The influence of landmark stability on control by occasion setters

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ABSTRACT

In an operant serial feature-positive procedure, an occasion setter (OS_X) signals that a response will be reinforced in the presence of a second stimulus (e.g., a discriminative stimulus, A). During a transfer test, the OS is paired with a different discriminative stimulus. Experiment 1a tested transfer effects in a touchscreen-based spatial occasion setting task with pigeons. During training, four OSs (OS_W, OS_X, OS_Y, and OS_Z) were paired on separate trials with landmark A (LM_A) or B (LM_B) and the opportunity for a reinforced response at one location to the immediate left (R_1) or right (R_2) of the LM ($OS_W \rightarrow LM_A{:}R_1$, $OS_X \rightarrow LM_A{:}R_2$, $OS_Y \rightarrow LM_B{:}R_1$, $OS_Z \rightarrow LM_B{:}R_2$). Training also included non-reinforced trials of LM_A and LM_B alone (LM_A- and LM_B-) and trials of a non-modulated LM with R_1 and R_2 reinforced across separate trials ($LM_C{:}R_1$ and $LM_C{:}R_2$). After training, the number and spatial location of responses during test trials of a LM paired with the same OS as in training did not differ reliably from transfer tests of an OS paired with a different, modulated LM ($OS_W \rightarrow LM_B$ and $OS_Y \rightarrow LM_A$), but did differ from transfer to the non-modulated LM ($OS_X \rightarrow LM_C$). Experiment 1b utilized the same pigeons and training with LM_B to test the degree to which the spatial stability of a LM influenced transfer. Retraining with LM_A was intended to establish it as a non-modulated, stable LM ($LM_A{:}R_2$). Subsequent tests with LM_A revealed reduced modulation by the formerly trained OS (OS_W), and complete disruption of modulation of spatial location during transfer with a different OS (OS_Y). These findings further our understanding of the conditions under which OSs may develop and transfer modulation.

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The environment in which behavior (e.g., foraging) occurs can consist of multiple stimuli (e.g., visual, auditory, and olfactory) that may signal the presence or absence of reinforcement (e.g., food). These conditions can be simulated in a laboratory using an operant serial feature-positive discrimination procedure. This procedure involves trials during which a specific response is reinforced in the presence of a discriminative stimulus (e.g., a tone, DS_A) when it follows the presentation of a second stimulus (e.g., a light, light $\rightarrow DS_A$) but not when DS_A is presented alone (DS_A-). The second stimulus is referred to as an occasion setter (OS) because the presence of the light, OS_X, sets the occasion for responses to DS_A to be reinforced. By the end of training with this procedure, animals respond to DS_A when preceded by OS_X, but not to DS_A when presented alone. Although Skinner (1938) identified a DS itself as an OS, the literature on operant occasion setting has primarily used the feature-positive procedure in which an OS signals the functionality of a DS. In a Pavlovian serial feature-positive procedure, an OS signals the functional value of a conditioned stimulus CS_A, which is paired with an unconditioned stimulus (US) only when preceded by OS_X ($OS_X \rightarrow CS_A+/CS_A-$). OSs in Pavlovian and operant serial feature-positive procedures function similarly by modulating the contingency between another stimulus and an outcome, and the terminology has been used interchangeably (e.g., Holland, 1995). The learning that supports occasion setting in these procedures continues to be the subject of debate (e.g., Bonardi et al., 2012). Post-training manipulations and transfer tests are two procedures that have been used to better understand occasion setting.

The mechanism by which an OS operates in an operant serial feature-positive procedure ($OS_X \rightarrow DS_A+/DS_A-$) is easily distinguished from that of a standard excitatory stimulus (Holland, 1995). An excitatory stimulus would be expected to control the response directly, whereas an OS modulates the link between DS_A and the reinforced response in a three-term contingency (DS_A-[response-reinforcer]). Holland (1995) used a transfer test to evaluate these possibilities. In Experiment 2, Holland trained rats in Group R_1+R_2 with two OS pairs and two different responses, a chain pull and paddle push. One response was reinforced on trials of $OS_X \rightarrow DS_A:R_1$ and the other response was reinforced on trials of $OS_Y \rightarrow DS_B:R_2$. No responses were reinforced on DS_A or DS_B alone trials. R_1 and R_2 were both reinforced on separate trials of a third DS ($DS_C:R_1$ and $DS_C:R_2$) that was not paired with an OS. Extinction trials of DS_C alone were given prior to testing. On transfer tests an OS was paired in a novel configuration with a previously modulated ($OS_X \rightarrow DS_B/OS_Y \rightarrow DS_A$) or a previously non-modulated ($OS_X \rightarrow DS_C/OS_Y \rightarrow DS_C$) DS. If OS_X and OS_Y controlled responding

directly, then responding should have been high during transfer with all DSs (DS_A, DS_B, and DS_C) and the form of the response should have matched that of OS_X and OS_Y during training. Alternatively, if OS_X and OS_Y acted as OSs that controlled the link between a specific DS and the response, then the mismatch of OS and DS during a transfer test should have resulted in little responding. Of the little responding that may occur, this account predicts it would have matched the form of the three-term contingency encountered during training (DS_A-[R_1-reinforcer] or (DS_B-[R_2-reinforcer]). The results of Test 1 indicated that responding in the presence of DS_B on the transfer test ($OS_X \rightarrow DS_B$) matched that of responding to DS_B during training and was complete relative to original training ($OS_Y \rightarrow DS_B$). Responding on transfer trials of DS_C paired with an OS was on average higher than trials of DS_C alone, but reliably less than responding during the $OS_X \rightarrow DS_B$ transfer test. The form of the response on the $OS_X \rightarrow DS_B$ transfer test matched responding during training with DS_B, providing strong evidence that OS_X and OS_Y did not control the response directly. The presence of complete transfer was evidence that control by the OS was not limited to the DS with which it was trained. Perhaps, the OS motivated responding via a direct connection to the reinforcer and the DS controlled the form of the response.

Holland (1995) also utilized a post-training manipulation in which OS_X (or OS_Y) was presented without a DS or an opportunity for reinforcement (i.e., in extinction) to evaluate any direct connection to the reinforcer. Following Test 1, the rats were given retraining of the original OS pairs ($OS_X \rightarrow DS_A:R_1/OS_Y \rightarrow DS_B:R_2/DS_A-/DS_B-$) and then two sessions of extinction with OS_X. Extinction should have eliminated transfer if OS_X directly controlled the response or reinforcer, but not if OS_X functioned as an OS. Responding on transfer trials with the modulated DS was reduced, indicating a small role for direct control by the OS. However, responding was still robust; it was greater than on test trials of the DS alone and on trials of the OS paired with the non-modulated DS. The finding of moderate transfer is at first glance inconsistent with the OS modulating a specific DS, but it is consistent with findings from similar Pavlovian procedures (Holland and Haas, 1993; Swartzentruber, 1995). Bonardi and Hall (1994) have explained successful transfer to a different CS as an instance of stimulus generalization. Stimulus generalization occurs when a different stimulus than was originally trained to control behavior elicits the same response as the trained stimulus. The response to the different stimulus typically approximates the magnitude and form of the trained response based on the degree of similarity (e.g., in sensory features) to the trained stimulus. In the