonstrator that lifts up, for example, may do so from beneath the lever, while pressing down may encourage demonstrators to assume a position above the lever. Thus, if the stimulus associated with food was encoded by the observers as the lever plus the demonstrator's body above it or below it, depending on whether the demonstrator was an up or down pusher, Groups UP and DOWN were exposed to different S-S relationships. Consider the case of an observer that has seen up responding, and who, in the course of exploring the demonstration compartment during the test session, approaches the underside of the lever. The stimulus associated with reinforcement, i.e., the lever plus the demonstrator below it, will have been re-encountered if the observer can identify its present position with that assumed by its demonstrator when making up responses. From the observer's position beneath the lever, a manipulatory CR might be expressed as an up response. An observer of down responding would perform a CR when it happened to encounter the situation corresponding to the stimulus it had associated with food, in this case a lever plus the demonstrator's body above it. For an observer of down responses this would be when the observer assumed a position above the lever. A manipulatory CR made by an observer standing over the lever might result in the lever being pressed down. Therefore, it seems that observational conditioning processes might be able to produce a direction effect.

The rationale of the bidirectional control seems to offer two solutions to the problem of identifying observational learning. The first, which might be difficult to achieve in practice, is to continue using the bidirectional control procedures, but to ensure through careful training that the manipulandum is in the same position relative to the demonstrator whatever the response performed by the demonstrator. In this case, observers of up and down responding would be exposed to the same S-S relationship, i.e., the lever plus, for example, a demonstrator that had been trained to operate on it from above. The remaining variable that differentiates the observational experience of Groups UP and DOWN is the movement of the lever relative to the demonstrators' body.

Second, according to the principle of stimulus substitution, responses that differ from, or, are opposed to, those unconditionally elicited by the US cannot be classically conditioned. This, the rationale for the bidirectional control, also suggests other procedures whereby the effects of, in our case, social response-reinforcer learning may be isolated. For example, shock unconditionally elicits crouching and freezing. Therefore, an animal that had learned to scratch itself to avoid shock must have done so instrumentally. So, if an observer that received shock except for periods after its demonstrator scratched, were itself to learn to scratch, it would suggest that the response was instrumental. In combination, two aspects of this procedure ensure that observational conditioning could not explain how an observer socially learned to scratch in order to avoid shock; 1) scratching is not a component of the UR to shock, 2) scratching is a self-directed behaviour, and therefore, when it is observed, its execution is unlikely to covary reliably with any features of the apparatus that might otherwise have become associated with relief from shock. The effect may not conform to a definition of observational learning or imitation, because the observer received, rather than observed reinforcement, but it provides evidence of a capacity common to all definitions of imitation, i.e., the ability to learn to do an act from seeing it done (Thorpe, 1911).

Chapter 6

A Demonstration of Local Enhancement in the Rat

6 Introduction

In Chapter 1, it was questioned whether an elevation in the bar-pressing behaviour of animals who had been previously exposed to a bar-pressing conspecific, constituted evidence of imitation (Denny, Clos and Bell, 1988). More generally, Denny et al argued that, if an increase in operant responding by animals exposed to demonstrators responding for reward is assessed relative to non-exposed controls, it could result from mechanisms other than observational learning. For example, an acting demonstrator not only responds to the bar, he also stands near it. Thus, perhaps because it attracts attention, the demonstrator's activity or presence in the vicinity of the bar, rather than its action on the bar, might produce an increase in the observer's bar-pressing. Local enhancement, the category to which the effect on learning of a demonstrator's presence/activity near a stimulus is often attributed (eg Zentall, 1988), was defined by Thorpe, (1963) as "apparent imitation resulting from directing the animal's attention to a particular object or to a particular part of the environment".

Since Morgan (1900) made a distinction between instinctive and reflexive imitation, the possibility that any correspondence in the behaviour of an observer and his model may be due to processes other than 'true' imitation, has been repeatedly acknowledged (see Galef, 1988 and Heyes, 1994, for classifications of social learning processes that may produce seemingly imitative behaviour). Rather than remain agnostic about mechanism when the design of an experiment has made it impossible to identify imitation with certainty, researchers have tended to conclude that a local enhancement process is responsible. Three assumptions drive the inference to local enhancement: 1) imitation is a cognitively complex process, 2) local enhancement is a simpler process than imitation, and, therefore, 3) local enhancement is a more parsimonious explanation of matching behaviour that is not definitively imitative. In particular, researchers have invoked Lloyd Morgan's Canon (Morgan, 1900) as a justification for inferring a local enhancement process (e.g. Galef, 1988, Hogan, 1988, and Denny et al, 1988). In the appendix, arguments are presented which suggest that, in fact, Lloyd Morgan's Canon does not licence the inference to local enhancement.

To the best of my knowledge, there are no experiments which control for all social effects other than local enhancement, and from which, therefore, the occurrence of local enhancement may be deduced. Therefore, it would be interesting to establish empirically whether observers are subject to the effects of local enhancement. Experiment 1 was designed to show a local enhancement effect.

6.1 Experiment 1

It is assumed in this chapter that a local enhancement process cannot be inferred from a paradigm where imitation could explain the behaviour that is taken to be evidence of local enhancement (see appendix). Therefore, the experiments in this chapter attempted to establish a social learning effect in circumstances which excluded the possibility of processes other than local enhancement.

When first presented, most stimuli elicit a typical behavioural response, or orienting response (OR). In the case of a light, rats will rear on to their back legs often licking or sniffing the bulb. The vigour of the OR changes with experience of the stimulus, and is thought to reflect the degree of attention, or processing which the stimulus is currently receiving (Hall, 1991, p.100). Thus, any socially mediated alteration in the attention paid to a stimulus might be reflected in the strength of an observer's subsequent OR.

In Experiment 1, observers were exposed to demonstrators that either oriented (Group DEM OR observed by Group OR) or did not orient (Group DEM NON-OR observed by Group NON-OR) in response to a light. If, having seen an orienting demonstrator, Group OR were themselves to orient to a greater number of light presentations than Group NON-OR, and if orienting is accepted as an adequate behavioural index of attention (see Hall, 1991, p.100-103), it would suggest that the attention that an animal pays to a stimulus can be influenced socially. For this to be an effect of local enhancement, i.e., the result of Group OR paying greater attention to the light, a third group (Group ASOC) exposed to the light without a demonstrator being present, must also orient less than Group OR. In this way ruling out the possibility that any Group OR/ Group NON-OR difference is produced by a socially induced reduction in orienting by Group NON-OR, rather than an elevation in Group OR's orienting.

The use of orienting behaviour is well suited to the purpose of distinguishing local enhancement from imitation effects for two reasons. First, the observer's target behaviour, i.e., orienting, is one which, to a greater or lesser extent, would have been elicited without social exposure. Therefore, it is possible to see a social effect on a behaviour which is not itself learned during social exposure. Second, because orienting is automatically elicited by a stimulus, it is possible to compare the effects on responding of a demonstrator who orients (local enhancement effects), and a demonstrator who is present but not responding (social facilitation control), in the absence of reinforcement. Thus, the observer does not learn how to orient, nor does it learn about the consequences of orienting behaviour. According to many definitions, however, imitation involves learning either about novel behaviours (Thorpe, 1963), or about the outcome which is contingent upon a behaviour (Heyes, 1994), or both, i.e., acquiring a novel behaviour and learning that it is followed by a particular outcome (Whiten and Ham, 1992).

Method

Subjects

Forty-four experimentally naive, male, hooded Lister rats obtained from Harlan Olac Ltd. (Bicester, Oxon) served as subjects in this experiment (ad lib weight range 408-558g). Twenty of these served as demonstrators. The remaining 24 were observers. Two of the three groups of observers (n=8) were assigned demonstrators. There were two demonstrators for each observer in Group OR. Every Group DEM NON-OR demonstrator demonstrated for two different observers. Throughout the experiment observers and demonstrators were housed separately in groups of four. Water was freely available in the home cage. The animals were maintained at 90% of their ad lib weights by being given a restricted amount of food on each day.

Apparatus

All training and testing was conducted in four identical operant chambers measuring 50 x 25 x 21 cm. The interior walls of each box were black painted sheet metal. The ceiling was made of translucent Perspex, and the floor consisted of parallel metal rods.

Each chamber was divided into two compartments of equal size by a wire-mesh partition. One compartment was used for demonstration and testing. In the centre of the side wall of this demonstration compartment, opposite the wire-mesh partition, there was a recessed food tray, 6 cm high x 5 cm wide, into which 45mg sucrose pellets could be delivered. If a subject entered the food tray, a photocell beam was broken and a response was recorded. The corresponding side wall of the other, observation, compartment was blank.

A 24 v light 1 cm from the top of the side panel in the demonstration compartment was used as the habituation stimulus. The chambers were illuminated throughout the session by a 24 v overhead light situated above the centre of the perspex ceiling in the demonstration compartment. A square, 5 x 6.5 cm, was marked on the perspex ceiling surrounding the panel light, i.e., one side of the square was flush with the chamber wall which contained the panel light. If an animal's nose entered the area of the square, an orienting response was recorded.

Responding by the subjects to the light was recorded by video cameras (Sanyo, model no. VW-D3P and JVC, model no. G2-S3) suspended 27 cm above the ceiling of the chamber. From this position, the entire demonstration compartment was visible.

A BBC Master Computer, running Spider on-line language controlled the equipment, governed the stimuli and collected the magazine entry data.

Procedure

Each session began with the houselight being switched on and finished when the houselight was extinguished.

Demonstrator training. Group DEM NON-OR received 10 daily sessions of habituation training. In each session a random time (RT) four minute schedule governed the presentation of ten 30s light CSs. Group DEM NON-OR's behaviour was videotaped on the tenth day. Group DEM OR received 40 minutes of context exposure on each of three days to ensure that, like Group DEM NON-OR, any unconditioned responding to the context had habituated. While they were in the chamber, the overhead light was on, but no stimuli were presented. The behaviour of Group DEM OR was videotaped during their first session of context exposure. Random numbers were generated and used to determine the beginning of ten, 30s 'dummy' CS periods, in which Group DEM OR's orienting behaviour was scored as if the light were on. These data were used as a baseline against which to assess whether Group DEM NON-OR had habituated to the light after 10 sessions. If Group DEM NON-OR had habituated to the light, they should not have oriented more to the light in their tenth session, than did Group DEM NON-OR during the dummy CSs of their first context exposure session.

Responding which has habituated will return if a stimulus is presented in a novel context (Hall, 1991). Therefore, 'dummy' observers, whose behaviour was not included in any analysis, were present while the demonstrators were being trained to ensure that, during the observation session that preceded observer testing, the experimental observers did not constitute a novel context in which Group DEM NON-OR's habituated orienting would be restored.

These training schedules ensured that, during the observation session prior to observer testing, behaviour to the light by the two groups of demonstrators differed. Having never previously encountered the light, the rats in Group DEM OR oriented in response to its presentation. By contrast, Group DEM NON-OR's orienting had habituated.

Observer training and testing. The observers were randomly assigned to one of three groups, each with eight subjects: Group NON-OR; Group OR; Group ASOC. For the first three days, each observer received a daily 30 minute session in the demonstration compartment with the houselight. This was to familiarise the observers with the context in which their orienting behaviour to the habituation stimulus would subsequently be tested. For these sessions, a dummy observer was placed in the observation compartment, so that, before being exposed to the demonstrators, observers had experienced animals in the experimental context. Thereby, it was hoped, the observers would be less aroused by the simple presence of a demonstrator during the observation session.

Habituation training. All observers received both an observation and a test session, separated by half an hour in the home cage. All sessions were videotaped. During the observation session, from their position in the observation compartment, observers in Groups NON-OR and OR were exposed to their demonstrator's responding to the light in the demonstration compartment. Each rat in Group ASOC was placed directly in the demonstration compartment for this session. The demonstrator for observers in Group OR was from Group DEM OR. Observers in Group NON-OR were exposed to a habituated demonstrator from Group DEM NON-OR. The panel light was illuminated for 30s on five occasions governed by an RT (4 min) schedule. All observers were tested in the demonstration compartment. Five 30s CSs, separated by a mean inter-trial interval (ITI) of four minutes, were presented.

Video Scoring. All observations of the subjects' behaviour were made from videotapes. The behavioural measure taken was whether or not the subjects' snout entered the box marked on the perspex ceiling during a given, or dummy, CS period, (Hall and Channell, 1985). All observations were made by a single rater who was aware of the animals' group assignments. A second rater, blind to group membership, randomly selected and scored a quarter of the habituation test sessions.

Results and Discussion

The number of CS presentations to which an animal responded such that its snout entered the marked box was calculated and, unless otherwise stated, this was the measure used for analysis.

Demonstrator behaviour. The behaviour of both orienting and non-orienting demonstrators to the light is shown Figure 6.1. Data from three animals in Group DEM OR are missing because the video failed to record. The left hand panel of Figure 6.1 shows the mean number of CSs (max = 10), or dummy CSs in the case of Group DEM OR, to which a response was made. Group DEM NON-OR's behaviour was measured during their tenth session of exposure to the CS. Responding by Group DEM OR was recorded during their first session. Analysis of variance showed the groups' behaviour to be equivalent (F< 1) at this stage. The presentation of a light to Group DEM NON-OR produced no more behaviour in the vicinity of the light than that produced by animals to which the light had not previously been presented This suggests that repeatedly exposing Group DEM NON-OR animals to the CS had been effective in habituating the orienting responses governed by that CS.

The right hand panel of Figure 6.1 shows the behaviour of the demonstrator groups and observer ASOC group towards the five CSs presented in the observation session. The data from one animal in Group ASOC, a statistical outlier whose responding fell more than two standard deviations from the group mean, were removed from the analysis (Tukey, 1977). The video failed to record the behaviour of two animals from Group DEM NON-OR. Two further NON-OR demonstrators were reassigned to Group OR. The observation sessions which used these demonstrators were much later in the day than their habituation training sessions had been, and, therefore, their behaviour was not typical of Group DEM NON-OR; one demonstrator responded to all five CSs, and the other oriented to four CSs. Analysis of variance revealed a marginal difference in group behaviour (F(2,18) = 3, p< .07) and pre-planned contrasts confirmed that Group DEM NON-OR made fewer

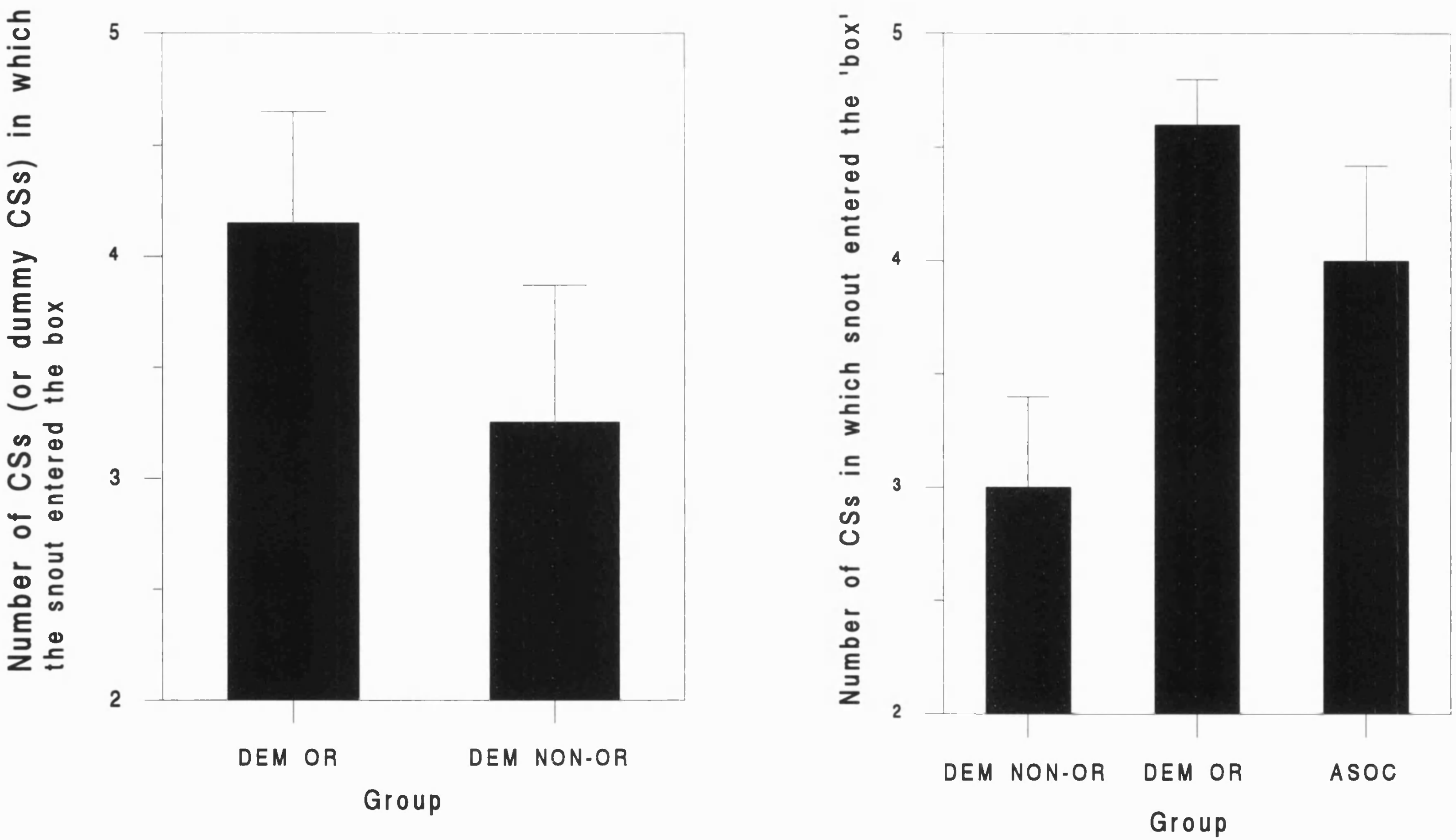

Figure 6.1. The left hand panel shows the number of CSs to which a response was made during the tenth (Group DEM NON-OR) and first (Group DEM OR) habituation training sessions in Experiment 1. Error bars indicate SEMs.

The right hand panel shows the number of CSs to which the demonstrator groups responded during the first observation session in Experiment 1. Error bars indicate SEMs.

responses to the CS than Groups DEM OR and ASOC (F(1,18) = 5.44, p< .03). Figure 6.1 shows that the orienting behaviour of Groups DEM OR and ASOC was comparable.

Observer behaviour. In addition to observers whose demonstrators had been removed from the experiment for any reason other than video failure, the data from one Group OR observer, a statistical outlier, were rejected. The numerical difference, shown in Figure 6.2, in the groups' orienting behaviour to the light on test, was found to be reliable (F(2,20) = 3.29 p< .058). Pre-planned contrasts confirmed that Group OR responded to more presentations of the CS than Groups NON-OR and ASOC (F(1,20) = 6.56, p< .019), which clearly did not differ from one another.

In summary, observers given the opportunity to respond to a light which had previously been presented in conjunction with an orienting demonstrator, oriented to a greater number of presentations of the light than observers whose demonstrators had habituated to the light. In addition, by including an observer group exposed to the light in the absence of a conspecific, Experiment 1 found evidence which supports the interpretation of this difference as an effect of local enhancement (Thorpe, 1963). Group OR responded more frequently to the light than either Group NON-OR or Group ASOC, and differed from the latter in having been exposed to the light while a conspecific was present. Thus, it seems that observation of a conspecific responding to a stimulus can indeed enhance the level of responding subsequently governed by that stimulus.

6.2 Experiment 2

Experiment 1 provided evidence to suggest that exposure to a conspecific responding to a light, can lead to an elevation in an animal's own orienting behaviour to that light. This finding is consistent with the early definitions of local enhancement (Spence, 1937; and Thorpe, 1956). Although they proposed different mechanisms to account for local enhancement; exposure (Spence), and attention (Thorpe), Spence and Thorpe were agreed that local enhancement affects the responses which a stimulus automatically elicits. For example, Spence claimed that responding on the part of a demonstrator enhances an observer's exposure to that part of the environment to which the demonstrator is responding, and so an animal comes to concentrate its responding in the enhanced region. Any appearance of imitation is then explained as the result of an increase in the probability that, by chance, the correct response or stimulus dimension will be sampled.

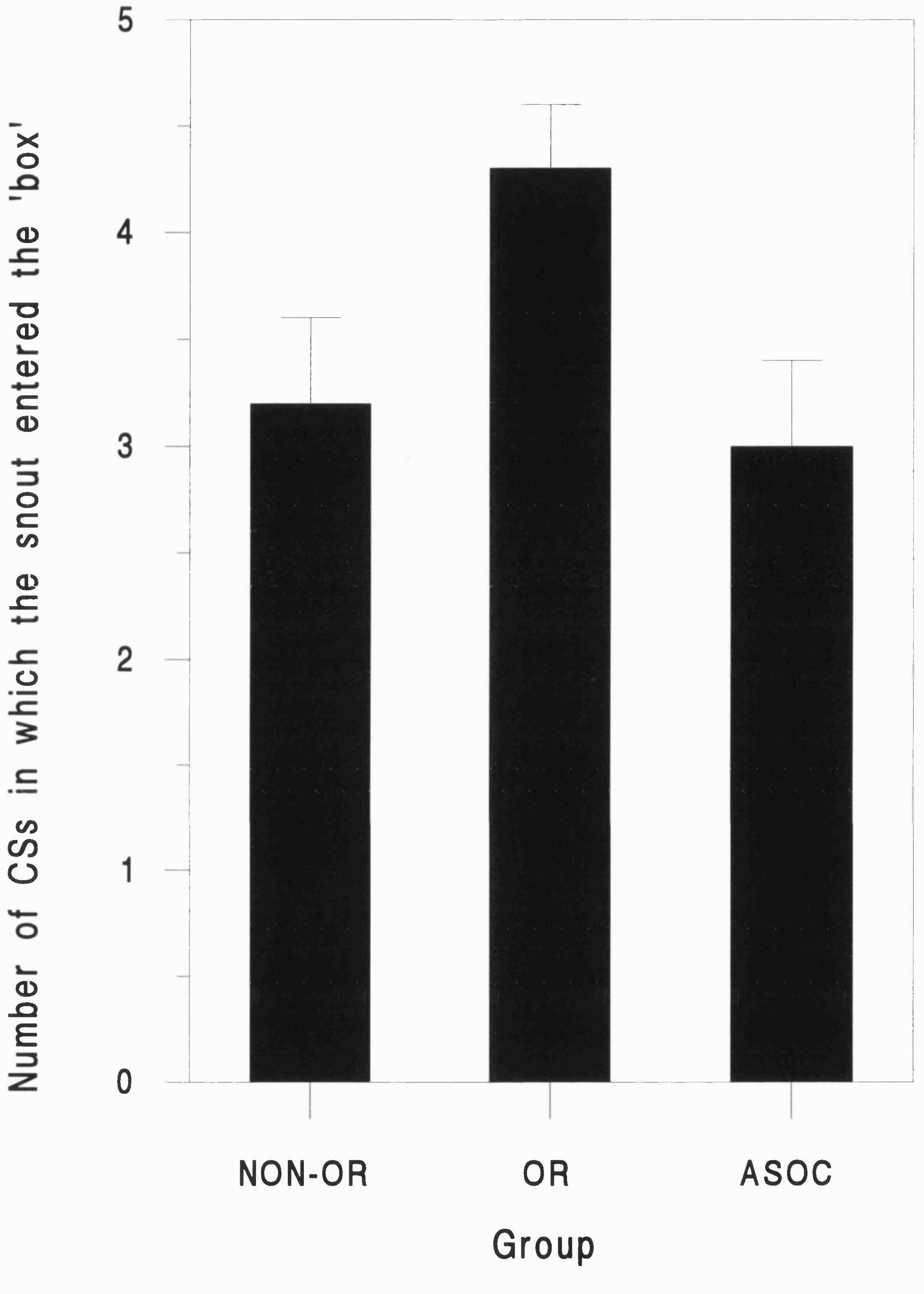

Figure 6.2. Number of CSs to which a response was made by observers on test in Experiment 1. Error bars indicate SEMs.

It has been assumed that local enhancement is a potential mechanism for any instance of matching behaviour irrespective of the parameters of the learning experience. For example, as mentioned at the beginning of this chapter, Denny, Clos and Bell thought it likely that local enhancement was responsible for their finding that animals exposed to a demonstrator responding selectively to one of two stimuli for reward, showed nearly perfect performance on an operant discrimination task. However, unlike the present experiment which found a local enhancement effect after five trials, the observers received an average of 232 observation trials before they were tested.

Using socially induced alterations in the attention paid to the light as a putative mechanism to account for the Experiment 1 result, Spence's reasoning would suggest that a demonstrator rearing in front of a light results in that light receiving a greater proportion of the limited attentional capacity available to an observer. A consequence of this could be enhancement of responding elicited by the stimulus, in this case an orienting response to a light. However, contrary to what is implied by Thorpe's and Spence's discussions of local enhancement, it is not clear that such an attentional mechanism would reliably result in matching behaviour by ensuring "that the probability of hitting upon [the same response as the demonstrator] is greatly increased" (Spence, 1937). In fact it seems possible to derive the opposite prediction.

It is known that a stimulus repeatedly presented asocially without consequent reinforcement will result in the habituation of the stimulus's OR, and slower learning about any subsequent relationships which involve the stimulus. The latter phenomenon is known as latent inhibition (Lubow, 1973). The greater the number of stimulus exposures, the more profound are the effects of habituation and latent inhibition. Thus, if the effect of an orienting demonstrator is to magnify the degree of processing a stimulus receives (similar to the cumulative effect of repeated exposure), then the kind of extended training given in the Denny, Clos and Bell experiment might be expected to result in 1) more infrequent orienting by the observers, i.e., a reduced probability that the observer will emit the relevant operant by chance, and 2) the loss of stimulus associability (latent inhibition), retarding learning about any new consequences the stimulus may have.

Experiment 2 had two purposes: 1) to replicate the finding that with few trials, observers of an orienting demonstrator will themselves orient more in response to a light; and 2) to investigate whether, after extended habituation training (30 trials), an effect of local enhancement is to accelerate what an observer learns about the light when it is subsequently paired with food in a conditioning phase.

Method

The method employed in Experiment 2 differed from that of Experiment 1 in the following respects.

Subjects

Thirty six male, hooded Lister rats served as subjects. Of these, 32 were experimentally naive, and served either as observers (n=16) (ad lib weight range 373-437g), or Group DEM OR demonstrators (n=16, ad lib weight range 383-457). The four remaining animals were the Group DEM NON-OR demonstrators used in the previous experiment. To ensure that exposure to the light was accompanied by an orienting demonstrator, there were two demonstrators for every Group OR observer.

Procedure

Demonstrator training. Following Experiment 1, Group DEM NON-OR received three daily sessions of supplementary habitation training. Their behaviour towards the panel light CS was videotaped on the third day.

Observer training and testing. Observers were randomly assigned to either Group OR (n=8), or Group NON-OR (n=8).

Habituation training. Following the test for habituation, the observers were exposed with their respective demonstrators to a further 25 presentations of a 30s panel light. Two sessions of 10 CSs each, and one session of five CSs occurred on consecutive days. Observers in Group OR saw two demonstrators that each demonstrated for 15 CSs. At the end of habituation training all demonstrators were removed from the experiment. For the remaining experimental sessions, the observers were placed in the demonstration compartment.

Magazine training. Following habituation training, all observers received one session of magazine training with the house light on. Thirty food pellets were delivered on an RT 60s schedule.

Conditioning. On each of three days, the observers received a daily experimental session which consisted of ten, 30s presentations of the light CS, with each CS presentation followed immediately by the delivery of a sucrose pellet to the food magazine. The mean inter-trial interval (ITI) was three minutes, governed by an RT schedule. The number of times the observer entered the food magazine during the session, in the 30s preceding the CS and during the CS, was recorded.

Results and Discussion

The number of CS presentations to which an animal responded such that its snout entered the marked box was calculated, and, unless otherwise stated, this was the measure used in analysis.

Demonstrator behaviour. The demonstrators' orienting behaviour is shown in Figure 6.3. The left hand panel shows behaviour during training. Group DEM NON-OR was videotaped during the final supplementary training session. Group DEM OR was recorded during dummy CS periods on the first day of exposure to the apparatus. Analysis of variance failed to reveal any group differences in orienting behaviour ($F< 1$). Group DEM NON-OR oriented to the light no more often than demonstrators for whom the light was never illuminated, suggesting that the habituation procedure had been successful.

The right hand panel of Figure 6.3 shows the demonstrators' orienting behaviour for the five CSs to which the observers were socially exposed before testing their orienting to the light. Group DEM OR responded to a greater number than Group DEM NON-OR, ($F(1,14)=15.44$, $p< .002$).

Observer behaviour. The observers' orienting behaviour is shown in Figure 6.4. Replicating the result of Experiment 1, analysis of variance showed that Group OR responded to a significantly greater number of CS presentations than Group NON-OR ($F(1,14) = 4.67$, $p<. 05$). That is, observers who had been exposed to demonstrators orienting to a light, themselves oriented to the presentation of the light on a greater number of occasions than observers of demonstrators that made less frequent orienting responses. Thus, there was less habituation to the light by observers of orienting demonstrators.

The observers' behaviour to the magazine was recorded during the final experimental phase

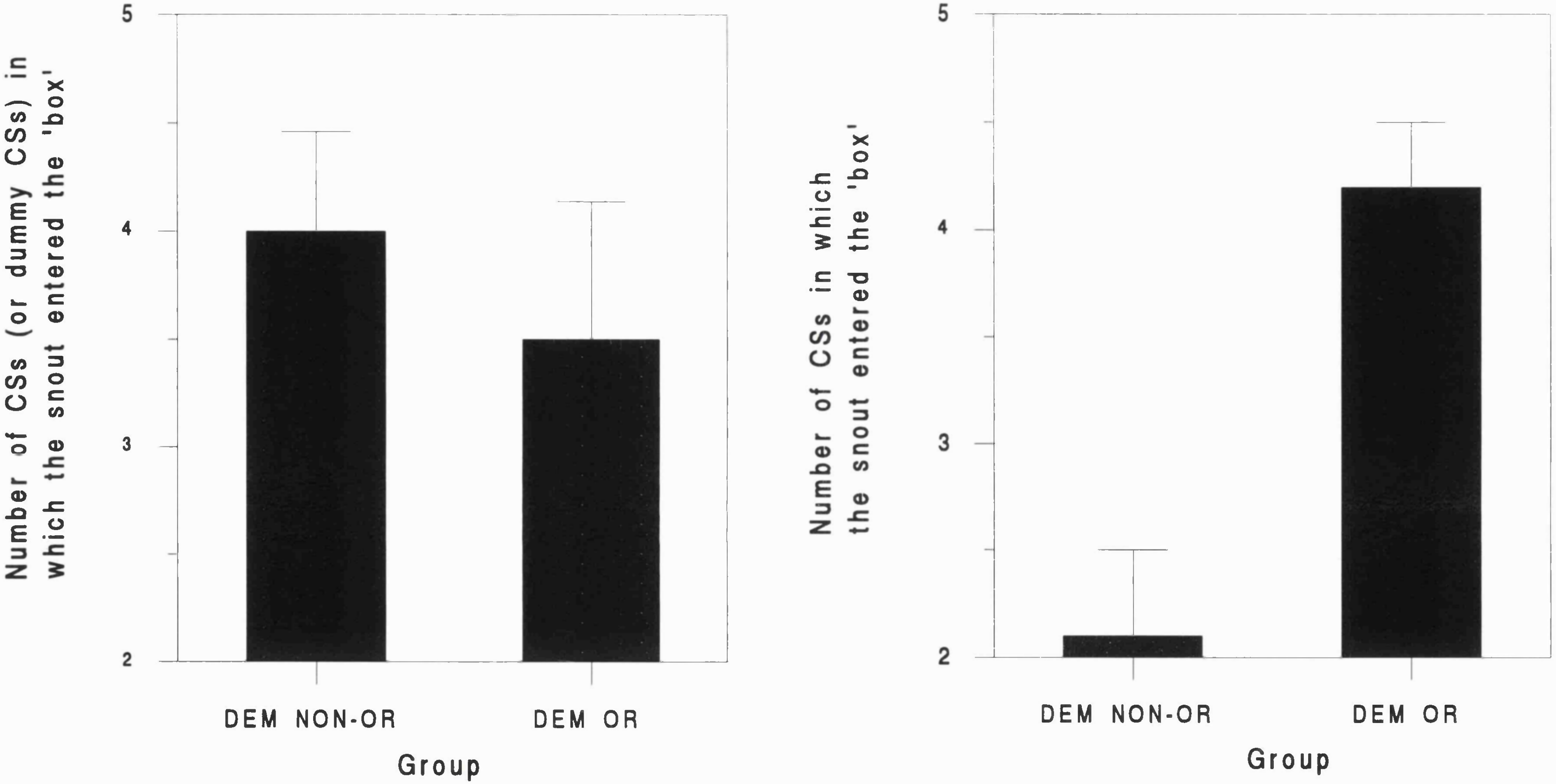

Figure 6.3. The left hand panel shows the number of CSs to which a response was made during the tenth (Group DEM NON-OR) and first (Group DEM OR) habituation training session in Experiment 2. Error bars indicate SEMs

The right hand panel shows the number of CSs to which the demonstrators responded during the first observation session in Experiment 2. Error bars indicate SEMs.

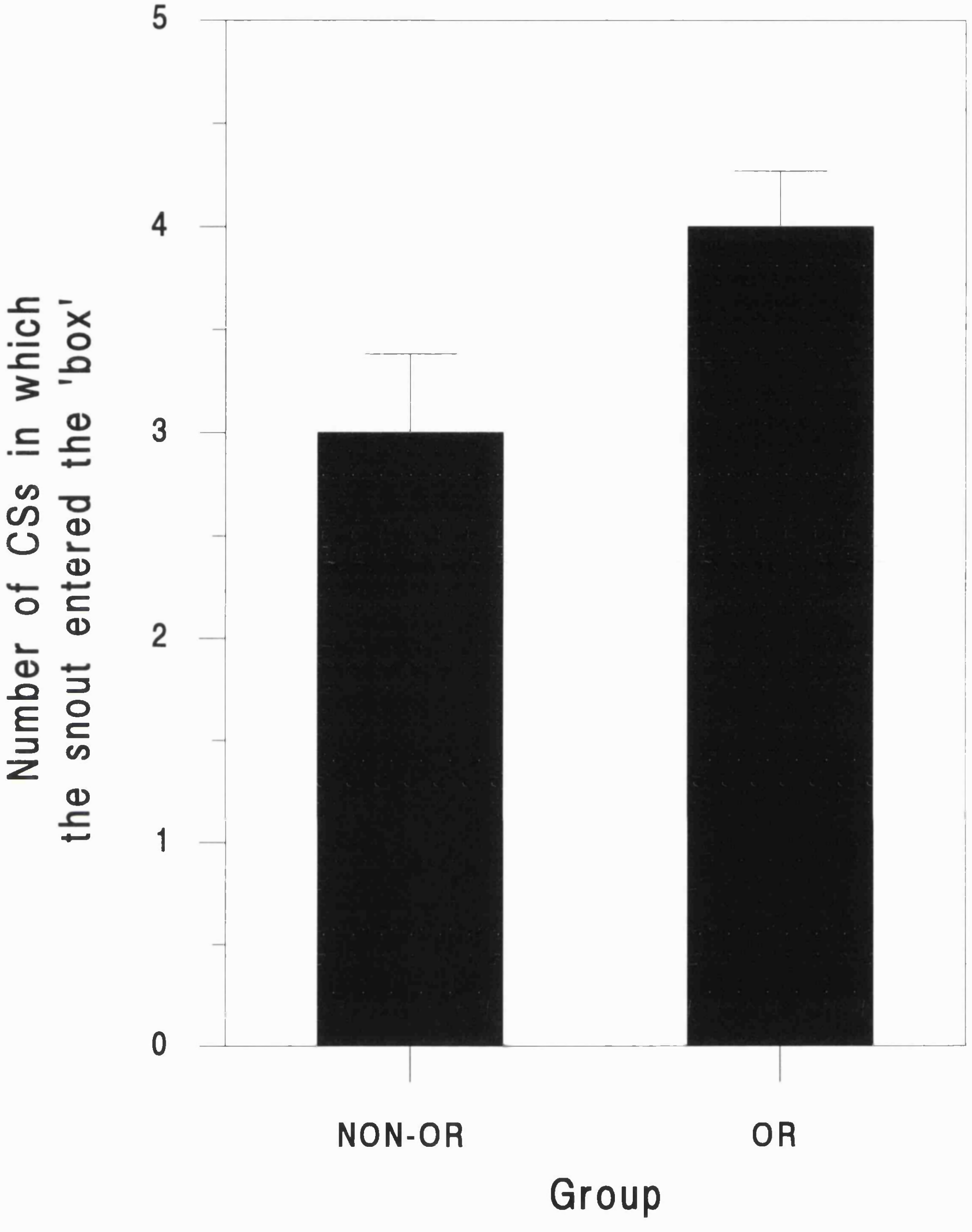

Figure 6.4. Number of CSs to which a response was made by observers on test in Experiment 2. Error bars indicate SEMs.

involving contingent light-food presentations. Figure 6.5 shows magazine behaviour expressed as an elevation ratio, A/A+B, where A is the number of the entries made during the CS, and B is the number made in a pre-CS period of equivalent duration. A score greater than .5 means that more responses were made during the CS. The proportion of responses made during the CS increased across sessions ($F(2,28) = 12.46$, $p< .0001$). The interaction between this sessions factor and group was reliable ($F(2,28) = 3.5$, $p< .04$) suggesting that the increase in elevation ratios was not reflected equally in the group performance. Simple effects analysis of variance of group behaviour at each session revealed that the light gained excitatory strength faster for Group NON-OR; animals in this group produced reliably higher elevation ratios at session three, ($F(1,17) = 5.17$, $p< .03$).

It was something of a surprise to find that observers of an orienting demonstrator will both orient more to a light (show less habituation) and learn more slowly about the light's predictive status, (more latent inhibition) than observers of a non-orienting demonstrator. The conditions that foster habituation, the nonreinforced presentation of a stimulus, are also those that support latent inhibition of a stimulus, and the magnitude of these effects is correlated with the amount of CS exposure (Hall, 1991). Thus, having found Group OR to be less habituated to the light it might have been expected that for this group the light would also be less latently inhibited. However, there is some evidence that with certain parameters, the two processes are dissociable. For example, Hall (1991) reported that salient stimuli may habituate slowly, but acquire latent inhibition especially rapidly. Although this inference is based on cross experiment comparisons, it raises the possibility, investigated in Experiment 3, that the presence of an acting demonstrator might mimic the effects of highly salient stimuli by increasing the amount of processing received by a stimulus.

6.3 Experiment 3

Experiment 3 had three aims. First, by repeating both the habituation and conditioning phases of Experiment 2, the present experiment sought to check the reliability of Group OR's early elevation in orienting and later retardation in conditioning when compared with Group NON-OR. Second, like Group ASOC of Experiment 1, a group of animals exposed to the light without a demonstrator was included in this experiment. If like Group NON-OR, Group ASOC were faster to learn a light-food relationship during the conditioning phase than Group OR, this would confirm that it was something about watching an orienting demonstrator that resulted in Group OR's slower

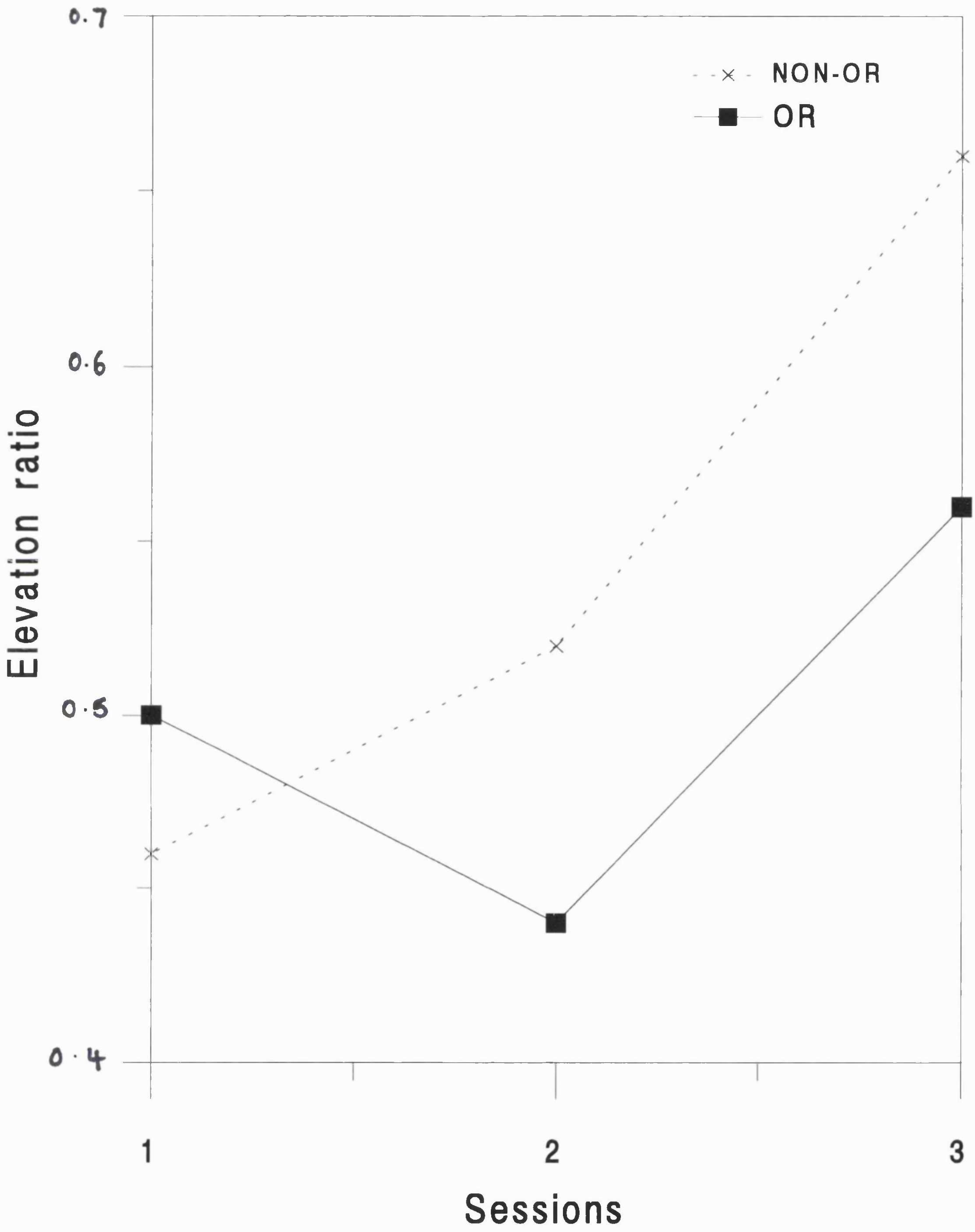

Figure 6.5. Mean elevation ratios produced by the observers in response to the light during conditioning sessions in Experiment 2. Error bars indicate SEMs.

learning. If instead the light was slow to condition in Group ASOC, it would suggest that exposure to a non-orienting demonstrator was responsible for faster learning in Group NON-OR. Finally, Experiment 3 began to investigate how this social effect on stimulus learning is mediated. A salient stimulus is one that receives more processing/attention than a non-salient one. If the finding (discussed earlier) that salient stimuli habituate slowly (i.e., command attention for longer) and acquire latent inhibition rapidly (show an accelerated loss of associability) (Hall, 1991), reflects the receipt of relatively greater processing by these stimuli because of their salience, then socially induced increments in the processing of a stimulus might account for the fact that Group OR's responding mirrors that to a salient stimulus. Two possible explanations of how a demonstrator's behaviour might increase the saliency of a stimulus to which it is responding were considered.

1) Context saliency. It seems possible that, a) the degree to which an experimental context is arousing might affect the processing that a stimulus receives, b) watching a demonstrator that orients in front of a light is a salient event which increases the overall level of contextual arousal experienced by an observer, and c) heightened arousal in the experimental context would increase an observer's baseline exploratory behaviour. According to this interpretation, in previous experiments, Group OR did not make a higher proportion of their responses during the light, but were more active in general. If so, Groups NON-OR and OR might be expected to differ on a pre-CS measure of orienting to the not-yet-illuminated light.

2) Stimulus saliency. Rather than generalised arousal, an animal may pay more attention to a light to which a conspecific is responding because of an effect on the stimulus itself. Loosely speaking, this hypothesis suggests that the light became more salient for Group OR. Unlike the context account, a stimulus specific effect would be suggested if a comparison of the orienting responses made during the 30s light, with the number made during that and a 30s pre-CS period, revealed group differences. A ratio measure would attenuate the effect of group differences in baseline orienting, and therefore, a difference on this ratio measure could not be because Group OR was just in general more responsive than Group NON-OR.

Method

The method employed in Experiment 3 differed from that of Experiment 2 in the following respects.

Subjects

Twenty-four experimentally naive rats, whose free feeding body weights ranged from 291g to 364g, served as subjects. Twelve of these acted as observers. The remaining 12 were randomly assigned to one of two demonstrator groups, Group DEM NON-OR (n=4) and Group DEM OR (n=8).

Procedure

Demonstrator training. Group DEM NON-OR were trained in the same way as in Experiment 1.

Observer training and testing.
Habituation training. In addition to scoring observer behaviour during the CS, the same measures were recorded during the pre-CS period.

Conditioning. Four conditioning sessions were given. The panel light was illuminated for 30s on ten occasions, governed by an RT three minute schedule. When the light terminated, a sucrose pellet was delivered.

Results and Discussion

The number of CS presentations to which an animal responded such that its snout entered the marked box was calculated, and, unless otherwise stated, this was the measure used in analysis.

Demonstrator behaviour. The behaviour of the demonstrator groups is shown in Figure 6.6. The left hand panel shows Group DEM OR's behaviour during the first context exposure session. Although the light was never illuminated, during 30s dummy CS periods their behaviour was scored as if it were. Group DEM NON-OR were videotaped during the final session of habituation to the light. Analysis of variance revealed no differences in the number of CSs to which the demonstrator groups made orienting responses (F(1,8) = 1.04, ns), suggesting that Group

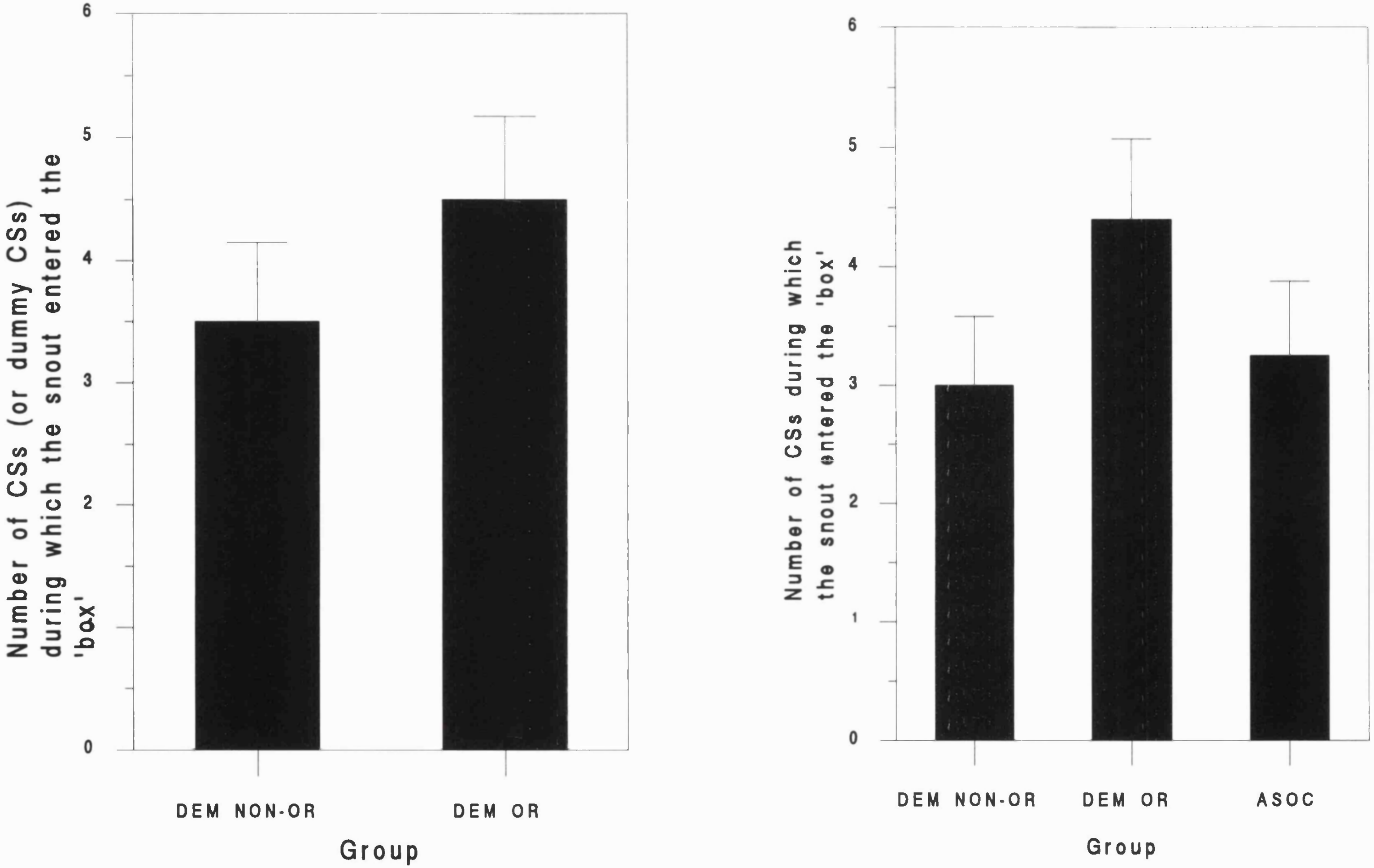

Fig 6.6. The left hand panel shows the number of CSs to which a response was made during the tenth (Group DEM NON-OR) and 1st (Group DEM OR) habituation training session in Experiment 3. Error bars indicate SEMs.

The right hand panel shows the number of CSs to which the demonstrators responded during the first observation session in Experiment 3. Error bars indicate SEMs

DEM NON-OR had habituated to the light.

The right hand panel of Figure 6.6 shows the orienting behaviour of the demonstrator groups and observer ASOC group to the five CSs presented in the observation session. Although, numerically, Group DEM OR responded to a greater number of CSs than Group DEM NON-OR, analysis of variance found no reliable difference (F(2,8) = 1.2, ns). It is likely that this is due to the small number of animals in each group (n=4), because the group means are comparable with those of Experiments 1 and 2 in which differences were found in the demonstrators' orienting.

Observer behaviour. Two Group OR observers were rejected from the analysis because they slept throughout the session. The left hand panel of Figure 6.7 shows the observers' orienting behaviour on test. The means indicate that Group OR responded to a greater number of light presentations than did either Group NON-OR or ASOC. A Brown-Forsythe test which corrects for non-homogenous variance was used for the analysis of variance. This was required because there was no variance in the responding of Group OR observers; they all oriented to five CSs. Analysis of variance revealed a marginal difference between the groups (F(2,5) = 4.26, p< .08). Pre-planned contrasts confirmed that Group OR oriented to more CSs than Groups NON-OR and ASOC (F(1,7) = 5.83, p< .046), which clearly did not differ. Thus, like the two previous experiments, Experiment 3 found that a light elicited a greater number of orienting responses if it had been pre-exposed in combination with a demonstrator that oriented, rather than a demonstrator which had habituated, to its illumination. The difference between Group OR and Group ASOC replicates that found in Experiment 1, and confirms that Group OR's orienting had been locally enhanced, as opposed to the experience of a non-orienting demonstrator having had a suppressive effect on orienting by Group NON-OR.

The observers' orienting responses during the 30s period before the light was illuminated were analysed in an attempt to explain the local enhancement evidenced by Group OR. It was argued in the introduction to this experiment that enhanced orienting might indicate that a light is effectively a more salient stimulus when it is experienced with a demonstrator that orients to it. It was suggested that an orienting demonstrator might either make the experimental context more arousing for the observer, and, therefore, cause a general increase in all exploratory behaviours, including orienting, or, increase the saliency of the light itself. The centre panel of Figure 6.7 shows the number of pre-CS periods during which the observers made orienting responses to the non-illuminated light. Consistent with the context arousal hypothesis, the graph shows that the

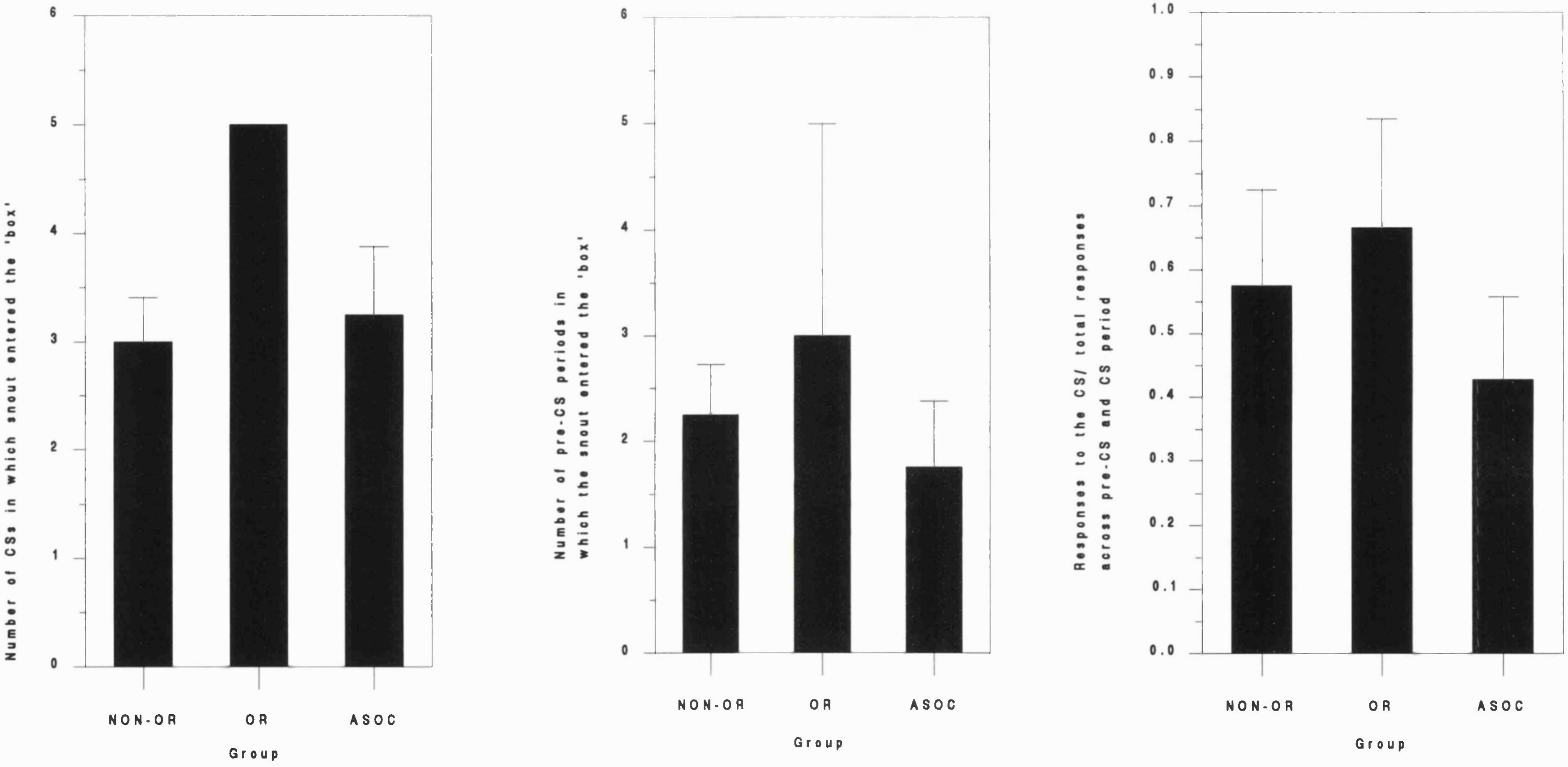

Figure 6.7. The left hand panel shows the number of CSs to which a response was made by observers on test in Experiment 3. Error bars indicate SEMs.

The centre panel shows the number of pre-CS periods during which the observers made a response to the non-illuminated light on test in Experiment 3. Error bars indicate SEMs.

The right hand panel shows the proportion of observers responses which occurred during the CS period on test in Experiment 3. Error bars indicate SEMs.

elevation in Group OR's orienting when compared with Groups NON-OR and ASOC was present during the pre-CS period. However, analysis of variance failed to confirm this difference (F< 1). The right hand panel of Figure 6.7 shows the observers' orienting behaviour to the light expressed as a ratio of their responding throughout the pre-CS and CS periods. A score of more than .5 indicates that more responses were made to the light during the CS period. The graph shows that, as would be expected if the effect of an orienting demonstrator is to increase the saliency of the light, Group OR made a greater proportion of their responses during the light than did Groups NON-OR and ASOC. However, analysis of variance failed to confirm this difference (F< 1).

In the final experimental phase of contingent light-food presentations, the observers' behaviour to the magazine was recorded. Figure 6.8 shows magazine behaviour expressed as an elevation ratio, A/A+B, where A is the number of the entries made during the CS, and B is the number made in a pre-CS period of equivalent duration. A score greater than .5 means that more responses were made during the CS. As the conditioning sessions progressed the proportion of responses that were made during the CS increased (F(3, 21) = 9.73, p< .0003). However, there was no effect of group, and no interaction between group and session (Fs< 1). Thus, Experiment 3 failed to replicate the finding that observation of a demonstrator responding to a stimulus enhances the latent inhibition that the stimulus accrues.

In summary, only the local enhancement effect was replicated in Experiment 3. It is not clear why, unlike Experiment 2, the light was not more latently inhibited for Group OR, however, with so few subjects it is unsurprising. Larger groups might also reveal differences in either the groups' pre-CS orienting, or in the proportion of their responses during the combined pre-CS and CS period that were made when the light was on.

6.4 General Discussion

Salient stimuli command more attention, and elicit more vigorous orienting responses (Hall, 1991). In the experiments reported here, the orienting responses elicited by a light were recorded and understood to index the attention that the light governed. In all three experiments, when compared with animals that saw a demonstrator whose orienting had habituated, observers that saw an orienting demonstrator, oriented more. They also oriented more than observers exposed to the light in social isolation. Therefore, it seems appropriate to categorise this effect of social context on stimulus pre-exposure as local enhancement because, in accordance with Thorpe's definition

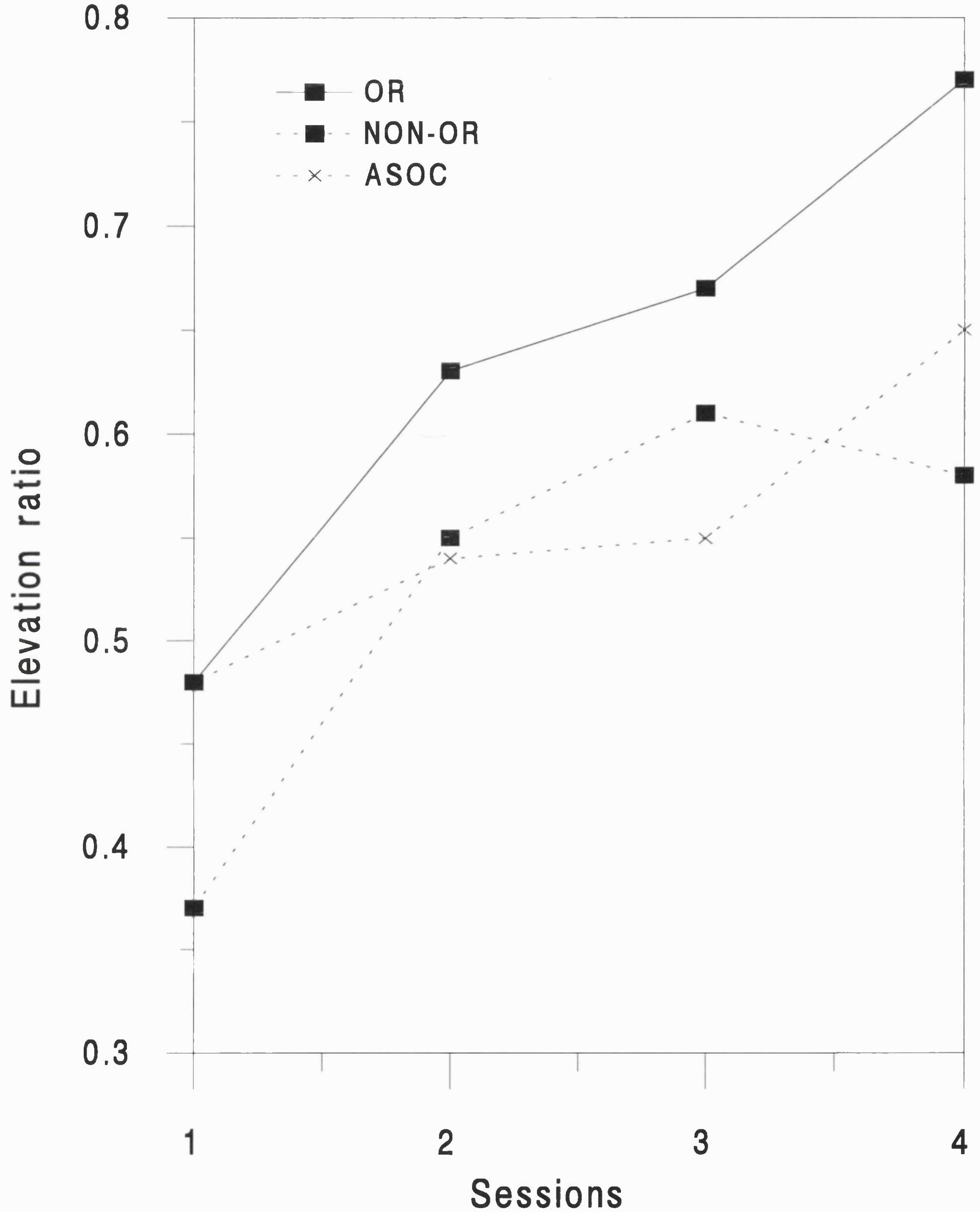

Figure 6.8. Mean elevation ratios produced by the observers in response to the light during conditioning sessions in Experiment 3. Error bars indicate SEMs.

of local enhancement, the light commanded greater attention when it had been experienced in combination with a demonstrator responding to it (Thorpe, 1963). Experiment 3 failed in its attempt to establish whether this effect was stimulus specific, or the result of general arousal. However, resolution of this issue is not important for the issues discussed below.

It is apparent from some of the instances of matching behaviour which have been interpreted as examples of local enhancement, that it has been assumed from Thorpe's definition that the effects, as well as the mechanism, of local enhancement are attentional. Thus, Denny, Clos and Bell (1988) assumed that the observers came to pay more attention to the lever because of the demonstrator's activity when they argued that local enhancement could explain why, when a demonstrator had been observed to lever-press for food reward, observers performed better than social isolates. However, it is not necessary to assume that because the mechanism of local enhancement is enhanced attention, so is its effect. Rather, it could be that in Denny et al's experiment the effect of the demonstrator was to increase attention to the lever, and that this had further consequences, a further local enhancement effect, which did not involve enhancement of attention. The data from the conditioning phase of Experiment 2 are relevant to this.

The light was more salient and governed more of the observers' attention initially if a demonstrator had been observed orienting to the light. However, after a further 25 exposures with an orienting demonstrator, the light was slower to condition than one experienced in tandem with a demonstrator whose responding had habituated (Experiment 2). If the latter effect is reliable, despite its failure to replicate in Experiment 3, then two things follow. First, because it is unlikely that retardation in learning about a stimulus is due to increased attention to that stimulus, enhanced attention should not be a definitive effect of local enhancement. Enhanced attention to a stimulus is unlikely to be a typical effect of local enhancement if it is, as Thorpe suggested, the basic mechanism of local enhancement, Second, the likelihood that local enhancement is always a sufficient explanation of matching behaviour is reduced, because with limited pre-exposure (30 CSs) a stimulus conditions more slowly. Inattention to a locally enhanced stimulus cannot explain examples of observers that have been exposed to a demonstrator responding for reward, learning to perform that response sooner than observers of a habituated demonstrator.

Although the traditional interpretation of local enhancement seems unable to offer a coherent understanding of data which show both an enhancement of orienting and latent inhibition, they can be assimilated by an analysis of local enhancement as socially mediated single stimulus learning (Heyes, 1994). According to learning theory, repeated presentation of a stimulus without correlated outcomes, has characteristic effects, i.e., habituation and latent inhibition (Mackintosh, 1983). What the processes of habituation and latent inhibition are, is disputed (Hall, 1991). By regarding local enhancement as the social counterpart of single stimulus learning, questions about its mechanisms and effects are kept similarly distinct. It is then possible to allow that a demonstrators' presence enhances attention to a stimulus, and accept that enhancing attention may facilitate processes, such as latent inhibition, which are typically associated with inattention (Pearce and Hall, 1980). Furthermore, not only can learning theory accommodate the finding of enhanced orienting and latent inhibition, there are data which suggest that this pattern of effects may be characteristic of salient stimuli (Crowell and Anderson, 1972; Thompson and Spencer, 1966).

Chapter 7

General Discussion

7 Introduction

It has been assumed that the formation of S-R links, whereby stimuli previously experienced contiguously with the execution of a response come to elicit that response, is either sufficient to explain social learning (e.g. Hogan, 1988; Mineka, Keir and Price, 1980; Thorndike, 1911) or, particularly in the case of observational learning, that it is inadequate to do so (e.g. Galef, 1990; Tomasello and Call, 1994; see also Chapter 1, section 1.1.1). Contemporary learning theory conceives of learning rather differently; as the formation and association of mental representations (Dickinson, 1980; Mackintosh, 1983; Chapter 1, section 1.2). It was argued in Chapter 1 that the problems which affected learning theory in the behaviourist era, and those which arise in trying to understand social learning, are similar. Therefore, it was reasoned, social learning theory might escape its difficulties by understanding learning to involve the cognitive processes that contemporary associative learning theory proposes.

The purpose of the empirical work in this thesis was to develop paradigms to investigate the extent to which social learning can be encompassed by contemporary associative learning theory. In particular, procedures were designed to expose observers to the conditions necessary for learning in isolated animals, and it was assumed that if social learning effects depend on these same conditions, it would suggest that they are mediated by the same associative mechanisms. In particular, evidence was sought that, like asocial learning, social learning is: 1) contingency dependent (Chapter 3); 2) subject to blocking and overshadowing (Chapter 4); 3) sensitive to both S-S and R-O relationships (Chapter 5); and 4) subject to the effects of stimulus pre-exposure (Chapter 6).

Before considering whether this thesis successfully achieved its aims, the main empirical findings will be summarised.

7.1 Summary of experimental findings

7.1.1 Experiments investigating contingency dependence

The experiments reported in Chapter 3 used a truly random control procedure to investigate whether, like learning that occurs when animals are in social isolation, social learning about a CS is dependent on its contingent relationship with a US (Rescorla, 1967). Observers were exposed to contingent presentations of a light (CS) and the delivery of a food pellet to a hungry demonstrator (US). Previous training ensured that, when the light was illuminated, the demonstrators made more magazine entries in anticipation of food delivery. To test whether any effects of this experience on observer behaviour were the result of the contingency that existed between the light and the demonstrator's food-related behaviour, the observers' magazine behaviour during the light was compared with that of truly random control animals. The control observers were exposed to a demonstrator for whom light and food presentations were independently scheduled.

The results suggested that the observers did indeed learn a CS-US relationship, and that this relationship was inhibitory in nature. In an extinction test in Experiment 1, when the observers were presented with the light, they suppressed their ongoing magazine behaviour. The inhibitory status of the light was supported by retardation and summation tests (Experiment 2 and Experiment 3, respectively). In addition, Experiment 3 provided evidence that the effect was socially mediated; for observers given exposure to light-> food pairings in the absence of the demonstrator, the light did not develop inhibitory properties.

In Experiments 1 to 3, between 10 and 13 observation sessions were given. If, as a result of observation of many pairings of the CS (the light) and the US (feeding demonstrator), the observers learned that the light had inhibitory qualities, it was expected that with fewer CS-US pairings, second order conditioning would be detected (Yin et al, 1994). However, in Experiment 4, in which four observation sessions were administered, no elevation in magazine entries was detected in an extinction test. Two explanations for the absence of any effect in Experiment 4 were suggested; the inhibition detected in the previous experiments was indirect (the reinforcer with which the light entered an inhibitory relationship could not, itself, support magazine behaviour) or, the suppression in magazine behaviour was caused by the performance of a competing, excitatory response. Experiments 5 and 6 measured orienting to the light in order to investigate these hypotheses.

Experiment 6 measured behaviour after four observation sessions and found that the experimental group observers oriented to the light more than the random controls. On the basis of this evidence it was tentatively suggested that the suppression of magazine behaviour reported in Experiments 1-3 was probably caused by the observers' inhibition of orienting to the light. Withdrawal from this region, which also contained the food magazine, meant that their responding to the magazine was suppressed. It was concluded that, as a result of paired presentations of the light and the feeding demonstrator, the light became a conditioned inhibitor. The inhibitory properties of the light may have resulted from its repeated non-reinforced presentation in compound with a second-order reinforcer, the sight of a feeding demonstrator.

7.1.2 Experiments on overshadowing and blocking

The amount that an animal learns about a CS (CS2) is reduced when CS2 is presented in compound with another CS (CS1); this phenomenon is known as overshadowing (Kamin, 1969). If CS1 has a history of US pairings at the time of the compound trial, its ability to interfere with the conditioning of CS2 is enhanced; CS1 is said to block learning about CS2 (Kamin, 1969). According to the Rescorla- Wagner model of associative learning, blocking and overshadowing occur because paired presentations of a CS and a US will be learned about only to the extent that the occurrence of the US is surprising (Rescorla and Wagner, 1972).

The experiments presented in Chapter 4 used a procedure developed by Galef and Durlach (1993) to investigate whether social enhancement of food preferences is subject to blocking and overshadowing, and, therefore, whether it is the result of associative learning. The social enhancement of food preferences effect refers to the finding that observers will choose to eat a flavour, CS2, that they have encountered on the breath of a demonstrator, in preference to a second alternative flavour (Galef and Stein, 1985).

Experiment 1 of Chapter 4 replicated the social enhancement of food preferences effect. Experiment 2 showed that observers ate less of CS2 if their demonstrators had eaten a combination of CS2 and a second flavour, CS1. Although an associative analysis predicted this overshadowing effect, it was argued that it could also be due to generalisation decrement. Better evidence for an associative mechanism was provided by comparing the consumption of CS2 by two further groups of observers; blocking and enhanced blocking groups. The enhanced blocking observers ate a smaller proportion of CS2 than blocking observers. The enhanced blocking observers were exposed to a demonstrator that had eaten CS1 on four occasions, three more than the blocking observers. Thus, the occurrence of the US following the CS1/CS2 compound trial was less surprising for the enhanced blocking group and, therefore, learning about CS2 by this group was blocked, and their preference for it reduced.

7.1.3 Experiments on observational conditioning and observational learning

Evidence for observational conditioning and observational learning effects on an observer's lever-pressing behaviour was sought in the experiments presented in Chapter 5. Observers were exposed to a demonstrator making responses in one or two directions (down or up) on one of two levers (left or right) for food rewards. It was assumed that social stimulus-stimulus learning, i.e., observational conditioning, would be indicated if the observers made the majority of their responses on the same lever as their demonstrator. Social response-outcome learning, or observational learning, would be indicated if the observers made the majority of their responses in the same direction as their demonstrator.

Experiments 1 and 2 recorded the number of up and down responses that the observers made on the one lever available on test. It was found that observers of up responses made a greater proportion of up responses on test than observers of down responses, and vice versa. It was also found that this response learning effect was not due to the demonstrator leaving scent on the top or underside of the lever.

During the test sessions of Experiments 3 and 4, the left and right levers were present in the experimental chamber, and observers were found to prefer responding on the lever that their demonstrators had manipulated. There was also some suggestion that observers of up responses made more up responses than observers of down responses and vice versa. That observers apparently learned about stimuli and responses is consistent with an associative analysis. However, further experiments would be required to confirm that the behaviour of the observers is dependent on the contingency between the responses made by the demonstrators and the food rewards.

7.1.4 Experiments on socially mediated stimulus pre-exposure

When a novel, non-reinforced stimulus is presented to an isolated animal, it elicits an orienting reflex which habituates with repeated exposure to that stimulus. If the stimulus is subsequently followed by reinforcement, it is slow to condition; the stimulus is said to be latently inhibited (Hall, 1991). The experiments presented in Chapter 6 investigated whether exposure to a stimulus is affected by the presence of a demonstrator who responds to the stimulus. Observers were exposed to a light and a demonstrator oriented towards that light. The effect of the demonstrator's orienting response on the observers' orienting to the light was compared with that of two further groups in which either the demonstrator had previously habituated to the light, and therefore made few orienting responses, or no demonstrator was present. Although it has not been established empirically, social learning researchers have assumed that exposure to a stimulus to which a demonstrator is responding results in the observer subsequently paying more attention to that stimulus, and facilitation of learning about the stimulus. This hypothetical effect is known as local enhancement (Thorpe, 1911).

Experiment 1 found that observers which had been exposed to an orienting demonstrator made more orienting responses to the light than those which had been exposed to a non-orienting demonstrator, and those for whom there was no demonstrator present. This would suggest that the animals which observed an orienting demonstrator did not habituate, and therefore paid more attention to the light on test. However, in Experiment 2, when, after 30 exposures, the light was paired with food, observers of orienting demonstrators were slower to condition compared to observers of non-orienting demonstrators. Retarded learning of associative relationships as a result of stimulus preexposure is usually thought to result from a reduction in attention to the stimulus. A possible explanation of these apparently contradictory findings is that the presence of an orienting demonstrator increased the salience of the light. Highly salient stimuli have been reported to habituate slowly and lose associability fast (Hall, 1991).

7.2 Evaluating a learning theoretic analysis of social learning

The framework for thinking about social learning offered by contemporary learning theory has not been tested against alternative S-R, and intentional accounts in this thesis. Rather, all the experiments sought evidence of associative social learning by investigating whether observers would learn under the conditions of associative learning. The extent to which observers have been shown to learn associatively is evaluated in the next section, 7.2.1. In section 7.2.2, the reported data is examined for examples of changes in an observer's behaviour that are most readily explained by assuming that the observer associated a stimulus (or response) with an outcome that was observed to occur contingently. Thus, for example, it is argued that a capacity to associate stimuli and responses will not explain how an observer's lever pressing was influenced by an observed contingency between a lever and food.

Finally, in section 7.1.3, it is considered whether it follows from the involvement of an associative mechanism in social learning, that a cognitive process of information acquisition is responsible for all instances of socially learned behaviour. Evidence from the asocial learning literature suggests that the operation of an associative mechanism in response to Pavlovian contingencies is not invariably accompanied by the acquisition of information (Rescorla, 1980). I would like to consider observational conditioning and observational learning separately. By referring to the assays developed by learning theory to establish whether cognitive processes are involved in learning, suggestions will be made for how the cognitive hypothesis, as it applies to social learning, may be tested against S-R and intentional accounts.

7.2.1 Has evidence for associative mechanism been provided?

The four procedures developed in this thesis have provided preliminary data that are consistent with the hypothesis that observers learn associatively. Each procedure, with some degree of success, sought to establish a social learning parallel for asocial learning effects that are diagnostic of an associative mechanism. A CS the occurrence of which was correlated with US presentation was socially conditioned (Chapter 3). A CS that had been trained with a US was shown subsequently to block learning about a second CS (Chapter 4). The lever pressing behaviour of observers was shown to be affected both by socially mediated S-S and R-O relationships (Chapter 5). Finally, a history of non-reinforcement was demonstrated to retard conditioning of a stimulus that had been pre-exposed in a social context (Chapter 6).

At the end of each empirical chapter, alterations to the methodology which might produce more definitive evidence of associative social learning, were recommended. In general, where the paradigms proved inadequate to diagnose associative learning, this was because I failed to recognise all the effects that the introduction of a trained demonstrator would have on the associative relationship under study. Therefore, the social versions of the controls used standardly to isolate associative learning were inadequate to do so in these cases. For example, with the two lever/two action paradigm (Chapter 5), it was not appreciated that there were different stimulus relationships associated with up and down responding demonstrators in addition to those produced by their behaviour, i.e., a demonstrator that pushed up probably assumed a different position relative to the lever than one who pressed down. Therefore, rather than imitating its demonstrator, an up pushing observer may make a greater proportion of up pushes than an observer that has seen lever presses, if its manipulatory CR is conditioned to a stimulus representation that comprises the lever plus the demonstrator's body below it. For such an observer, the CS would be reencountered when the lever was approached from the underside, and from this position a manipulatory CR may be expressed as an up response.

7.2.2 Has it proved useful to understand social learning to involve cognitive processes?

A second aim of this thesis was to establish whether, understanding social learning to involve cognitive processes has advantages over a behaviourist/ S-R habit conception of social learning

The first step taken to justify a cognitive conception of social learning was to illustrate in Chapter 1 the similarities between the problems encountered in the understanding of social learning and those presented by earlier S-R theories of learning. It could then be argued that the success of contemporary learning theory in explicating the difficulties of a behaviouristic analysis of learning, suggested that it might be similarly useful for understanding social learning. Investigating empirically whether asocial mechanisms underlie social learning was predicated on this basis.

In this section I want to highlight those effects reported in this thesis that are more readily understood within a cognitive conception of learning. In particular, I wish to examine the data which suggested that a) inhibitory relationships can be learned socially (see Chapter 3), b) socially mediated non-reinforced exposure to a stimulus affects subsequent learning about that stimulus (see Chapter 6) and, c) a lever press response can be observationally conditioned (see Chapter 5).

7.2.2.1 Inhibitory social learning

In Chapter 3, evidence was found to suggest that a light acquired inhibitory properties when it had been observed to elicit magazine approach from a demonstrator who was rewarded with food when the light was extinguished. Under these conditions, observers subsequently avoided the magazine when the light was on.

Finding inhibitory social learning is noteworthy for two reasons relevant to the present discussion. First, the hypothesis that observers acquire information about relationships is unique in highlighting the possibility of inhibitory social learning (see Chapter 1, see section 1.3.3). An S-R account of social learning proposes that observed behaviour is acquired directly and elicited by the stimuli that preceded its occurrence (Hogan, 1988) and is, therefore, constrained to recognising only matching behaviour as an outcome of social learning. Thus, the application of learning theory to social learning generated an empirical prediction which was subsequently confirmed, and thus provided perhaps the first demonstration of inhibitory social learning (but see Darby and Riopelle, 1959). Second, S-R theorists have assumed, and an intentional account requires, that matching behaviour is the result of, loosely speaking, the observer learning what the demonstrator knows. However, in the procedure used in Chapter 3, the observer's inhibitory learning resulted from exposure to a demonstrator whose behaviour was maintained by an excitatory relationship between the light and the food.

7.2.2.2 Socially enhanced latent inhibition

The data reported in Chapter 6 suggested that showed that a light was slower to acquire excitatory properties when it was paired with food, if, in a previous pre-exposure phase, a demonstrator had been seen to orient to that light. As the previous discussion of inhibitory learning suggests, these data are more readily assimilated by a theory which recognises social learning effects other than the development of matching behaviour. Latent inhibition to the light was indicated by retarded acquisition of magazine entry behaviour by observers that had seen a demonstrator that made a different, orienting, response.

7.2.2.3 Observational conditioning of a lever pressing response

The two-lever/ two-action paradigm was designed to demonstrate separate effects of observational conditioning and observational learning on an observer's socially lever pressing behaviour (see Chapter 1, section 1.3.2; and Chapter 6). Assuming that observers preferentially responded to the same lever as their demonstrator because of observational conditioning, S-R accounts of social learning are again in difficulty. S-R theories have tended to assume that CRs must closely resemble the form of the original UR, and, therefore, have difficulty encompassing a lever pressing

CR to a lever that has been paired with food. Lever pressing is not unconditionally elicited by food, therefore, for lever pressing to develop in response to observed stimulus relationships, a learning process with greater behavioural flexibility than that envisaged by S-R theory is required. Thus, the observational conditioning of a lever press response points to a learning process that has wide ranging behavioral consequences. It was argued in Chapter 1, that one of the advantages of a contemporary learning theory analysis of social learning was its acknowledgement of the behavioral flexibility a capacity for learning S-S relationships confers.

7.2.3 Is social learning 'cognitive'?

The present research represents a preliminary phase in the investigation of social learning which has yielded data favourable for its interpretation as involving an associative mechanism. This section considers the kind of studies necessary to establish whether as a result of social learning, observers acquire information about contingencies. Experiments are suggested that would test a contemporary learning theoretic account of social learning against specific alternative hypotheses, in particular S-R and intentional accounts.

7.2.3.1 Is observational conditioning cognitive?

It was argued in Chapter 1 that the formation of S-R links could not explain instances of Pavlovian conditioning where animals had learned about stimulus-outcome relationships for which there were no behavioral consequences (Rizley and Rescorla, 1972). This is prima facie evidence that conditioning involves the acquisition of information, not behaviour, i.e., that it is a 'cognitive' process. Reinforcer revaluation experiments have confirmed that animals learn about S-S relationships (Rescorla, 1980). The premise of the revaluation procedure is that if a representation of the US is involved in learning, then degrading the value of the US following conditioning should attenuate responding to the CS. Holland and Straub (1979), for example, have shown that rats for which a noise has been repeatedly paired with the delivery of a food pellet, will suppress magazine entry during the noise if, in an intervening phase, they were poisoned after consuming food pellets.

In combination with evidence that asocial associative learning involves cognitive processes, the present evidence that social learning is associative could be interpreted to mean that it too is cognitive. However, not all Pavlovian CRs are affected by devaluation. In particular, CRs that result from pairings of a CS with a conditioned reinforcer seem to be immune from the effects of devaluation (Rescorla, 1980). As Rescorla argued, this is prima facie evidence that second order conditioning is S-R in nature.

A typical social learning experiment is one in which observers watch a trained demonstrator perform a particular response for reward. It was argued in Chapter 3 that under these circumstances here is no obvious source of primary reinforcement for the observer and, therefore, if evidence of reinforcement is found, it is likely to be higher order in nature. Thus, it is plausible that, unlike most examples of asocial Pavlovian conditioning, the majority of observational conditioning CRs are the result of S-R learning. US devaluation procedures could resolve this issue. An observer for which a US was devalued following observational exposure of the US contingently related to a stimulus, should cease to perform observationally conditioned CRs if it has associated the US and CS.

7.2.3.2 Is observational learning cognitive?

Instrumental responding is often sensitive to a change in the value of its consequences. For example, Adams (1982) found that averting a rat to the sucrose pellets that had previously reinforced its lever pressing response, caused an immediate decline in the lever presses that the animal made during an extinction test. It was explained in the previous section that the attenuation of a response following reinforcer devaluation is consistent with the idea that a US representation was formed during learning, because an S-R link, once established, should be unaffected by devaluation. In this, the instrumental case, the US representation is associated with the response that caused its delivery.

However, under certain circumstances, for instance when training on the instrumental contingency is extensive, performance of an instrumental behaviour will persist despite revaluation of the US (Adams, 1982). This suggests that following extended training, responding was controlled by an S-R link; the response was elicited irrespective of its consequences by stimuli with which it had been previously associated .

There seems no reason to doubt that, where observers have been shown to imitate their demonstrators behaviour, this could be because either an R-O or an S-R link has been formed. Revaluation procedures could be used to indicate the most likely associative structure underlying a particular observationally learned behaviour. If an imitative behaviour were to persist despite the observer being averted to the US that controlled its demonstrator's performance, it would suggest that the US was not involved in controlling that observer's performance of that behaviour.

7.2.3.3 Intentional imitative behaviour.

In those cases where instrumental training results in an association between representations of the response and its outcome, it is not clear how the association is translated into performance. Where an S-R structure is implicated, whether it has resulted from a Pavlovian or an instrumental relationship, performance of the CR is accounted for; it is an automatic consequence of the S-R link. Similarly, in the case of S-S learning, presentation of the CS activates a representation of the US, and thereby elicits the responses that normally occur unconditionally when the US is presented. However, it is not obvious how the activation of a representation of the US by a response can explain why that response is elicited in the first place. Therefore, an intentional account of instrumental responding is implicated by default (Dickinson, 1989)

This is not an appropriate place to consider the arguments against the possibility of a mechanistic account of associative performance in detail (see Dickinson, 1980). Suffice it to say that there are no successful accounts of instrumental performance that rely on the transfer of excitation between cognitive representations via associative links (Mackintosh, 1983; Dickinson, 1980). Thus, it would seem that instrumental responses are not elicited by the activation of a representation; rather, they are directed towards a goal.

To explain instrumental performance we must assume that the information that has been learned, the R-O association, interacts with the current value of the goal in an inference process to guide action (Mackintosh, 1983). Pointing to the involvement of an inference process is not sufficient to explain instrumental performance, but, as Heyes and Dickinson (1990) have shown, it can be used to establish empirical criteria for the attribution of intentionality to a behaviour.

Briefly, Heyes and Dickinson argued that, to support an intentional interpretation, a behaviour must be shown to meet two criteria. First, the behaviour must be sensitive to whether or not the environmental contingencies support the instrumental belief (the belief criterion). Thus, for example, if a desired goal is omitted each time a response is performed, to warrant consideration as an intentional action, the response must decline in the face of these contingencies. (For examples of particular behaviours that are maintained despite an omission schedule, see Herendeen and Shapiro (1975); Hershberger (1986); and Sheffield (1965)). Second, because the instrumental belief interacts with the value of the US to govern responding, to be intentional, a response must decline if the US is no longer valued (the desire criterion).

Heyes and Dickinson's criteria could, in principle, be applied to observationally learned behaviour to establish whether it was intentional. An observationally learned behaviour would fulfil the belief criterion if, having seen a demonstrator performing a rewarded response, the observer's performance of that response was disrupted by an omission schedule. If, in addition, performance of the imitative response was disrupted by averting the observer to the reward contingent on its performance, then, as an intentional account requires, it would suggest that the observer's beliefs about the consequences of a behaviour interacted with its desire for that US, to control behaviour.

It is important to note that research of this kind would investigate whether observationally learned behaviour is guided by the observer's own beliefs and desires, i.e., whether it has first order intentionality. It would seem prudent to investigate this possibility before broaching the hypothesis that observationally learned behaviour has higher order intentionality, i.e., whether it is based on beliefs about the mental states of the demonstrator (Tomasello, 1996; Whiten and Ham, 1992).

To clarify the distinction between intentional accounts of action and of learning, consider the hypothetical case of observers exposed to a demonstrator lever pressing for food after the demonstrator has received either 100 or 500 lever press-> food training trials. These are the parameters used by Adams (1982) to demonstrate intentional and habitual lever pressing, respectively. Unlike an intentional account of imitative learning, an intentional account of imitative responding does not have to conclude that, whereas in the former case the demonstrator can be imitated, in the latter case it cannot. After 500 trials, the demonstrator's lever press responding is not governed by its belief that lever pressing causes food, or his desire for food, which an intentional account of observational learning requires the observer to appreciate.

7.4 Conclusions

This thesis has used contemporary learning theory to provide a framework within which to investigate social learning. Several lines of argument have been advanced to suggest why a contemporary associative analysis of social learning is appropriate. For example, it provides testable predictions about social learning, and a system of categorising types of learning such that they can be distinguished empirically. The empirical component of the thesis sought evidence that social learning occurs under the same conditions as asocial learning, and the results have tended to confirm that it does. For example, experiments showed that social inhibitory learning depends on there being a contingency between two stimuli, and that socially exposed stimuli are subject to latent inhibition. However, evidence of this kind is not sufficient to establish that a particular socially learned behaviour is controlled by an associative structure involving mental representations. To do so, it would be necessary in addition to rule out the possibility that socially learned behaviour derives from S-R learning, and reinforcer devaluation procedures could be used to this end.

Appendix

The Use of Lloyd Morgan's Canon to Infer the Occurrence of Local Enhancement

The ability to imitate is broadly understood as being able to 'from an act witnessed learn to do an act' (Thorndike, 1911) where "act" refers both to the perception and the production of a goal directed behaviour. It is this intentional characterisation which has led many researchers (e.g. Galef, 1988) to regard imitation as the most cognitively complex of the proposed social learning processes, (see Heyes, 1994 for an example of a non-intentional characterisation) and it is because of this assumed cognitive complexity that imitation has earned a reputation as an 'onerous concept to be employed only when no other explanation of an observed social influence on behaviour is possible' (Galef, 1988).

When social learning researchers discuss the onerous nature of imitation, or infer the operation of a social learning process other than imitation on the grounds of parsimony (Hogan, 1988) they seem to be invoking a principle like Lloyd Morgan's Canon (1894). Lloyd Morgan's Canon is not synonymous with principles of parsimony, such as Ockham's razor (Sober, in press), the former refers to the complexity of the postulated mechanism, the latter is concerned with the complexity of theories (simplistically, the number of mechanisms which a theory requires irrespective of their complexity). Although social learning theorists cite parsimony as the reason for the non-deductive inference of local enhancement, it is Lloyd Morgan's Canon which is of interest to us here, because, in fact, it is the relative complexity of mechanisms, rather than theories, which drives the inference to local enhancement. The Canon claims that in those cases where a behaviour can be explained by the exercise of both a 'higher' and a 'lower' 'psychical faculty', the valid inference is that the lower faculty is responsible.

Sober (in press) argues for two alternative sets of conditions which, if met, will each justify the inference that of two putative mechanisms that may account for a behaviour, it is the simpler one that is operative. The degree to which the existing data on imitation fit the two conditions will be assessed in turn.

a) *Behavioural equivalence.* The first justification of Lloyd Morgan's canon applies when two putative mechanisms are behaviourally equivalent, i.e., when they would generate the same behaviours under all possible conditions. Thus, if one mechanism, X, the higher mechanism, entails the second, simpler mechanism, Y, and if, and only if, the mechanisms are behaviourally equivalent, then the existence of Y may be inferred.

For example, if X is the mechanism for imitation, and X entails Y which is the mechanism for local enhancement, and if imitation and local enhancement are behaviourally equivalent, then it is possible to infer that a given instance of matching behaviour is an effect of local enhancement. According to Sober, the inference to Y is valid because if X entails Y, then considerations of energetic efficiency in evolution make it unlikely that Y would be supplemented by the evolution of X when the evolution of X has no behavioural impact, ie, in cases where X and Y are behaviourally equivalent. Without this argument from evolution, probability theory alone licences only the belief that the probability of Y is higher than X, not that the probability of Y alone is higher than the probability of X and Y. With respect to local enhancement, in the absence of behavioural equivalence the likelihood of an animal having only the simple mechanism for local enhancement is no greater than the likelihood of it having both this and the 'higher' imitation mechanism.

There are two reasons why the requirement of behavioural equivalence is a problem for the inference of local enhancement from matching behaviour that could instead be imitative. First, there are evolutionary reasons for doubting that two processes are ever in fact behaviourally equivalent to one (Sober and Wilson, 1996). Second, and more specifically, although both imitation and local enhancement may be able to explain a particular example of matching behaviour, it is not at all obvious that they have the same implications for all possible behaviours, i.e., that they are behaviourally equivalent. Recently, experiments which, because they used a bi-directional control procedure (see Chapter 1, section 1.3.2), had the requisite methodology to uncover 'true imitation' have been conducted (Galef, Manzig and Field, 1986; Heyes, Dawson and Nokes, 1992), and the data suggests that both budgerigars and rats are capable of imitation. An unconfounded demonstration of imitation shows that this process and local enhancement are not behaviourally equivalent, and, therefore, it is not possible to use Lloyd Morgan's Canon to infer the operation of local enhancement.

2) *The non-occurrence of X.* Sober argues that the inference of 'lower' rather than 'higher' can also be justified in cases where X entails the behavioural capacities, rather than the actual mechanism, of Y, and where, despite the opportunity to express the behavioural capacities unique to X, the animal fails to do so. That is, if the non-occurrence of X is empirically supported, the

existence of Y can be deduced. In the case of imitation, it requires evidence that the opportunity for an animal to imitate has been provided and evidence that it failed to do so. The only evidence that, until recently, researchers on social learning have had is of behaviour consistent with the ability to imitate in situations insufficiently controlled to be diagnostic of mechanism. To warrant an attribution of local enhancement in the case of this sort of behavioural tie, would require negative results from an experiment with the potential to disambiguate the operation of an imitative process. Yet it is precisely because the processes of imitation and local enhancement have been confounded that social learning theorists have used Lloyd Morgan's Canon to deny the operation of imitation.

More generally, use of Lloyd Morgan's Canon to infer that a particular behaviour is under the control of a lower mechanism is valid only when there is no independent evidence of the operation of the higher process (Morgan, 1900). Thus, if the studies mentioned above really are demonstrations of imitation, then the status, as imitation, of all previous inadequately controlled social learning experiments with budgerigars and rats, is a question answerable only by empirical investigation.

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