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CONTRIBUTIONS OF ELICITATION TO MEASURES OF SELF-CONTROL

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Pigeons' not pecking or pecking constituted choice between a delayed, large reinforcer and an immediate, small reinforcer (self-control) and at other times between a delayed reinforcer and no reinforcer (omission). Both a tone and a keylight were tested as choice signals, and the delayed reinforcer was either response independent or response dependent. Pigeons pecked during the choice signals on over 95% of the trials in the self-control procedure, and pecked during the choice signals on over 75% of the trials in the omission procedure. Consistent pecking was observed with either the tone or the keylight as a choice signal, with the exception that a tone paired with a response-independent delayed reinforcer did not maintain pecking in the omission procedure. Pigeons pecked during more choice signals when delayed reinforcers were response dependent than when the delayed reinforcers were response independent. These results indicate that Pavlovian conditioning influences self-control experiments, especially in single-key procedures.

Key words: self-control, signal control, Pavlovian conditioning, key peck, pigeons

Contemporary research on self-control comprises situations in which an organism chooses between two events arriving at different times (Rachlin, 1974). Typically, the choice is between a relatively small reinforcer that can arrive soon after the choice point and a relatively large reinforcer that only arrives later. The choices are mutually exclusive. Self-control is the choosing of the delayed, large reinforcer; if the immediate, small reinforcer is chosen, the behavior is regarded as impulsive (Ainslie, 1975) or as exhibiting a lack of self-control (Navarick & Fantino, 1976). A popular research strategy has been to consider self-control as operant behavior and to derive predictions from the relative magnitude and delay of the two reinforcers. Often prediction is aided by the matching equation (Navarick & Fantino, 1976; Rachlin & Green, 1972).

An example of a two-reinforcer self-control procedure was reported by Ainslie (1974). Pigeons were exposed to a series of 19-s trials. After 12 s had elapsed in a trial, a response key was illuminated for 3 s by a red light. If the 3-s period elapsed without a key peck, then 4-s access to grain was presented. If, on the other hand, the pigeon pecked the red key, 2-s access to grain was presented immediately. Eight of 10 pigeons pecked during over 95% of red-key presentations. An interpretation of this result based on the relative magnitude of reinforcers is that the immediacy of the 2-s reinforcer overcame the larger magnitude of the 4-s reinforcer. The present study was undertaken to investigate an alternative interpretation.

A two-reinforcer procedure like the one just described requires that the moment of choice be signaled. In experiments with pigeons as subjects, the signal at the choice point is often a keylight. If the keylight is followed by food, as it usually is, then the conditions are conducive to signal-controlled responding (e.g., autoshaping, Brown & Jenkins, 1968). The autoshaping procedure of Brown and Jenkins consisted of occasional presentations of an 8-s keylight followed by food. Pigeons came to peck at the illuminated key, indicating that the keylight had become a conditioned stimulus that elicited pecks.

The problem using key-peck responses in a

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self-control procedure is that the elicited key pecks are known to be relatively insensitive to their consequences (Williams & Williams, 1969). The experimenter may incorrectly conclude that response-consequence parameters account for the presence or absence of self-control. Signal control may produce a lack of self-control, not through the greater effectiveness of the immediate reinforcer as consequence, but rather because the signal at the choice point may elicit key pecks. How elicited responses may influence self-control is illustrated by the Williams and Williams (1969) study in which pigeons were exposed to a 6-s keylight followed by food. Pigeons persistently key pecked during the keylight despite a contingency whereby pecks during the keylight omitted food. It might be said that Williams and Williams observed a lack of self-control in pigeons, because the pigeons did not wait and obtain the delayed reinforcer. That description is questionable, however, if we believe that self-control or the lack of it depends on the consequences of the response. There was no immediate reinforcer.

The present study compared self-control and omission procedures for the purpose of evaluating the impact of elicited responding on self-control and its measures. In one condition pigeons had a choice between a delayed, large reinforcer and an immediate, small reinforcer. In a second condition pigeons had a choice between a delayed reinforcer and nothing (omission). It was expected that pigeons' omission responding would mimic the choice of the immediate reinforcer, indicating that choice was influenced by elicited pecking.

METHOD

Subjects

Twelve male adult White Carneaux pigeons were obtained from the Palmetto Pigeon Plant. The pigeons were reduced to 80% of their free-feeding weights. Water and grit were available in their home cages.

Apparatus

The operant conditioning chamber was a BRS/LVE pigeon test chamber measuring 45 cm long, 35 cm wide, and 36 cm high. Two response keys, 2 cm in diameter, were mounted one above the other in the center of the front panel. Only the top key was used; it was illuminated red or white and could be depressed by a force of 0.1 N.

In sessions involving an auditory signal, the key was illuminated white throughout the experimental session. When the signal was visual, the key turned red. The auditory signal was a tone (2800-Hz, 70 dB) produced by a Mallory Sonalert mounted behind the front panel of the chamber. General illumination was provided by two CM 313 lamps mounted near the ceiling. These lamps were lit at all times except when the feeder was operating. The feeder, located in the lower left corner of the front panel, was illuminated with a white light during operation.

White noise masked extraneous sounds. The onset of white noise marked the beginning of an experimental session; its offset marked the end of a session. Solid-state programming equipment, located in an adjacent room, controlled experimental events and recorded data.

Procedure

Key-peck training. All birds were trained to peck a key by the method of successive approximations. During this training the key was white, and reinforcement was 4-s access to grain. On the day following the acquisition of key pecking, each bird received one session in which each key peck was reinforced. The session was terminated after 50 4-s reinforcers.

The two experimental conditions are described below. The contingencies were the same in both conditions when the pigeons did not peck; the two conditions differed when the pigeons pecked the key during the signal. Six birds (10840, D-1, D-4, D-6, 3081, and 3342) were initially exposed to the no-small-reinforcer condition. The remaining 6 birds were initially exposed to the small-reinforcer condition (see Table 1).

No small reinforcer (omission). Each daily session, which lasted about 1 hr, consisted of 35 signals presented on a variable-time 90-s schedule. The duration of the signal was always 4 s, regardless of the pigeon's behavior.

Table 1
Order of No-Reinforcer and Small-Reinforcer Conditions

Bird	Signal Type	Delayed Reinforcer Contingency	Order of Conditions (Sessions)
D-6	Keylight	Resp-dep	No(7), Small(6), No(16), Small(6)
D-4	Keylight	Resp-dep	No(7), Small(6), No(11), Small(6)
6602	Keylight	Resp-dep	Small(5), No(19), Small(9), No(13)
10840	Tone	Resp-dep	No(8), Small(10), No(9), Small(6)
6600	Tone	Resp-dep	Small(15), No(9), Small(7), No(10)
3081	Tone	Resp-dep	No(16), Small(5), No(8), Small(5)
2185	Tone	Resp-dep	Small(10), No(15), Small(9), No(13)
D-2	Keylight	Resp-ind	Small(5), No(14), Small(5), No(12)
3646	Keylight	Resp-ind	Small(12), No(20), Small(10), No(11)
D-1	Keylight	Resp-ind	No(8), Small(6), No(13), Small(8)

Note: The order of conditions for Birds 1193 and 3342 are shown in Figures 4 and 5.

If the pigeon pecked the key during the signal, the pigeon received no reinforcer. If the pigeon did not peck during the signal, then 4-s access to grain was either presented (response-independent procedure) or was available (response-dependent procedure) at the offset of the signal.

Small reinforcer. Each session consisted of 35 signals presented on a variable-time 90-s schedule. If the pigeon pecked the key during the signal, the signal was immediately terminated and 2-s access to grain was produced. If the pigeon did not peck during the signal, then the signal terminated after 4 s and 4-s access to grain was either presented or made available, as discussed below.

Types of signals. For one group of 6 pigeons the signal was a 4-s red keylight. The key was white at other times. For another group of 6 pigeons the signal was a 4-s tone, and the key was white continuously.

Food contingency. Three pigeons exposed to the red keylight (D-1, D-2, 3646) received the delayed, 4-s reinforcer independently of a response. The other 3 pigeons in the red-keylight group (D-4, D-6, 6602) received the 4-s reinforcer following the first postsignal key peck.

Two pigeons (2185 and 6600) were exposed to a procedure in which the signal was a 4-s tone and the 4-s reinforcer was response independent. When it was determined that the pigeons did not peck under these circumstances, they were exposed instead to a tone and response-dependent food. The lack of responding in the procedure with a tone and response-independent food was further examined in the following manner. Pigeons 3342 and 1193 were initially trained with a tone and a response-dependent 4-s reinforcer. When responding was established, these pigeons were switched to response-dependent food. Two pigeons (3081 and 10840) were exposed to the tone and response-dependent food throughout the experiment.

The dependent variable, percentage of periods with a peck, is described below. The experiment was carried out using an ABAB design with the initial treatment counterbalanced across subjects. A pigeon remained in a condition until stable responding in the signal period was observed, as defined by three consecutive daily data points not indicating an upward or downward trend and not changing by more than 15%.

RESULTS

The dependent variable was the percentage of periods in which at least one peck was recorded. The percentage of periods with a peck (PPP) was calculated for both signal and control periods in a session. Signal periods were periods when the signal occurred; control periods were arbitrary 4-s periods measured during the absence of signals and of food presentations. These 4-s periods were measured during the session; they were not created after the fact. Control period PPP indicated how fre-

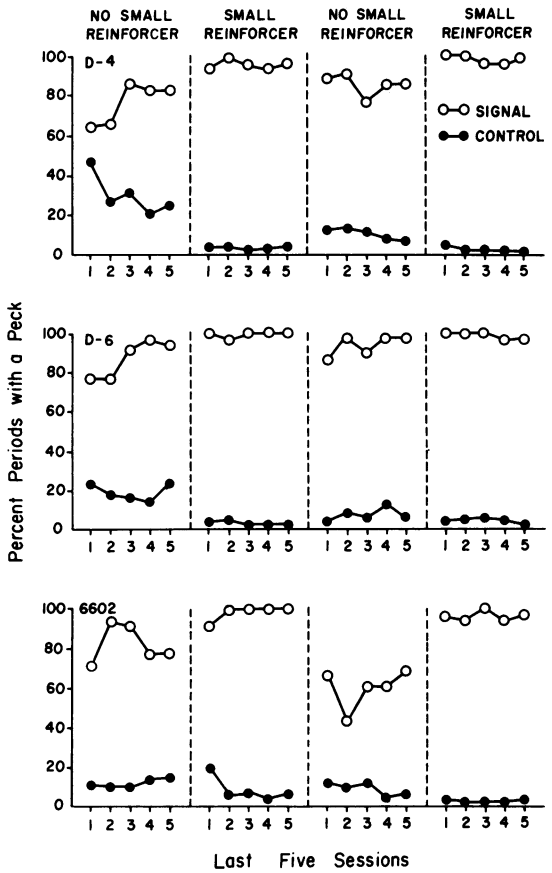

Fig. 1. Percentage of signal and control periods in which at least one peck occurred, for pigeons exposed to a red keylight and a response-dependent delayed reinforcer. Pecking during the signal is represented by lines with unfilled circles; pecking during control periods is represented by lines with filled circles. Data are from the last five sessions of each condition. Bird 6602 was exposed to the small-reinforcer condition first, but the panels are reversed for ease of reading.

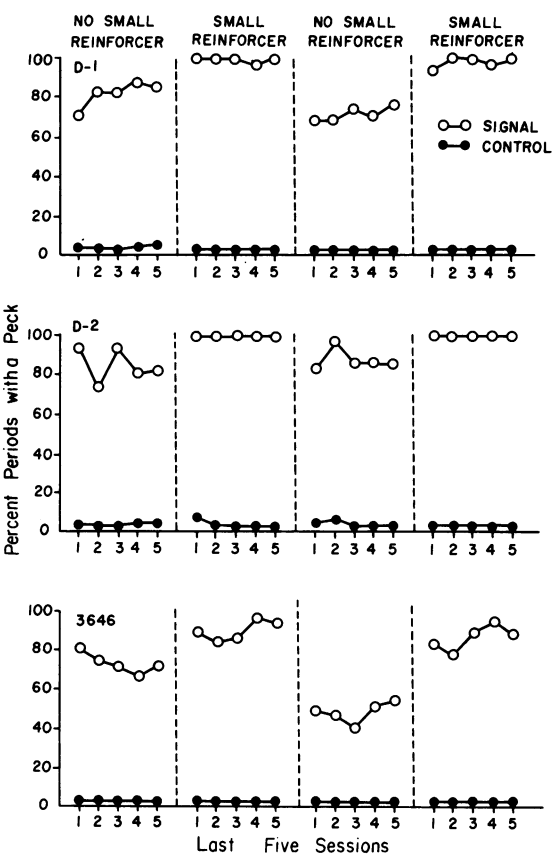

Fig. 2. Percentage of signal and control periods in which at least one peck occurred, for pigeons exposed to a red keylight and a response-independent delayed reinforcer. Pecking during the signal is represented by lines with unfilled circles; pecking during control periods is represented by lines with filled circles. Data are from the last five sessions of each condition. Birds D-2 and 3646 were exposed to the small-reinforcer condition first, but the panels are reversed for ease of reading.

quently the pigeon was pecking in the absence of the signal.

If a pigeon was in the small-reinforcer condition, the percentage of signal periods with a peck indicated the percentage of immediate, small reinforcers the pigeon chose. If the pigeon was in the no-small-reinforcer condition, the percentage of signal periods with a peck indicated the percentage of signals that were followed by no reinforcer.

Pecking during the signal was frequent in three of the four combinations of signal type and food contingency. The exceptional combination consisted of a procedure in which a tone was followed by response-independent food, the results of which are presented later.

For the other combinations of signal and food contingency, pigeons pecked frequently when the signal occurred and infrequently when the signal was absent. Figures 1, 2, and 3 illustrate the performances of 10 subjects. The results are categorized by procedure. Figure 1 shows the percentage of periods with a peck for the last five sessions from each of 3 pigeons exposed to a red keylight and a response-dependent delayed reinforcer. Figure 2 shows the PPP for the last five sessions from each of 3 pigeons exposed to a red keylight and a response-independent delayed reinforcer. Fig-

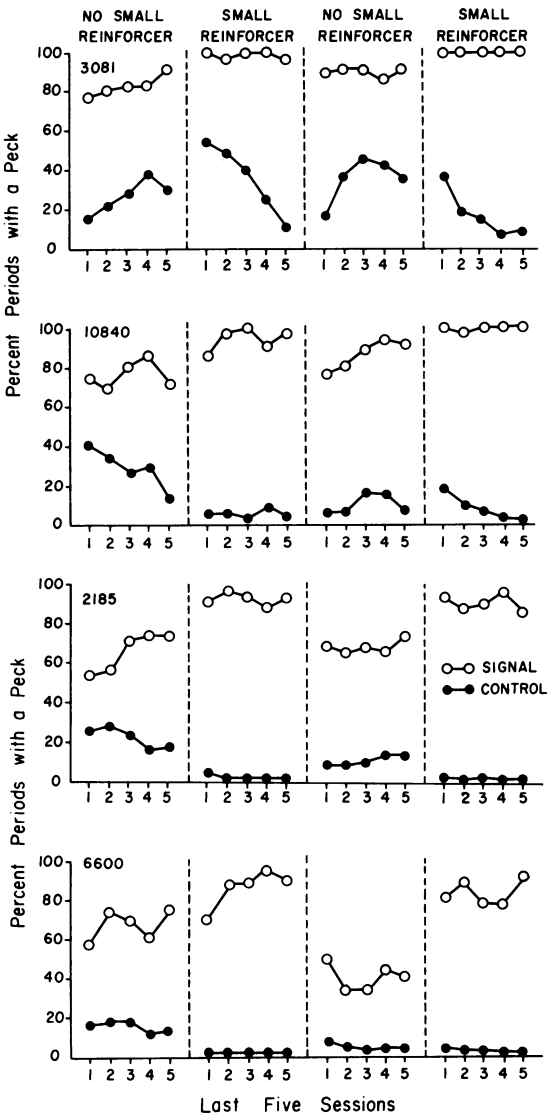

Fig. 3. Percentage of signal and control periods in which at least one peck occurred, for pigeons exposed to a tone and a response-dependent delayed reinforcer. Data are presented in the same manner as in the previous figures. Birds 2185 and 6600 were exposed to the small-reinforcer condition first, but the panels are reversed for ease of reading.

ure 3 shows the PPP for the last five sessions from each of 4 pigeons exposed to a tone and a response-dependent reinforcer. In each figure, the panels are labeled according to the availability of the immediate, small reinforcer in the procedure. Panels marked "small reinforcer" indicate that pecking in the signal produced 2-s access to grain; panels marked "no small reinforcer" indicate that pecking in the signal omitted food for that signal. Both PPP during the signal and in the absence of the signal are presented.

Table 2

Mean percentage of periods with a peck for data in Figures 1, 2, and 3.

Signal Type	*Delayed Reinforcer Contingency*	*Signal PPP*	*Control PPP*	*N*[a]
	Small-Reinforcer Condition			
Keylight	Resp-dep[b]	97.5	3.6	3
Keylight	Resp-ind	95.6	0.3	3
Tone	Resp-dep	93.2	9.0	4
	No-Small-Reinforcer Condition			
Keylight	Resp-dep	80.4	14.8	3
Keylight	Resp-ind	74.6	1.9	3
Tone	Resp-dep	72.0	19.4	4

[a]*N* = number of pigeons in that condition

[b]Resp-dep means the delayed reinforcer was response dependent. Resp-ind means the delayed reinforcer was response independent.

Overall means for the data presented in Figures 1, 2, and 3 are presented in Table 2. The means are categorized by signal type and food contingency. If all the data in the figures are averaged, pigeons pecked during 95.2% of all signals when pecking produced a small reinforcer and during 75.3% of all the signals when pecking produced no reinforcer. The means for control-period pecking were 4.8% when a small reinforcer was present in the procedure and 12.8% when no small reinforcer was present.

In each of the three procedures, the data confirmed our prediction that pigeons peck frequently in both self-control and omission conditions. When pecks produced a small reinforcer, pigeons pecked during more than 90% of signal presentations. When a small reinforcer was not available, pigeons nevertheless pecked during more than 70% of signal presentations.

Exceptional results occurred when the signal was a tone and the delayed reinforcer was response independent. Preliminary training with a response-dependent delayed reinforcer was necessary in order to observe pecking during this procedure. Two pigeons (2185 and 6600) were exposed to the tone and the response-independent delayed reinforcer imme-

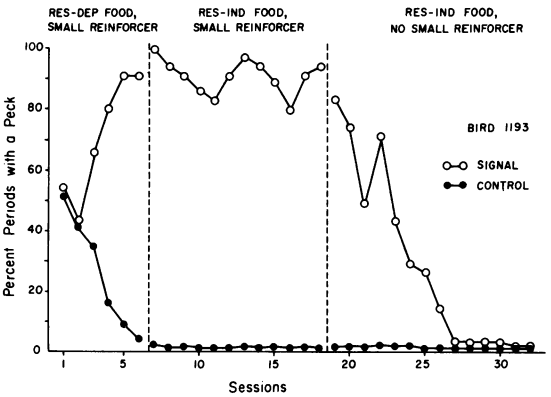

Fig. 4. Percentage of signal and control periods in which at least one peck occurred, for Pigeon 1193. All sessions are shown. Pecking during the signal is represented by lines with unfilled circles; pecking during control periods is represented by lines with filled circles. Switching to a response-independent delayed reinforcer following a tone maintained pecking only so long as an immediate, small reinforcer was available.

diately after shaping. The pigeons stopped pecking after three sessions. These data are not shown. For both pigeons, key pecking was maintained by a procedure that included a tone and a response-dependent delayed reinforcer, as shown in Figure 3.

Pigeons 1193 and 3342 were initially exposed to a tone and the response-dependent delayed reinforcer, and they were switched to the response-independent delayed reinforcer after responding was established. The behavior of Pigeon 1193 is represented in Figure 4, which shows that Pigeon 1193 pecked when the delayed reinforcer was response dependent and continued to peck when the delayed reinforcer was response independent, so long as the small reinforcer was available. When changed to the no-small-reinforcer condition, the pigeon stopped pecking.

Pigeon 3342 was trained initially with a tone and a response-dependent delayed reinforcer. When changed to a response-independent delayed reinforcer, the pigeon pecked less frequently than did pigeons exposed to other combinations of signal and delayed reinforcer. Figure 5 shows the performance of Pigeon 3342 in the last five sessions of each condition. When the delayed reinforcer was response dependent, Pigeon 3342 pecked during 74.8% of the signal periods, despite the absence of the small reinforcer. When the delayed reinforcer was response independent, Pigeon 3342 pecked during 27.2% of the signal periods, despite the absence of the small reinforcer. When the small reinforcer was added to the procedure, the percentage of signal periods with a peck rose to 54.5%.

DISCUSSION

In the experiment described here, pigeons in a self-control procedure pecked frequently during prefood signals, obtaining immediate, small reinforcers rather than larger, delayed reinforcers that would result from not pecking during the signals. In a similar procedure, pigeons also pecked frequently when pecking completely omitted potential reinforcers on a given trial. The frequency of pecking was affected by both signal modality and response-reinforcer contingency of the delayed reinforcers. A keylight as signal followed by a response-dependent delayed reinforcer produced the most frequent signal pecking in both the self-control and omission procedures. A keylight as signal followed by a response-independent delayed reinforcer produced fewer pecks during signals, and a tone as signal followed by a response-dependent delayed reinforcer produced pecks during still fewer signals. For most birds, a tone followed by a response-independent delayed reinforcer did not support pecking unless an immediate, small reinforcer was contingent upon pecking. A tone paired with a response-independent delayed reinforcer did support some pecking by Bird 3342.

The usual view of self-control is that it is a choice between two reinforcers arriving at different times (Rachlin, 1974). Pecks during stimuli that signal the choice between response-contingent small, immediate reinforcers and larger, delayed reinforcers are considered to show lack of self-control. The present study demonstrates that an immediate, small reinforcer is not necessary for observing this lack of self-control. The concept of self-control could include choices between a delayed reinforcer and no reinforcer. When choices between a delayed reinforcer and no

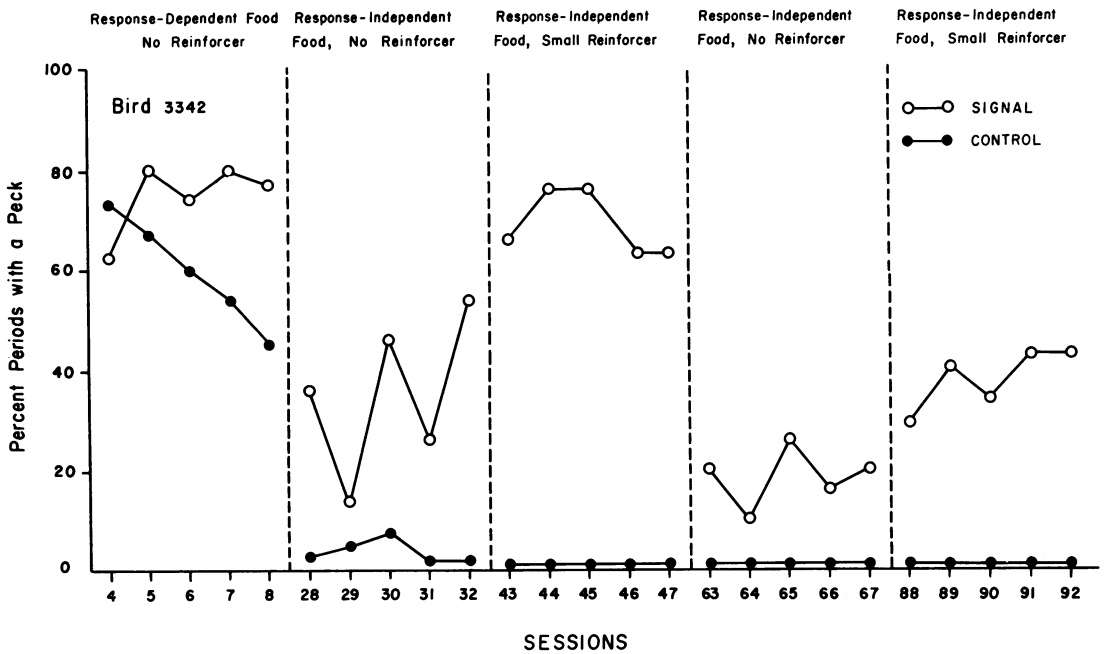

Fig. 5. Percentage of signal and control periods in which at least one peck occurred for Pigeon 3342. The last five sessions of each condition are shown. Data are represented as in previous figures. Pecking during a tone followed by a response-independent delayed reinforcer was infrequent when compared to other procedures tested in the experiment.

reinforcer are included under the concept of self-control, it is difficult to explain a lack of self-control using only reinforcement parameters.

As an alternative we could examine the stimulus used to signal the choice period. That is, we could conceptualize the immediate event in the self-control situation as including either a small reinforcer or a conditioned stimulus. The occurrence of a small, immediate reinforcer or a conditioned stimulus may decrease self-control. Stimuli that accompany the choice period, including the sight of the primary reinforcer itself, can decrease self-control. For example, Grosch and Neuringer (1981) demonstrated that pigeons that could see grain during the waiting period did not show self-control to the same extent as pigeons that could not see grain during the waiting period. Grosch and Neuringer also found that stimuli previously paired with grain decreased self-control.

Signal-controlled pecks occur in the course of self-control experiments, so that some of the behavior that has been attributed to the immediate reinforcer is actually due to the signal that accompanied the choice period. Estimates of the effectiveness of the immediate reinforcer as a consequence of an operant response have been inflated by signal-controlled pecks. The present study suggests that elicited pecks of the sort responsible for omission responding may play a role in self-control procedures involving an apparatus with a single key. The role played by elicited pecks in two-key self-control procedures (e.g., Rachlin & Green, 1972) remains to be investigated.

Pavlovian conditioning is frequently offered as accounting, at least in part, for omission responding (Locurto, 1981). According to the Pavlovian view, food is an unconditioned stimulus that elicits the unconditioned response of pecking. A signal paired with food may become a conditioned stimulus that elicits pecking. The advantage of the Pavlovian view is that conditioned responses depend on the occurrence of a prior signal, not on the occurrence of a subsequent reinforcer. Therefore, responding may be maintained despite the omission of food. This is not to say, however, that signal-controlled responding is entirely insensitive to re-

inforcement contingencies (Schwartz & Williams, 1972).

The Pavlovian view has not been universally accepted. Hursh, Navarick, and Fantino (1974) suggested that pecking in an omission procedure is maintained either by stimulus change or by secondary reinforcement. According to the stimulus-change hypothesis, pecks that occur just prior to the offset of a signal may be maintained by signal offset. The experimental procedures most susceptible to this sort of explanation are those in which a peck during the signal turns off the signal (e.g., Williams & Williams, 1969). In the present experiment the duration of the signal was 4 s regardless of the pigeon's response, so it is uncertain whether stimulus change affected the results.

According to the secondary-reinforcement hypothesis, a signal offset just prior to the presentation of food may become a secondary reinforcer and maintain responding. Generally, the evidence is against this hypothesis (Locurto, 1981). For example, Lewis and Stoyak (1979), using an omission procedure similar to the present one, demonstrated that pigeons continued to peck during the signal when the signal did not end until 2 s after the last peck. Although the secondary-reinforcer hypothesis is not generally supported, it may have special relevance to the present study, in which the presence of absence of the immediate reinforcer was a within-subject manipulation. A secondary reinforcer created in one condition may have carried over to the other. In the small-reinforcer condition, the signal was always followed by food, whether the pigeon pecked during the signal or not. It is certainly possible that signal offset became a secondary reinforcer, and if that were so, perhaps a Pavlovian explanation of the present results is not necessary. But we have already noted that secondary reinforcement does not account for omission responding, and further, that 6 of the 12 pigeons in this study were exposed to the no-small-reinforcer condition before their exposure to the small-reinforcer condition. Although later exposure to experimental manipulations may have been influenced by secondary reinforcement, it remains that pigeons pecked and omitted food before they were ever exposed to the immediate reinforcer.

We believe that signal-controlled pecking in the no-small-reinforcer condition is best described as the result of the influence of Pavlovian conditioning, and that signal-controlled responses occurred also when the immediate, small reinforcer was present in the procedure. In two of the present procedures the delayed reinforcer was response dependent and, it could be argued, could not engender Pavlovian responding because they were not truly autoshaping procedures (Brown & Jenkins, 1968). Procedural descriptions of Pavlovian conditioning usually include the response-independent delivery of the unconditioned stimulus. In the present case, the unconditioned stimulus was response dependent for some birds. But a comparison of the behavior of pigeons exposed to response-dependent food and response-independent food shows no substantial differences in responding, except when the food was paired with a tone. The results lead us to believe that signal-food pairings influence responding when the delayed reinforcer is response dependent.

Indeed, negative automaintenance (Williams & Williams, 1969), single-key self-control (Ainslie, 1974), and signal control (Lewis & Stoyak, 1979) all generate behavior in pigeons that is remarkably similar. In all three cases, pigeons do not refrain from pecking a signal paired with food. There is other evidence that self-control and signal-controlled responding resemble each other. The significance of these similarities is that some instances of self-control, often described as operant behavior, may be strongly influenced by Pavlovian conditioning.

REFERENCES

Ainslie, G. W. (1974). Impulse control in pigeons. *Journal of the Experimental Analysis of Behavior,* **21,** 485-489.

Ainslie, G. W. (1975). Specious reward: A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin,* **82,** 463-496.

Brown, P. L., & Jenkins, H. M. (1968). Autoshaping of the pigeon's key-peck. *Journal of the Experimental Analysis of Behavior.* **11,** 1-8.

Grosch, J., & Neuringer, A. (1981). Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior,* **35,** 3-21.

Hursh, S. R., Navarick, D. J., & Fantino, E. (1974). "Automaintenance": The role of reinforcement. *Journal of the Experimental Analysis of Behavior,* **21,** 117-124.

Lewis, P., & Stoyak, M. (1979). Signal-controlled responding. *Journal of the Experimental Analysis of Behavior,* **31,** 115-125.

Locurto, C. M. (1981). Contributions of autoshaping to the partitioning of conditioned behavior. In C. M. Locurto, H. S. Terrace, & J. Gibbon (Eds.), *Autoshaping and conditioning theory* (pp. 101-135). New York: Academic Press.

Navarick, D. J., & Fantino, E. (1976). Self-control and general models of choice. *Journal of Experimental Psychology: Animal Behavior Processes,* **2,** 75-87.

Rachlin, H. (1974). Self-control. *Behaviorism,* **2,** 94-107.

Rachlin, H., & Green, L. (1972). Commitment, choice and self-control. *Journal of the Experimental Analysis of Behavior,* **17,** 15-22.

Schwartz, B., & Williams, D. R. (1972). The role of the response-reinforcer contingency in negative automaintenance. *Journal of the Experimental Analysis of Behavior,* **17,** 351-357.

Williams, D. R., & Williams, H. (1969) Automaintenance in the pigeon: Sustained pecking despite contingent non-reinforcement. *Journal of the Experimental Analysis of Behavior,* **12,** 511-520.

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