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Can existing associative principles explain occasion setting? Some old ideas and some new data

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ABSTRACT

Since occasion setting was identified as a type of learning independent of 'simple' associative processes, a great deal of research has explored how occasion setters are established and operate. Initial theories suggested that they exert *hierarchical* control over a target CS → US association, facilitating the ease with which a CS can activate the US representation and elicit the CR. Later approaches proposed that occasion setting arises from an association between a *configural* cue, formed from the conjunction of the occasion setter and CS, and the US. The former solution requires the associative principles dictating how stimuli interact to be modified, while the latter does not. The history of this theoretical distinction, and evidence relating to it, will be briefly reviewed and some novel data presented. In summary, although the contribution of configural processes to learning phenomena is not in doubt, configural theories must make many assumptions to accommodate the existing data, and there are certain classes of evidence that they are logically unable to explain. Our contention is therefore that some kind of hierarchical process is required to explain occasion-setting effects.

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Contents

1. Introduction 00
2. US modulation and hierarchical accounts 00
   2.1. CS-specificity 00
   2.2. Memory systems 00
   2.3. Role of stimulus generalisation 00
   2.4. Summary 00
3. Configural theory 00
   3.1. US-specificity 00
   3.2. Specificity to CS/US combination 00
   3.3. Perceptual interactions 00
   3.4. Summary 00
4. Mechanisms of occasion-setter formation 00
   4.1. Learning rules 00
   4.2. Summary 00
5. Elaborations of hierarchical and configural theory 00
   5.1. Elaborated hierarchical account 00
   5.2. Nature of the association representation 00
   5.3. Extended configural theory 00
   5.4. Summary 00
6. Further discriminating evidence 00

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6.1. OS/CS symmetry 00
6.2. Parsing of the association 00
7. Conclusions: do we need a hierarchical theory? 00
Acknowledgement 00
References 00

1. Introduction

Skinner (1938) was the first to suggest that performance of an operant response could come under the control of a *discriminative stimulus*. The idea spread to the cognitive behaviourist literature, with Holland (e.g. 1983; 1985) and Rescorla (e.g. 1985; 1986) demonstrating the same effect in Pavlovian conditioning. Specifically, after training that a conditioned stimulus (CS) signalled an unconditioned stimulus (US), animals could confine performance of their conditioned response (CR) to the CS in the presence of a stimulus termed a *modulator* (Rescorla, 1985), a *remote initiating stimulus* (Jenkins, 1985) or an *occasion setter* (OS; Holland, 1983).

The truly novel finding was that the control exerted by the OS was *independent of its associative properties*. An OS could enhance performance of a CR that it could not itself elicit (Ross and Holland, 1981; Rescorla, 1985), even after OS extinction (Holland 1989a), and pretraining the OS to signal the US impeded its ability to acquire control over the CR (e.g. Rescorla, 1986).[1] This suggested that an OS's effect on behaviour did not rely on activation of the US, CS or CR – that it was not mediated by standard associative principles.[2] Two classes of theory emerged in response to this challenge to associative theory, which had until this point dominated accounts of learned behaviour. The first assumed additional, nonassociative principles must be invoked, giving rise to the *US modulation*, *memory systems* and *hierarchical* accounts. The second asserted that existing associative principles could explain occasion setting – provided *combinations* of stimuli could be represented and be subject to associative learning; this class includes the various versions of *configural* theory (e.g. Rescorla, 1972; Brandon et al., 2000; Pearce, 1987, 1994). As independent evidence for such configural theories accumulated (e.g., Haselgrove et al., 2008; Pearce et al., 2002; Williams et al., 1994), this seemed the more parsimonious explanation, with the result that alternative accounts of occasion setting were eclipsed. This article will revisit evidence relating to these issues, and evaluate the extent to which associative theory can explain occasion setting, or whether additional nonassociative principles are required.

We begin with the *US Modulation and Hierarchical Accounts* theories of occasion setting, for which the evidence, predominantly favouring the hierarchical account, is described. The *Configural Learning* alternative to the hierarchical approach, and its failure to account for evidence of US and CS/US specificity, is then considered; after this the evidence on *Mechanisms of Occasion-Setter Formation* which challenged the hierarchical approach is reviewed. *Elaborations of Hierarchical and Configural Theories* are then presented that can, with added assumptions, explain most of the existing data. Some *Further Discriminating Evidence* that could allow us to choose between these elaborated theories is discussed. We conclude by considering whether or not there is a need to suppose hierarchical processes to explain occasion-setting effects.

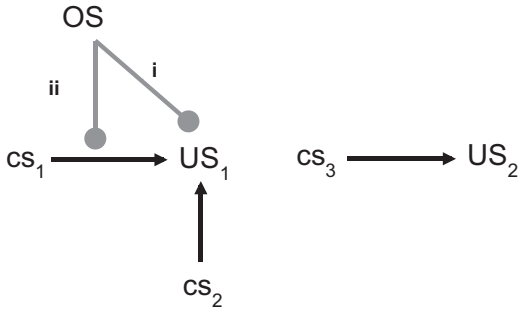

Fig. 1. According to hierarchical accounts an OS signalling that cs_1 will be followed by US_1 acts either on the US_1 representation (i; e.g., Rescorla, 1985) or on the $cs_1 \rightarrow US_1$ link (ii, e.g., Holland, 1983). The accounts differ in their predictions about the OS's action on a stimulus cs_2 that has signalled US_1; neither predicts that the OS will have an effect on a stimulus cs_3 that signals US_2. The pointed arrow indicates an associative link; round-headed arrow indicates facilitation of (i) activation of US_1 representation or (ii) transmission of activation via $cs_1 \rightarrow US_1$ association. For further details, see text.

2. US modulation and hierarchical accounts

The first key theories were the US modulation (Rescorla, 1985) and hierarchical accounts (Holland, 1983). *US modulation* elaborated on the existing conceptualisation of a conditioned inhibitor (a stimulus predicting the omission of an otherwise expected US, and counteracting the effect of CSs predicting that US; e.g. Konorski, 1948; Rescorla, 1969) as acting through suppression of activation in the US representation. The US modulation account proposed the complementary process, that a positive occasion setter lowers the activation threshold of the US representation, increasing its sensitivity to excitatory cues. This allows the CS to activate the US representation with greater ease in the presence of the OS than in its absence. In contrast, the *hierarchical account* asserted that the OS facilitates operation of the association between CS and US (Fig. 1).[3]

The accounts may be discriminated in terms of *transfer*. Suppose an OS signals that cs_1 predicts US_1 (Fig. 1). If the *OS* facilitates activation of US_1, it will enhance responding to cs_2 associated with US_1, but be without effect on cs_3 associated with US_2 – it is *US-specific*, not *CS-specific*. But if the *OS* enhances operation of the $cs_1 \rightarrow US_1$ association it will have no effect on cs_2, even if cs_2 is also associated with US_1: it will be *both* CS-specific and US-specific. Evidence suggests that occasion setters are both CS- and US-specific, and that the extent to which such specificity is observed is influenced by procedural factors (Swartzentruber, 1995).

2.1. CS-specificity

Many studies have shown that OS_1 signalling that cs_1 predicts US_1 (OS_1: $cs_1 \rightarrow US_1$), may control the CR to a cs_2 that *also*

[1] probably because such pretraining blocked acquisition of associative strength by the target CS (see Swartzentruber, 1995 for a review of related findings)

[2] This should not be taken to imply that an OS may not also have associative properties that influence behaviour, simply that its action cannot be explained solely in those terms.

[3] An alternative conceptualisation of the hierarchical account is that as an occasion-set CS is typically both reinforced and nonreinforced during training, it must have both excitatory and inhibitory associations with the US, and that the occasion setter inhibits the inhibitory association (Bouton and Nelson, 1998). However this account assumes that occasion setting is impossible if the occasion-set CS has no inhibitory strength, and there is evidence against this position (e.g. de Brugada et al., 1995; Hall and Honey, 1989).

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