Book Review

Putting Learning Back in Context: A Review of Balsam and Tomie's *Context and Learning*

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Early learning theorists, who accepted the principle of contiguity as a prime (if not exclusive) determinant of conditioning, recognized that many stimuli in the experimental environment (contextual stimuli) had the potential to become conditioned to the unconditioned stimulus (US) along with the arbitrarily designated conditioned stimulus (CS). Thorndike, for example, while not directly addressing the issue of the conditioning of contextual stimuli, consistently used the broad term "situation" rather than the narrower term "stimulus." Thus, in 1911, Thorndike phrased the Law of Effect as follows: "Of several responses made to the same *situation* [italics added], those which are accompanied or followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation . . ." (p. 244).

Guthrie (1935), in *The Psychology of Learning*, addressed the issue of conditioning of contextual stimuli as follows:

Through proprioceptive stimuli we are continuously in touch with our own movement and one movement can be related to another. Through exteroceptive stimuli we are in continuous touch with the world about us. The resultant behavior is a response to this *total stimulation* [italics added], a continuous compromise, a continuous integration . . . The best that [the psychologist] can do is to select certain outstanding and conspicuous parts of the total stimulus situation and keep some record of their consequences. (p. 27)

In a similar vein, Hull (1943) wrote in *Principles of Behavior*: "The conditioned

stimulus in the experiment under consideration includes all of the immensely complicated stimulus elements here enumerated and many more besides . . ." (p. 206). He went on to list several principles according to which associative strength was allocated to the elements of the stimulus aggregate. The first of these is reprinted below because of its relevance to current thinking:

. . . it is probable that static, i.e., unchanging, elements or aggregates in a conditioned stimulus situation are considerably less potent in the acquisition of habit-strength loadings than are the more dynamic, i.e., changing, elements or aggregates. (p. 207)

Skinner also recognized that contextual stimuli associated with reinforcement have the potential to become functional discriminative stimuli. The importance of these environmental stimuli in the control of behavior is demonstrated in Skinner's (1950) account of spontaneous recovery:

No matter how carefully an animal is handled, the stimulation coincident with the beginning of an experiment must be extensive and unlike anything occurring in the later part of an experimental period. Responses have been reinforced in the presence of, or shortly following, this stimulation. In extinction it is present for only a few moments. When the organism is again placed in the experimental situation, the stimulation is restored; further responses are emitted . . . (p. 205)

Clearly, early learning theorists did indeed recognize the existence of contextual conditioning. Nonetheless, a systematic investigation of the determinants of contextual conditioning and the relationship between contextual conditioning and the "primary" conditioning process has not been pursued vigorously by students of the experimental analysis of behavior. It is interesting to speculate on some of

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the factors that may have led to the neglect of this area of study.

One possible factor was the growing body of evidence which suggested that contiguity (between two stimuli, or a response and a stimulus) was not a sufficient condition for response acquisition. The concept of "superstition," or conditioning through adventitious pairing of a response and a reinforcer, for example, was called into question (Staddon & Simmelhag, 1971). In addition, evidence indicated that only those events which were informative or predictive about reinforcers were capable of becoming conditioned (Rescorla, 1967). In its simplest form, this hypothesis seems to imply that stimuli not explicitly correlated with reinforcement (including contextual stimuli) should not acquire any control over behavior.

A second factor which might have contributed to the neglect of this area of study was the increasing acceptance of the concept of selective attention or the notion that subjects "tuned out" irrelevant environmental stimuli such that their behavior was controlled only by relevant ones (Mackintosh, 1965; Reynolds, 1961). The widely cited work of Hernandez-Peon, Scheerer, and Jouvett (1956) suggested that nerve impulses from stimuli to which the subject was not attending were blocked at the level of the peripheral nervous system. Thus, physiological support was given to the belief that irrelevant stimuli could not acquire associative strength.

Finally, the great burgeoning of interest in steady-state behavior may have supplanted interest in the acquisition of conditioned responding. Thus, the question of how certain stimuli came to control behavior, while other stimuli did not, was not raised. When evidence for contextual control arose, it was attributed to nonassociative processes such as novelty effects, emotional disruption, or changes in perceptual or motivational state. For example, when Eckerman, Lanson, and Cumming (1968) reported that cleaning the experimental chambers produced disruption of a well-established matching-to-sample response, it was implied

that this change was due to a perceptual alteration in the appearance of the stimuli. Similarly, Mandell (1980) and Nevin (1974, 1979) reported several studies in which the strength of maintained responding was assessed by manipulations of the experimental context, but the mechanism by which these manipulations altered responding was not explored.

Within the broader field of animal learning, however, there has been renewed interest in the study of contextual control. In 1969, Kamin published a highly influential paper on the role of surprise and predictability in learning, in which he suggested that the necessary conditions for learning could only be established by consideration of the current experimental context. The relationship between acquisition of associative strength by a conditioned stimulus and contextual stimuli was formalized by Rescorla and Wagner (1972), who wrote: "... the effect of a reinforcement or non-reinforcement in changing the associative strength of a stimulus depends upon the existing associative strength, not only of that stimulus, but also of other stimuli concurrently present" (p. 73). A great deal of empirical research has since been directed to the testing of the Rescorla-Wagner model and to the generation and testing of alternative models of contextual conditioning (e.g., Gibbon & Balsam, 1981; Mackintosh, 1975). This body of research has been brought together by Balsam and Tomie in *Context and Learning*, with the purpose of stimulating "further debate, analysis and theoretical integration" (Balsam, Chapter 1, p. 19).

OVERVIEW

Context and Learning is a compilation of fourteen individually authored chapters, each dealing with the role of contextual stimuli in conditioning. Contextual stimuli are generally presumed to be static as opposed to phasic, diffuse as opposed to localized, and unpredictable as opposed to predictive of local contingencies of reinforcement. It is the thesis of

most of the chapters in this book that traditional models of learning are unable to account for certain phenomena which can be explained parsimoniously with reference to contextual conditioning and that these theories must therefore be modified accordingly.

Most of the chapters in this volume are authored by individuals who have already made significant contributions to the understanding of contextual conditioning. Each chapter describes a program of research (some new, but much previously published) investigating the mechanisms of interaction between conditioning and the surrounding environment. The chapters vary in the level of detail with which they model contextual conditioning. For example, while Kaplan and Hearst (Chapter 8) simply offer some suggestions about the possible mechanisms of contextual conditioning, Medin and Reynolds (Chapter 12) provide a fairly detailed mathematical model of contextual conditioning phenomena.

The book is roughly organized into two major sections. Chapters 1 through 8 describe research programs involving some form of Pavlovian conditioning, and attempt to specify the nature of the mechanism governing the interaction between learning and context. The initial chapters within this grouping tend to describe studies using appetitive conditioning procedures (e.g., autoshaping), while the later ones describe studies using aversive and inhibitory procedures (conditioned emotional response procedures and extinction). The remaining chapters are more heterogeneous, and include such topics as the role of context in conditioned taste aversions, state-dependent learning, conditional discriminations in operant conditioning, and complex learning situations such as category sorting and spatial problem-solving. Several of the chapters in this section demonstrate contextual conditioning effects rather than analyze the underlying mechanisms. Others contain detailed models, including the final chapter which proposes a neurophysiological model of contextual conditioning.

A fundamental concern of *Context and*

Learning is the adequacy of the Rescorla-Wagner model to account for much of the research that has appeared since 1972. There are several lines along which the Rescorla-Wagner model is challenged. Certain chapters question the assumption that the primary mechanism for contextual effects is through the association of context and the US. Rather, context is assigned a facilitatory role in the primary conditioning process. Thus, Bouton and Bolles (Chapter 6) view context as a "disambiguator," or a cue which provides meaning to CS-US relationships. They predict contextual effects only if the subjects have had a fairly complex conditioning history (e.g., if they have experienced extinction as well as conditioning). In a similar vein, Baker, Singh, and Bindra (Chapter 4) argue that contextual cues evoke representations of the nature of the CS-US relationship and these representations in turn influence the conditioning process. Medin and Reynolds (Chapter 12) believe that the context serves as a retrieval cue for the CS-US relationship. Yet another point of view, expressed by Thomas (Chapter 11), holds that contextual stimuli provide conditional information about the relationship between the explicit discriminative stimuli and the prevailing contingencies of reinforcement.

A second challenge to the Rescorla-Wagner model raised in several of the chapters in this volume is that interference by contextual cues produces performance deficits rather than learning deficits. This is one point of dispute between the Rescorla-Wagner model and the Gibbon and Balsam (1981) model. Supporting evidence is provided by Miller and Schactman (Chapter 7) who report that the associative strength of the conditioning context at the time of testing, rather than at the time of conditioning, governs responding. In contrast, Rescorla, Durlach, and Grau (Chapter 2) report that training context strength, rather than testing context strength, governs the rate of emission of the conditioned response, suggesting the reverse.

A third point of divergence from the Rescorla-Wagner model is the notion that

context plays multiple roles in conditioning. In Chapter 2, for example, Rescorla et al. suggest three possible roles for context. The first is that which was originally stated in the Rescorla-Wagner model—contextual cues become associated with the US. The associative strength of the contextual cues then summates with the associative strength of the conditioned stimulus to determine responding. Second, context-CS associations are assumed to form and interact with primary conditioning in complex ways. Third, the context may potentiate CS-US relationships, as has been suggested above. A similar view is expressed by Miller and Schactman (Chapter 7) who also assign a comparator function to context (similar to Gibbon & Balsam, 1981), and by Nadel, Willner, and Kurz (Chapter 14) who suggest that contextual cues provide a general set of expectations about the environment as well as specific cues about particular relationships.

Other themes run through this volume. One concerns the comparability of contextual conditioning processes and discrete stimulus conditioning processes. For example, Tomie (Chapter 3) compares conditioning of contextual stimuli, which are unpredictable of the local rate of reinforcement but continuously present, to conditioning of discrete stimuli, which are uncorrelated with reinforcement but are of brief duration. Thomas (Chapter 11) compares conditioning of contextual stimuli which are global and diffuse in nature to conditioning of localized stimuli typically used in conditional control procedures. In a fairly extreme position, Nadel, Willner, and Kurz (Chapter 14) assert that learning processes associated with contextual stimuli not only differ from those associated with discrete stimuli, but learning processes associated with physical space differ from those associated with other contexts, such as temporal or internal context. For this reason they reject the notion of a “general context” view, and suggest that different types of contextual information may be subject to different associative processes.

Another theme concerns the relationship between excitation and inhibition

and contextual conditioning. For example, Bouton and Bolles (Chapter 6) examine inhibitory processes with respect to their influence on contextual conditioning. Kaplan and Hearst (Chapter 8) explore the symmetry of excitatory and inhibitory conditioning processes via their interaction with contextual cues.

A final theme concerns the need to develop measures of contextual control that are independent of the primary measure of conditioning. Thus, Rescorla et al. (Chapter 2) and Balsam (Chapter 1) use measures of general activity to describe contextual conditioning. Baker et al. (Chapter 4) suggest that in conditioned emotional response procedures the baseline response rate can be used as a sensitive index of contextual control (a procedure which is subsequently criticized by Randich and Ross in Chapter 5). Randich and Ross and Bouton and Bolles (Chapter 6) use context preference tests in which the subjects can choose between the conditioning context and an alternative context.

EVALUATION

Balsam and Tomie have produced a fine volume that should serve as a valuable resource to researchers involved in the study of learning. It is scholarly, thought-provoking, and comprehensive. It touches on issues that are on the forefront of current research and that are fundamental to our conceptions of the learning process. The chapters are well-integrated to produce a coherent whole.

A number of factors contribute to making this volume more than a collection of disconnected readings. First, there is the excellent opening chapter in which Balsam reviews varied definitions of context, methods used to study context, and problems that are often faced by researchers in this area. Second, the practice of referencing the work of other contributors to the volume is widely used. Third, there is a general uniformity of orientation, methodology, and focus to most of the chapters in this volume.

Only two of the chapters struck a somewhat discordant note. Hulse, Cynx,

and Humpal's chapter (Chapter 10), although interesting, seemed to be dealing with the issue of relational learning and stimulus generalization, rather than contextual control. This chapter described several studies involving discrimination of acoustic patterns. Context referred to the internal order of the stimuli, or the pattern itself, in contrast to the more common definition in which context referred to stimuli accompanying the primary discriminative stimuli. Moreover, contextual control was assessed by altering the absolute pitch of the acoustic patterns themselves, rather than the associated stimuli that make up what has elsewhere been referred to as the context.

Similarly, Overton's chapter (Chapter 13) on state-dependent learning, differed in focus from the remainder of chapters in the book. Overton reviewed the literature on state-dependent learning, and pointed out that although it has long been realized that altered states may be treated as changing internal contexts, modern theories of context, which view stimulus change as an additive process, have not generally been applied to state-dependent learning. Application of such models can account for a range of hitherto problematic findings, such as the occurrence of both symmetrical and asymmetrical state-dependent learning effects. Thus, the focus of this chapter, was on accounting for state-dependent learning through contextual conditioning models rather than on analyzing contextual control.

At the end of Chapter 8, Kaplan and Hearst write "Our chapter has certainly raised more questions than it has answered" (p. 222). The same, unfortunately, can be said of this volume as a whole. It is clearly the case, however, that a first step to answering these questions is to synthesize and integrate the relevant information and Balsam and Tomie have succeeded admirably in that end. It might have been desirable to have included a final integrative chapter, as well as the introductory one, to highlight the emergent trends and contradictions in the data. This task, however (and it is a significant one), is left to the reader.

Despite the remaining questions, *Con-*

text and Learning should serve another important function, namely, to bring the issue of contextual control once again to the attention of researchers in learning. Morris and Larsen (1986) note that behavior analysts, in particular, have been criticized for the narrowness of their approach in these regards, yet they also note that, in his early works, Skinner (1938) pointed to the need for study of contextual relationships that produce changes in the primary "reflex" relationships (the so-called dynamic laws). By examining the nature of one of these factors, the physical context, Balsam and Tomie may be instrumental in leading to a broader approach to the experimental analysis of behavior, in which behavior is studied in its physical, historical, and biological context.

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