Effects of discriminative control and of emitting behavior different on self-controlled behavior[1, 2]

Brenda E. Ortega[3]
Raúl Ávila
School of Psychology, National Autonomous University of Mexico

Abstract

The effects of facilitating the emission of behavior different from taking an available reward, as well as the discriminability and spatial location of a stimulus change on self-controlled behavior were assessed. A food dispenser was presented for 4 seconds ($S^R{}_1$) within a repetitive time cycle, and the food dispenser was presented again after the cycle had elapsed ($S^R{}_2$). If the pigeon did not approach $S^R{}_{1;}$ it could then consume $S^R{}_2$. If, however, the pigeon approached $S^R{}_1$, the food dispenser was immediately withdrawn, and the $S^R{}_2$ presentation was cancelled. In Experiment 1, the effects of adding an operandum (e.g., the illumination of a response key) to emit behavior different from approaching the food dispenser on self-controlled behavior were tested; in Experiment 2, a discriminative stimulus for not approaching to $S^R{}_1$ presentation and its spatial location were also manipulated. The number of $S^R{}_1$ interruptions and the number of added-operandum presentations with at least one key peck varied within and between subjects in Experiment 1. To increase the discriminability of the stimulus and its spatial location (Experiment 2) resulted in a low number of $S^R{}_1$ interruptions. The effectiveness of adding an operandum to do anything else except taking $S^R{}_1$ or presenting a discriminative stimulus to facilitate the occurrence of self-controlled behavior (not approaching to the food dispenser) depends on their spatial location and discriminability.

***Key words**:* Self-controlled behavior, added-operandum, spatial location, discriminative stimulus, pigeons.

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[3] Correspondence: Cubículo 205-C, Facultad de Psicología, UNAM. Av. Universidad 3004, Copilco-Universidad, C.P. 04510, Ciudad de México, México. Email; beomPsicol@gmail.com

Resumen

Se evaluaron los efectos de facilitar la emisión de una conducta diferente de tomar una recompensa disponible, así como la discriminabilidad y ubicación espacial del cambio de estímulo sobre la conducta autocontrolada. Se presentó un dispensador de alimento durante 4 segundos dentro de un ciclo de tiempo repetitivo (E^R_1), y se volvió a presentar al finalizar el ciclo (E^R_2). Si la paloma no se acercaba al E^R_1, entonces podía comer de E^R_2. Sin embargo, si la paloma se acercaba al E^R_1, el dispensador de alimento se retiraba inmediatamente, y se cancelaba la presentación del E^R_2. En el Experimento 1, se probaron los efectos de agregar un operando (e.g., la iluminación de una tecla de respuesta) para emitir una conducta diferente a acercarse al dispensador de alimento sobre la conducta autocontrolada; en el Experimento 2, se manipuló la presentación de un estímulo discriminativo para no aproximarse al E^R_1 así como su ubicación espacial. El número de interrupciones al E^R_1 y el número de presentaciones del operando-agregado con al menos un picotazo varió intra y entre sujetos en el Experimento 1. Incrementar la discriminabilidad del estímulo y su ubicación espacial (Experimento 2) resultó en un número bajo de interrupciones al E^R_1. La efectividad de agregar un operando para hacer cualquier otra cosa excepto tomar E^R_1 o presentar un estímulo discriminativo para facilitar la ocurrencia de la conducta autocontrolada (es decir, no aproximarse al dispensador de alimento) dependió de su ubicación espacial y su discriminabilidad.

Palabras clave: Conducta autocontrolada, operando-agregado, ubicación espacial, estímulo discriminativo, palomas.

In behavior analysis, self-controlled behavior has been defined in accordance with the procedures employed to study it. For instance, in the choice procedure different delay lengths between the choice response and the delivery of rewards that differ in magnitude are emphasized; self-controlled behavior is deduced from the number of larger-later rewards obtained (Mazur, 1987; Smethells & Reilly, 2015). On the other hand, in the delay-of-gratification procedure, a subject is required to wait for a preferred or larger reward while a less preferred or smaller one is continuously available during the waiting period. In this case, self-controlled behavior is inferred if the subject emits any behavior incompatible with taking the smaller or less preferred reward which is available, to obtain the larger or more preferred one at the end of the waiting period (Beran & Evans, 2009; Grosch & Neuringer,1981; Mischel, et al., 1972). For instance, Mischel, et al. reported that children were able to wait more for a preferred reward if they could emit any activity, like playing with toys, during the waiting period. In the same vein, Grosch and Neuringer (1981) reported that pigeons exposed to a delay-of-gratification procedure would obtain a preferred or larger reward if they could peck a response key available during the waiting period. From this evidence it can be suggested that to emit behavior different with taking the reward during the waiting period is an aspect that defines self-controlled behavior (cf. Skinner, 1953, chapter 15). Thus, in the delay of gratification procedure self-controlled behavior could be conceptualized as doing anything different with taking a small or less preferred reward to obtain a more preferred or larger reward at the end of the waiting period.

Another procedure, congruent with the previous suggestion, was reported by Cole, Coll and Schoenfeld (1982/1990), which described self-control as a situation in which the subject does anything else except taking an available reward until a pre-established response requirement (i.e., a criterion of time or effort) is reached, even if there is nothing that avoids the subject from taking the reward. The authors followed the suggestion of Schoenfeld and Farmer (1970) of a behavioral stream from which the specified response is selected from a context of behavior (no-responses; *no-r* for brevity). Thus, Cole et al., suggested that, with eating behavior as an example, self-controlled behavior could be facilitated considering a sequence of doing anything else (no-r) in the presence of available food for a period and then taking it (specified response, *R* for brevity) after this period has finished. Therefore, two fundamental aspects of self-controlled behavior are: 1) the free availability of a reward (a "temptation") and 2) a self-imposed restriction for not approaching the reward (R) during a period (a requirement of time or effort) (cf. Coll, 1983). It must be notice that, instead of two rewards as in the choice procedure or the delay of gratification one, in this case only one reward is presented and could be taken or not. For instance, a child is told that he/she has available a tasty candy that could eat only after finishing his/her homework, however, the child is alone in his/her room and could eat the candy before but resists the "temptation". Hence, according to this procedure, self-controlled behavior is defined as to resist the "temptation" of taking an available reward until a waiting criterion is reached.

Cole et al. (1982/1990) implemented a self-control procedure with naive, food-deprived pigeons which had to wait in the presence of an available food dispenser (the "temptation", for brevity $S^R{}_1$) before they could eat from it ($S^R{}_2$). If the subject approached $S^R{}_1$, the food dispenser was withdrawn and $S^R{}_2$ presentation was immediately cancelled; if the subject did not approach $S^R{}_1$ then $S^R{}_2$ was presented, and the subject could approach (R) and consume it. The number of obtained $S^R{}_2$ or its inverse, $S^R{}_1$ interruptions, were the measures of self-controlled behavior, because by not interrupting $S^R{}_1$ or obtaining $S^R{}_2$, means that the pigeon did not take $S^R{}_1$; in other words, and according to Cole et al., the subject "resisted the temptation". Specifically, as more $S^R{}_2$ obtained or less $S^R{}_1$ interruptions more self-controlled behavior was assumed.

In addition to exploring other variables that influence self-controlled behavior, according to the "resistance-to-temptation" procedure, Coll (1983) suggested that facilitating the occurrence of any activity different from approaching the food dispenser (no-r) during $S^R{}_1$ presentations could increase the likelihood of receiving $S^R{}_2$. This activity (no-r) could function as "behavior different from taking the reward" and could be captured by an appropriate operandum added to the procedure, and the subject could be responding to it (no-r) instead of approaching the available reward.

The effects of the occurrence of behavior (no-r) different from the operant (R) specified to deliver a reinforcer, on the acquisition and maintenance of the last one have been shown in the area of differential reinforcement of inter-response times in rats and pigeons (Wilson & Keller, 1953; Zuriff, 1969), the acquisition of responding under delayed reinforcement with rats (Lattal & Glesson, 1990), omission training and automaintenance of key pecking in pigeons (Williams & Williams, 1969), as well as delay-of-gratification procedures in pigeons and humans (Grosch & Neuringer, 1981; Mischel, et al., 1972). In the latter situation, emitting any behavior (no-r) during the waiting period increases the likelihood that the subject will continue waiting for the larger and later reward.

Following the suggestion by Coll (1983), Gonzalez, Avila, Juarez, and Miranda (2011) with three food-deprived pigeons as experimental subjects, in one of their manipulations tested the effects of adding an operandum to the procedure (i.e., an illuminated response key that the pigeon could peck without any programmed contingency; for brevity *added-operandum*). In this way, the responses to the operandum (no-r) could function as "behavior different from taking the reward" during $S^R{}_1$ presentations. Gonzalez et al., reported that the simultaneous presentation of an illuminated response key and S^R_1 resulted in a relatively low number of S^R_1 interruptions. Specifically, a high number of added-operandum presentations with at least one key peck (as a shorthand, R>0) was observed, but only with one subject.

Besides the possible contribution of "behavior different from taking the reward" in the resistance to "temptation" procedure, another potential variable that could modulate the occurrence of self-controlled behavior is setting a discriminative stimulus for not approaching the available reward until a waiting criterion is reached. In this vein, Colotla, McArthur and Casanueva (1976) exposed two turtledoves to a self-controlled procedure like that reported by Cole et al. to determine if self-controlled behavior could be established under the control of a discriminative stimulus (i.e., signaling when to approach or not to the food dispenser). Briefly, they illuminated a response key in white or red immediately before the food dispenser was presented. If the response key was illuminated in white light, the turtledove could eat without restrictions. If the response key was illuminated in red light, the turtledove could not eat from the food dispenser. The approaches to the food dispenser preceded by the key illuminated in red resulted in its withdrawal. Thus, the authors demonstrated that the subjects could be trained to discriminate when to approach or not the food-dispenser presentations preceded by a stimulus change. Although the previous results showed that self-controlled behavior could be established under the control of a discriminative stimulus, these findings were observed with only one subject.

A similar procedure to that employed by Colotla et al., was used by Fantino (1966) who exposed food-deprived pigeons to a choice procedure to test if signaling a "penalty period" (i.e., a blackout) after responding for the smaller-sooner reward would increase self-controlled behavior (the choices of a larger and later reward). At the start of the experimental session, one response key was illuminated in red for a period. A single peck to the red key resulted in the delivery of a smaller-sooner reward followed by an extinction period during which the red key remained inoperative. However, if the pigeon did not peck the key until its color changed to green, it obtained a larger-later reward, and the extinction period was cancelled. Fantino reported that although the pigeons did not show self-controlled behavior in most of the sessions, self-controlled behavior increased slightly as the penalty period increased.

In summary, it has been suggested that self-controlled behavior can be controlled when emitting behavior different from taking an available reward is allowed or by signaling when the subject can approach or not the reward and consume it. These variables have been tested mainly with the "resistance-to-temptation" procedure; however, the control of both variables over self-controlled behavior has been barely explored. In addition, the effects of the previous variables have not been conclusive; that is, they have been observed consistently in few subjects. A possible explanation could be that these effects can be mixed with the effects of other variables. For example, whereas Gonzalez et al. (2011) used the illumination of the right response key as "behavior different from taking the reward", Cole et al. (1982/1990) used the illumination of the center key. It has been shown that the spatial distribution of the operandum can modulate the acquisition and maintenance of operant and respondent behavior (e.g., Hemmes, et al., 1979). Thus, to use the center versus the right key could explain the different findings between the studies by Cole et al. and by Gonzalez et al. In the same way, in the study by Gonzalez et al., the houselight was on from the beginning to the end of the experimental session, whereas Coll (1983) employed the houselight as a stimulus to signal that S^R_2 was available and could be consumed. According to the findings of Colotla et al., (1976) and Fantino (1966), self-controlled behavior can be submitted to the control of a discriminative stimulus; for example, signaling when the subject can approach or not to the food-dispenser (e.g., with an illuminated key or houselight); however, this effect was not considered by Coll and by Gonzalez et al.

The present study evaluated the effects of the spatial location of an added operandum (i.e., illumination of a response key without any programmed contingency) and the control of a discriminative stimulus on self-controlled behavior. The last one was conceptualized as doing anything else except taking an available reward until a pre-established response requirement (i.e., a criterion of time or effort) is reached.

In Experiment 1 a systematic replication of the condition reported by Gonzalez et al. (2011), of presenting or not a stimulus concurrently with $S^R{}_1$ was conducted with pigeons exposed in successive conditions to the added-operandum during $S^R{}_1$ presentations (no-r). In Experiment 2, the effects of signaling $S^R{}_1$ with a diffuse stimulus (i.e., houselight) or with a localized stimulus change (i.e., illumination of a response key) on $S^R{}_1$ interruptions were evaluated. In this second experiment the effect of the spatial location of the added-operandum was further evaluated.

Experiment 1

Method

Subjects

Three naive pigeons, four years old at the beginning of the experiment, served as subjects. All subjects were food-deprived and maintained at 85% of their free-feeding body weight by giving them supplementary food at the end of each experimental session. All pigeons were housed in individual cages with free access to water.

Apparatus

Three experimental chambers were used (Med Assoc. Mod. ENV-007), each equipped with a grid floor (Med Assoc. Mod. ENV-005P). Located in the center of the front wall and 3 cm above the grid floor was a 6×6 cm opening through which the subjects had access to the receptacle of a food dispenser (Med Assoc. Mod. ENV-205 M) that delivered a mixture of grains as the reward (wheat, millet, corn, green beans, and lentils); a white ultra-shining LED illuminated the food receptacle. A photoreceptor beam inside the walls of the receptacle registered each pigeon´s head entrance.

Three response keys (Med Assoc. Mod. ENV-123-AM), each of which could be transilluminated with red or green light, were located 15 cm above and at the center, right, and left from the food receptacle in the front wall. The response keys were separated from each other by 6 cm and required a minimum force of 0.15 N to register a key peck. A houselight was located on the rear wall of the chamber, 20 cm above the grid floor. Each experimental chamber was located inside a sound-isolated box (Med Assoc. Mod. ENV-018 MD) with a fan and a buzzer that provided white noise. The chambers were situated in a room separate from the main lab as an extra precaution against external noises. The chambers were connected to a personal computer (DELL® Mod. Dimension 9200) through a Med Assoc. interface. Med-PC IV presented the experimental events and registered the corresponding response key pecks and interruptions of the photoreceptor beam.

Procedure

Preliminary training

In two, one-hour sessions of 60 trials each, the pigeons were trained to eat from the food receptacle as follows: The houselight was turned on at the beginning of the session and remained on throughout the session, and the food dispenser was presented for 12 s every minute. After the pigeon approached and consumed food on four consecutive presentations, the duration of the food dispenser was decreased in 1-s steps until a 4-s duration was reached, and it was kept constant for the duration of the experiment. Thereafter, the pigeons were trained to peck the center key using an autoshaping procedure (Brown & Jenkins, 1968; Procedure 8). Specifically, a repetitive time cycle (T-cycle) was programmed according to which the center response key was illuminated red and then green, followed by 4-s food delivery. In the first 10 sessions of exposure to the autoshaping procedure, the response key was illuminated for 8 s; in the next 10 sessions the key was illuminated for 4 s. Each session consisted of 50 trials. In the following experiments, to peck the key illuminated in green light (added operandum) was the measure of *no-r* or "does anything else except taking the reward", as conceptualized by Schoenfeld and Farmer (1970).

Self-control Conditions

The pigeons were exposed to 50 T cycles of 64 s each, and the food dispenser was presented during the last 4 s of each cycle (S^R_1) and it could be presented for other 4 s (S^R_2) once the T cycle had elapsed, according to the following contingency: If during S^R_1 presentation the pigeon interrupted the photoreceptor beam of the food receptacle, it was immediately withdrawn and the S^R_2 presentation was cancelled. If the pigeon did not interrupt the photoreceptor beam, the food receptacle was withdrawn at the end of the T cycle and it was presented again (S^R_2) and remained available for 10 s or until the pigeon started eating; once the pigeon introduced its head into the food receptacle, the food dispenser remained accessible for 4 s, after which it was withdrawn. Figure 1 shows the procedure of the study.

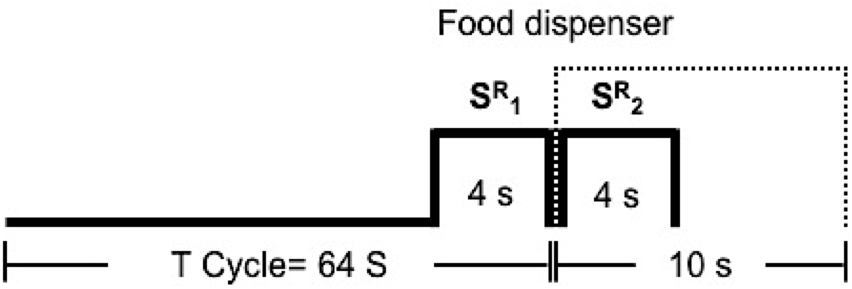

Figure 1. Scheme of the self-controlled procedure. Briefly, according to a constant T cycle a food dispenser is presented during some seconds, and it could be presented after the cycle ended according to the contingencies of the experiment (see the procedure section). Notice that in this procedure S^R_1 and S^R_2 consist of two operations of the food dispenser; thus, the same reward is used.

Each session started with the houselight on, and the center key illuminated in red light. In the first condition, a color change of the center key (the term added operandum will be used hereinafter only as a shorthand to describe the change of stimuli during S^R_1 presentation) from red to green was presented during S^R_1 (added-operandum condition → CK). In a second condition, S^R_1 was presented without any added operandum; the center key remained illuminated in red throughout the whole T cycle (No-added-operandum condition → No K). During $S^R{}_1$ and $S^R{}_2$ presentations, the food receptacle light was illuminated in white light. When $S^R{}_2$ presentations were cancelled because the pigeon sticked its head inside the receptacle during $S^R{}_1$ presentation, a 2-s blackout took place. An ABAB design was used in which A was the added-operandum condition (CK) and B was the no added-operandum condition (No K) (i.e., CK - No K - CK - No K). The subjects were exposed to this procedure for a different number of sessions, based on visual inspection of the data (i.e., if a clear increasing or decreasing tendency of the data was not observed, then they were considered stable, like in the study by Gonzalez, et al., (2011)). Thus, Subject S1 was exposed for 40 sessions to each of the first three conditions, and 15 sessions to the last one. Subjects S2 and S3 were exposed for 40, 60, 40 and 30 sessions to the four conditions of the experiment, respectively.

Results

Two dependent variables were registered: the number of $S^R{}_1$ interruptions and the first key peck in each added operandum presentation (R>0, for brevity; this dependent variable was taken as an index of doing something else instead of interrupting $S^R{}_1$). It must be clarified that although key pecks were also registered when the key was illuminated in red, there was hardly any peck during this period. Therefore, this data was omitted in this section. Figure 2 shows the number of $S^R{}_1$ interruptions and the number of R>0 per session in each experimental condition for each pigeon.

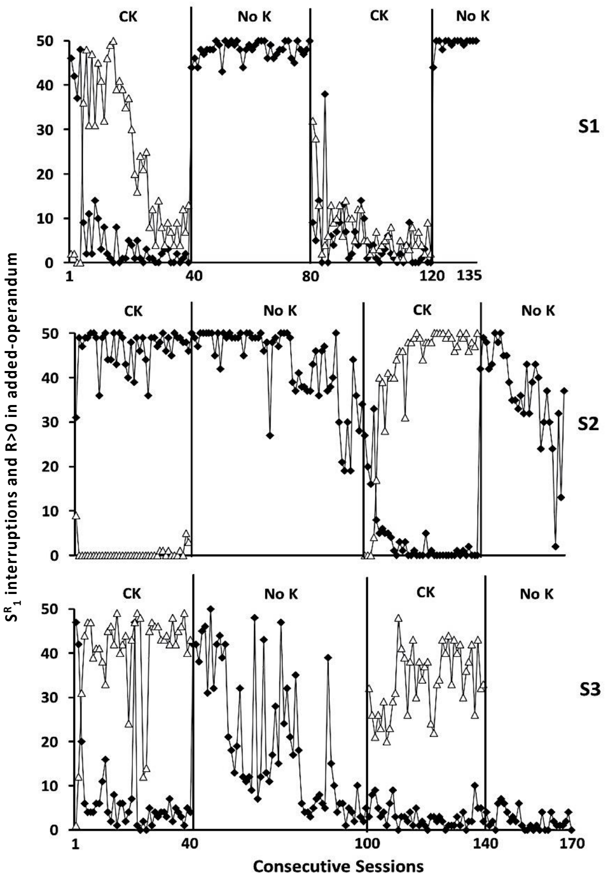

Figure 2. $S^R{}_1$ interruptions (black diamonds) and trials with at least one key peck to the added operandum (R>0) (white triangles) for each subject (panels) in the conditions where the illumination of the key changed from red to green (Added-operandum condition → CK) or remained in red (No added-operandum condition → No K).

In the first added-operandum condition (CK), pigeons S1 and S3 did not interrupt S^R_1 presentations. In the No-added-operandum condition (No K), all three pigeons showed high or very variable numbers of interruptions. When the CK condition was reinstituted, there were few S^R_1 interruptions in all three of the pigeons. In the final No K condition, the number of S^R_1 interruptions was near 100% for S1, highly variable for S2, and low for S3. Although the effect of presenting the added operandum was not homogeneous within and between subjects, the number of S^R_1 interruptions was comparatively low in five of the six conditions in which the added operandum was present and comparatively high in five of the six conditions in which it was absent. Regarding R>0 (the added operandum on which a response to it was emitted), often co-varied with S^R_1 interruptions: R>0 was high when S^R_1 interruptions were low, and low when interruptions were high, in four of the six conditions when added operandum was available (e.g., S2 and S3).

Discussion

In this experiment, a clear effect of the added operandum presentation on the number of S^R_1 interruptions was observed only in one subject (S1), as was the case in the study by Gonzalez et al. (2011). For S1, the number of S^R_1 interruptions was high when the added operandum was absent and low when it was present. For S2, there seemed to be a time-of-exposure effect: In the first CK condition, number of S^R_1 interruptions was high, and remained high in the first No K condition but decreased to near zero in the second CK condition, and then increased in the final No K condition. It should be noted that for this subject in the first CK condition there were almost no pecks to the added operandum, which might also explain that the subject interrupted almost all S^R_1 presentations in this condition. Regarding the R>0 measure, there was evidence for co-variation with S^R_1 interruptions (e.g., S2 and S3).

As mentioned in the introduction, Gonzalez et al. (2011) used the right key of their experimental chambers as the added operandum, and Cole et al. used the center key. In the present study the center key was also used, and the results were more congruent with those reported by Cole et al than with those from Gonzalez et al study. Thus, to use the center or the right key could explain the differences in results between this study and Cole´s et al, with those by Gonzalez et al. Therefore, one conclusion of this study is that the spatial location of the added operandum could have had an effect on self-controlled behavior. However, in both, the Gonzalez et al and the present study this discriminative function could have been mixed with other variables, such as the houselight, as in the study by Coll (1983) (diffuse stimulus). Varying the spatial location of the added operandum and its discriminability without confounding their effects with those of a houselight were addressed in Experiment 2.

Experiment 2

Experiment 2 evaluated the effects of signaling S^R_1 with a diffuse stimulus change (i.e., houselight) or with a localized stimulus change (i.e., illumination of a response key or "added operandum") on the behavior of not taking an available reward. The viability of such a manipulation is suggested by the comparison between the procedures and results reported by Gonzalez et al. (2011) and Coll (1983) and by the evidence that self-controlled behavior (not taking an available reward) could be subjected to discriminative control (i.e., Colotla, et al., 1976; Fantino, 1966). In the first phase of the present experiment, the houselight (e.g., Coll, 1983) or the illuminated response key (e.g., Gonzalez, et al., 2011) were presented concurrently with S^R_1; there were no other stimuli present in the experimental chamber. In the second phase, the effects of varying the spatial location of the added operandum were explored only with the illuminated response key signaling S^R_1.

Method

Subjects

Seven four-year-old pigeons with prior experience in different self-control procedures served as subjects. All subjects were food-deprived and maintained at 85 % of their free-feeding body weight by supplemental feeding at the end of each experimental session. All pigeons were housed in individual cages with free access to water.

Apparatus

The same apparatus from Experiment 1 were used for this experiment.

Procedure

The self-controlled procedure used in Experiment 1 was modified. During both S^R_1 and S^R_2 food-dispenser presentations, the food receptacle was illuminated with white light but, unlike Experiment 1, the chamber remained dark throughout most of the experimental session. In the first phase of the experiment, the houselight and the key lights were turned on only in the following conditions: For three pigeons (S4, S5, and S6), S^R_1 was signaled by the illumination of the houselight (HL Condition) or with the illumination of the center, white key (Added-operandum Condition' → CK') in the following sequence: HL – CK' - HL – CK'. For the other four pigeons (S7, S8, S9, and S10), S^R_1 was signaled by the illumination of the center, white key (Added-operandum condition' → CK') or it was not signaled (No- added-operandum condition' → No K') in the following sequence: CK' -No K'– CK' -No K'. Subjects S4, S5, and S6 were exposed for 30 sessions to the first two conditions and for 15 sessions to the last two. Subjects S7, S8, S9, and S10 were exposed for 30 sessions to each of their corresponding conditions. These different number of sessions of exposure to the conditions were decided, as previously mentioned, by visual inspection of the tendency of the data; if they were deemed stable, the condition was changed.

In the second phase of the experiment, the spatial location of the added operandum was tested; that is, S^R_1 was signaled by the illumination of the center (CK" condition), left (LK condition), or right (RK condition) keys with green. Subjects S4, S5, and S6 were exposed to the following order: LK - CK"- RK - CK", whereas subjects S7 and S8 were exposed to the conditions: RK - CK"- LK - CK". (Pigeons S9 and S10 were not studied in the second phase because R>0 was relatively low, and a high level of this dependent variable was a necessary baseline for the second phase of this experiment). In this phase, all subjects were exposed to the Left and Right Conditions for 30 sessions each, and for 15 sessions to the Center Conditions.

Results

As in Experiment 1, the main dependent variables were the number of S^R_1 interruptions and the first key peck in each added operandum presentation (R>0, for brevity). Figure 3 shows the results for pigeons S4, S5, and S6, and Figure 4 shows the results for pigeons S7, S8, S9, and S10, in each session of the first phase.

As Figure 3 shows, for Subjects S4, S5, and S6, for whom S^{R}_{1} presentations were signaled by turning on the houselight (HL condition) or by illuminating the center key (Added-operandum Condition' → CK'), the general finding was that the number of S^{R}_{1} interruptions was higher when the houselight was used as the signaling stimulus and lower when illumination of the key light was the signaling stimulus. For almost all the sessions in the CK' conditions, the number of R>0 was higher than the number of S^{R}_{1} interruptions.

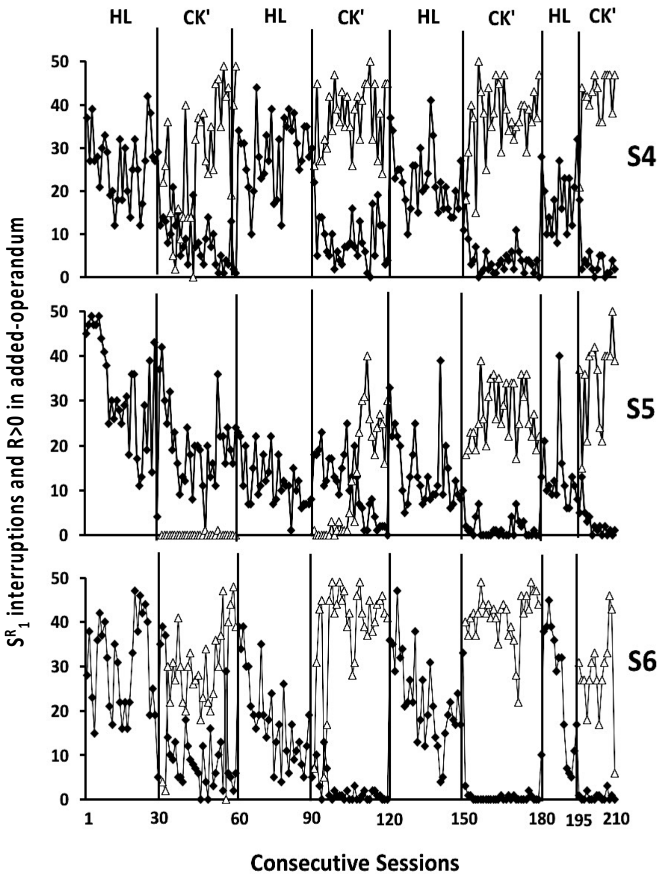

Figure 3. S^{R}_{1} interruptions (black diamonds) and trials with at least one key peck to the added operandum (R>0) (white triangles) for each subject (panels) in the conditions where only the houselight (HL condition) or the center key (Added-operandum condition → CK') was illuminated with white light during S^{R}_{1}.

As may be seen in Figure 4, for Subjects S8, S9, and S10 in the first CK' condition, the number of S^{R}_{1} interruptions was reasonably low and R>0 trials was relatively high; for S7, the opposite result was observed: S^{R}_{1} interruptions were high and R>0 trials were low. For all four of the subjects in the first condition No K', the number of S^{R}_{1} interruptions was high: it was near 100% for Subjects S7 and S8 and higher than in the previous condition for Subjects S9 and S10. In the next four conditions (CK' – No K' – CK' – No K'), similar response patterns were observed; that is, lower numbers of S^{R}_{1} interruptions when the added operandum (CK' condition) was present and higher number of S^{R}_{1} interruptions when the added operandum was absent (No K' condition).

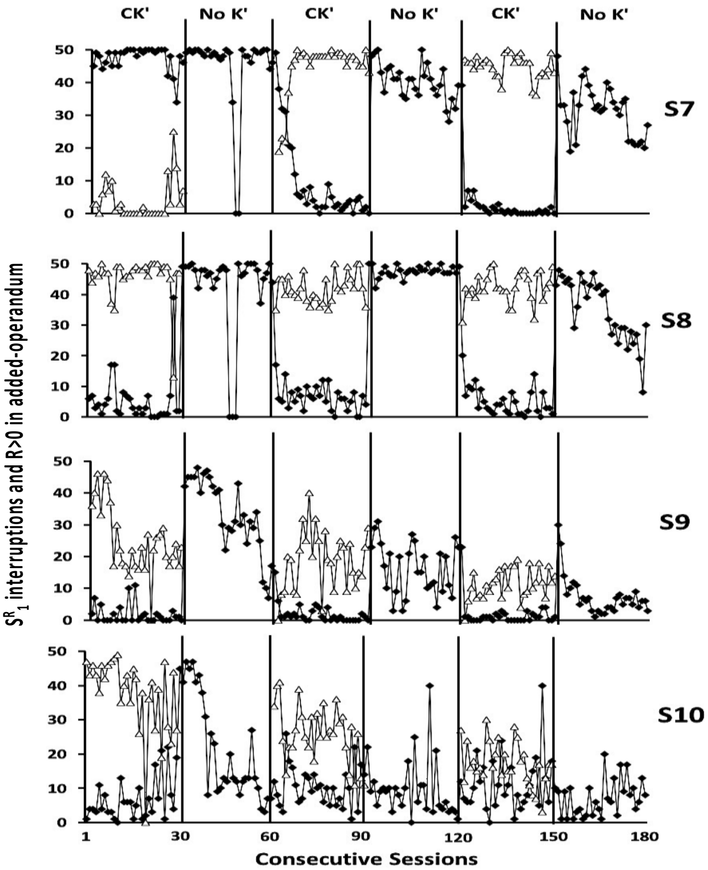

Figure 4. S$^{R}_{1}$ interruptions (black diamonds) and trials with at least one key peck to the added operandum (R>0) (white triangles) for each subject (panels) in the conditions where only the center key was illuminated or not (Added-operandum condition →CK' or No added-operandum condition → No K' condition, respectively) with white light during S$^{R}_{1}$.

In the second phase of the experiment, the location of the added operandum was varied from the center to the left and right positions of the front panel of the chamber. As shown in the left panels of Figure 5, for Subjects S4, S5, and S6, the number of S$^{R}_{1}$ interruptions was high for two of the pigeons when the left key (LK condition) was illuminated and decreased and/or remained at a low level in all the following conditions (i.e., CK", RK and CK" conditions, respectively). For Subjects S7 and S8 (right panels of Figure 5), the number of S$^{R}_{1}$ interruptions was low to moderate when the right or center keys were illuminated and near maximum when the left key was illuminated. For all subjects, R>0 trials were higher only when the center key was illuminated; when the left or right keys were illuminated, they were virtually zero.

Discussion

In the first phase of Experiment 2, the added operandum during S$^{R}_{1}$ presentations had clear effects, with all subjects and most of the conditions, on the number of S$^{R}_{1}$ interruptions and on the number of added-operandum presentations with at least one key peck. In previous studies using the "resistance-to-temptation" procedure, the right key was illuminated during the T cycle and the houselight was on throughout the experimental session (e.g., Gonzalez, et al., (2011). Therefore, the stimulus change occurs in the context of other incidental stimuli. When the stimulus change clearly signals the S$^{R}_{1}$

presentation the subject did not take the reward, as the findings of this second experiment confirmed. When a diffuse, non-localizable stimulus (i.e., houselight) was used as the stimulus change, self-controlled behavior was less evident, as was also the case in Experiment 1 in which the illumination of the key (Added operandum condition→ CK) occurred within the context of the chamber being illuminated throughout the session, possibly making the key illumination less discriminable. According to these findings it is suggested that the discriminability and localizability of the stimulus change is a critical feature in the effectiveness of the self-controlled procedure (see also Wasserman, 1973).

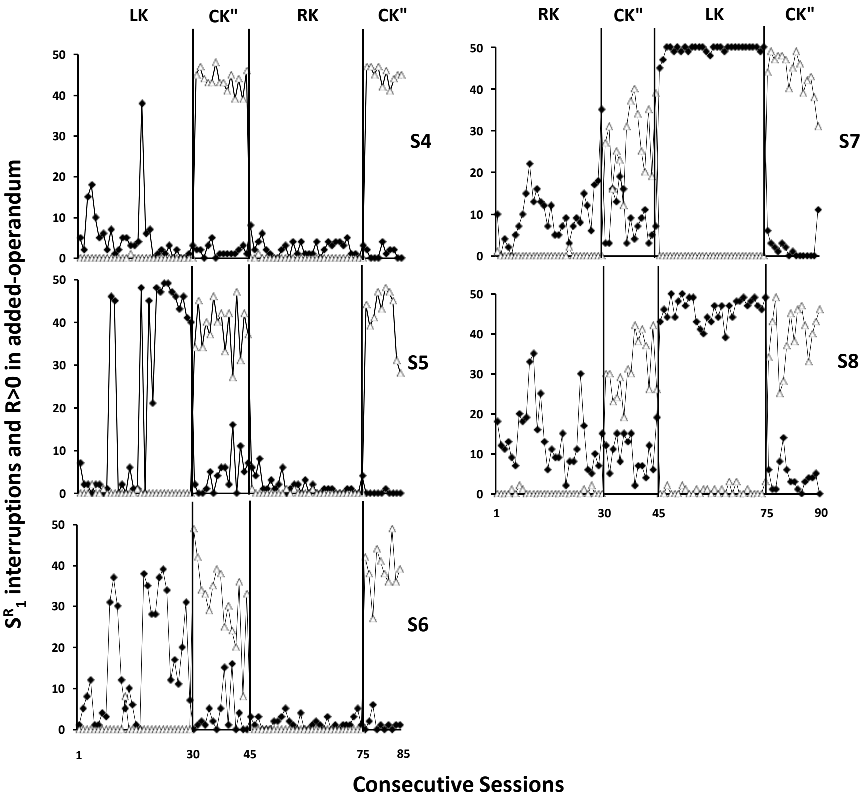

Figure 5. S^R_1 interruptions (black diamonds) and trials with at least one key peck to the added operandum (R>0) (white triangles) for each subject (panels) in the conditions where the ubication of the added operandum was the center (CK" condition), left (LK condition), or right (RK condition) key illuminated with green light during S^R_1.

In the second phase of this experiment, we evaluated the effects of varying the spatial location of the added operandum on the number of S^R_1 interruptions and the number of added-operandum presentations with at least one peck (R > 0). Illumination of the center key, located above the food receptacle, was the spatial location that controlled self-controlled behavior the most. This finding suggests a kind of induction effect from the feeder light to the illuminated center key, an effect commonly reported in autoshaping procedures with pigeons (e.g., Hearst & Jenkins, 1974).

Another finding shown in Figure 5 was a possible sequence-of-conditions effect on the number of S^R_1 interruptions when the left key was illuminated (LK Condition). That is, for the three subjects that were exposed to the left key as the first condition, the dependent variable (number of S^R_1 interruptions) was relatively low and fluctuating; in contrast, for the two subjects that were exposed to the same condition after the RK and CK" conditions, the number of $S^R{}_1$ interruptions was notably higher and stable.

General Discussion

The first purpose of the current experiments was to replicate the findings of Gonzalez et al. (2011) who tested the effects of presenting an added operandum during $S^R{}_1$ presentations on pigeons' self-controlled behavior (i.e., any activity different from taking the reward). The authors reported that the number of $S^R{}_1$ interruptions (which would immediately withdraw the food and cancel the later food presentation) was lower when pecking at the added operandum was higher. The first experiment of the present study replicated Gonzalez et al.'s findings: the number of $S^R{}_1$ interruptions and the number of responses to the added operandum tended to co-vary for two of the three subjects –the greater the one, the lower the other. The subject that interrupted almost every $S^R{}_1$ presentation had virtually no responses on the added operandum. This finding suggests that engaging in another behavior (*no-r*) can facilitate not taking an available reward, which has been considered an index of self-controlled behavior (Cole, et al., 1982/1990). Notwithstanding this finding, it is to be noted that pecking the added operandum was not necessary for not approaching to eat from the food receptacle. Notably, Subject S1 successfully refrained yet came to make few responses to the added operandum. This last finding was also seen in Subject S9 and clearly in Subjects S4, S5, and S6 of the second phase of Experiment 2. The added operandum seemed to work as a delta stimulus for taking the food regardless of its function as a discriminative stimulus for key pecking or to "*do anything else except taking the reward*". This function of the stimulus was enhanced by the discriminability (diffuse vs localized) and the spatial location (the closer to the available reward) of the added operandum (see Figure 5).

The second phase of Experiment 2 evaluated whether the spatial location of the added operandum would have a moderating effect on self-controlled behavior. Spatial variables have been shown to affect operant (e.g., Hemmes, et al., 1979) and respondent (e.g., Testa, 1975) behavior. The further the operandum from the place where the reinforcer is presented, the greater the decrement in the frequency of occurrence of the operant or respondent response. In the present experiment, there was evidence of a similar effect on the number of key pecks on the added operandum. Thus, besides this contribution to the resistance to "temptation" procedure, explicit manipulation of the spatial location between an added operandum and the place in the experimental chamber where the reinforcer is presented remains to be conducted in the choice and delay of gratification procedures as well.

It is recognized that the findings of this second phase also could be interpreted under the argument that to signal $S^R{}_1$ presentations results in autoshaped key pecking, and the lack of $S^R{}_1$ interruptions could not be interpreted as self-controlled behavior. This argument is based on the temporal contiguities between pecking the added operandum with $S^R{}_1$ deliveries. However, in the present study it was found that to present the added operandum in the left or right keys resulted in few key pecks, while the center key resulted in a high number of pecks. Furthermore, to present the added operandum in the right key resulted in very few key pecks and $S^R{}_1$ interruptions. This last finding suggests that the added operandum was controlling the behavior of not taking the available reward regardless of key pecking occurrence; a contradictory finding with the autoshaping argument.

The effects of providing another activity to "do anything else except taking the reward" in self-control procedures, such as the delay-of-gratification procedure, have been documented in pigeons

(Grosch & Neuringer, 1981) and humans (e.g., Mischel, et al., 1972). In this context, the general results of varying the spatial location of the added operandum in the present resistance to "temptation" procedure, extend those results by manipulating not only the presence or absence of another activity but also its discriminability and its location regarding the available reward in the same procedure.

A clear and important contribution of the current study to the analysis of the variables that influence the occurrence of self-controlled behavior is that increasing the discriminability of the stimulus change that signaled $S^R{}_1$ presentations enhanced the behavior of not taking the food reward. Presenting a diffuse signal (the houselight) together with $S^R{}_1$ was less effective in facilitating self-controlled behavior than presenting a localized, salient signal, illumination of a response key during $S^R{}_1$ presentations (added operandum). This finding is consistent with that reported by Colotla et al., (1976) and Fantino (1966), who demonstrated that self-controlled behavior (food-eating) could come under stimulus control.

In the present study, the number of $S^R{}_1$ interruptions served as the index of self-controlled behavior (Cole et al., 1982/1990; Gonzalez et al., 2011). If few $S^R{}_1$ presentations were interrupted, then the subject was considered as not taking the presented reward and doing something else, this behavior in turn was reinforced by $S^R{}_2$ presentations. Not emitting an experimenter-specified response (R) but to emit any other behavior different from taking the available reward (*no-r*) is a viable conceptualization of self-controlled behavior (cf. Schoenfeld & Farmer, 1970). For example, in the five-choice-serial-reaction-time procedure, a rat is trained to withhold from responding to any of five different holes, until a stimulus is presented randomly in one of the holes; it must "inhibit" a nose-poke response until the stimulus is presented and thus it obtains a food reinforcer (Bari, et al., 2008). In the delay-of-gratification procedure, it has been convincingly demonstrated that adding another activity "do anything else except taking a reward", such as key pecking in pigeons, facilitates not taking a small and available reward (Grosch & Neuringer, 1981). In the present experiments, then, fewer numbers of $S^R{}_1$ interruptions could be considered as an index of self-controlled behavior.

The contribution of emitting any behavior (*no-r*) on the acquisition and maintenance of operant behavior (R) under conditions in which behavior is distributed in time, or is withheld, to obtain a reinforcer, has been well documented in behavior analysis (Zuriff, 1969). The findings of the present experiments demonstrated the ubiquitous character of this no-r behavior to self-control procedures where the subject is required not to approach a reward to obtain it in another moment.

It is to be noted that the experimental history of the pigeons might be a contributing factor to the present results. For example, the prior exposure to the first phase in Experiment 2 might have contributed to the performance in the second phase. In addition, the prior experimental history with different self-control and choice procedures for pigeons in Experiment 2 may have played a role in the findings. All three of the subjects in Experiment 1, however, were naive.

In future research, the interaction between adding an operandum adequate to capture *no-r* (i.e., "do anything else except taking a reward") to the procedure and varying its spatial location could be extended from this self-controlled procedure --also named "resistance-to-*temptation*" procedure- to the choice or delay-of-gratification procedures, which are commonly used to study self-controlled behavior in both animals and humans (Logue, 1988).

In conclusion, the common procedures to study self-controlled behavior, the choice and the delay of gratification ones, have emphasized the functional contiguities (or the dependent variable). By contrast, the resistance to "temptation" procedure, emphasized the quantitative contiguities (or the independent variable) of self-controlled behavior (cf. Sidman, 1960). Although the emphasis in the dependent variable has generated a lot of valuable data, this exclusive emphasis could also slow down the "research momentum" on self-controlled behavior. From the point of view of these authors, self-control research could gain *momentum* if the emphasis is balance from the dependent variable to the independent variables responsible of self-controlled behavior. This last point is the main conceptual contribution of the present study to the literature on self-controlled behavior.

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