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EFFECTS OF COMPONENT LENGTH AND OF THE TRANSITIONS AMONG COMPONENTS IN MULTIPLE SCHEDULES[1]

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Pigeons received equal variable-interval reinforcement during presentations of two line-orientation stimuli while five other orientations appeared in extinction. Component duration was 30 seconds for all orientations and the sequence was arranged so that each orientation preceded itself and each other orientation equally often. The duration of one component (0°) was shortened to 10 seconds and the other (90°) was lengthened to 50 seconds. All animals showed large increases in response rate in the shortened component and this increase was recoverable after an interpolated condition in which all components were again 30 seconds in duration. This effect was replicated in a second experiment in which component duration was changed from 150 seconds to 50 seconds and 250 seconds. An examination of local contrast effects during the first experiment showed that the shortened component produced local contrast during subsequent presentations of the lengthened component, just as would a component associated with more frequent reinforcement. When the presentation sequence was changed so that the lengthened component was always followed by the shortened component, response rates generally increased during the lengthened component. When the sequence was arranged so that the shortened component always preceded the longer component, response rate decreased in the former. These effects, as well as the increases in response rate following change in component length, seem not to be the product of local contrast effects among components.

Key words: component length, transitions, local contrast, key peck, pigeons

There are many ways of altering response rates during multiple schedule performance. The most obvious and by far the most frequently used is to vary the reinforcement schedule in force. Either the type of schedule used or the frequency of reinforcement provided may affect overall levels of responding. Similarly, the subject's level of deprivation may be altered, changing the effectiveness of the reinforcer being used and thus changing overall response rate.

Aside from these direct methods of influencing response rates there are others that do not involve any changes in deprivation level or in reinforcement contingencies. For example, behavioral contrast (*e.g.,* Reynolds, 1961) appears as large increases in response rate during one component produced by some change in conditions in a second component, such as a decrease in frequency of reinforcement.

A second and probably related effect, local contrast, was first described as *transient* contrast by Nevin and Shettleworth (1966). These authors showed that the magnitude and pattern of responding during one component of a multiple schedule depended on the immediately preceding component. When the frequency of reinforcement during the preceding component was lower, responding in the subsequent component was initially elevated and decreased during the component (positive local contrast). When the preceding component provided more frequent reinforcement, responding during the subsequent component was initially low, and increased during the component (negative local contrast). Thus, the most direct method of producing local contrast is to arrange a sequence of components providing different frequencies of reinforcement. If the number of components is large enough and/or the stimuli associated with them are

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sufficiently similar, both positive and negative local contrast may persist indefinitely (Malone, 1976).

In some cases, indirect methods of altering response rate may have the same effect as changing reinforcement frequency. For example, Malone and Staddon (1973) produced stable differences in responding during eight line-orientation stimuli arranged to form a maintained generalization gradient (*cf.* Pierrel, 1958). Response rates were high in a VI component accompanied by a vertical line orientation and were progressively lower during extinction components associated with orientations less and less similar to vertical. The interesting aspect of these data was that local contrast effects appeared among presentations of the extinction components.

Malone and Staddon found that their local contrast effects depended on the *average* rate of response associated with each of the extinction components comprising the maintained generalization gradient. If the average response rate in one component was higher than that in a subsequent component, then negative local contrast appeared during the latter. If the preceding component was associated with a lower average response rate than that obtaining in a subsequent component, then positive local contrast appeared during the latter component. Thus, a single transition between a (*e.g.,*) higher- and a lower-response rate component produced negative local contrast in the second component, even when response rate *on that particular occasion* was zero in the "high response rate" component. Therefore, these components, all presented in extinction, produced the same local contrast effects as components associated with differing frequencies of reinforcement.

Another way to alter response rates is to manipulate the duration of components. Earlier work has shown that component length may influence response rates when the frequencies of reinforcement in two components differ (*e.g.,* Shimp and Wheatley, 1971; Todorov, 1972). Wilton and Clements (1971) and Kodera and Rilling (1976) showed that response rate in one component of a multiple schedule was greater when an accompanying extinction component was made longer. However, when identical reinforcement schedules are in effect in two components there would seem no reason to suppose that variations in component length should affect response rates. Preliminary data from our laboratory indicated that large differences in average response rate occur when components of different length alternate in a multiple schedule, even though the reinforcement schedules in force in each component are identical.

The experiments below examined the effects of differences in component length and of the direction of the transition among components on average response rates. Of additional interest were the effects of the component-to-come on responding in the preceding component.

EXPERIMENT I

Local contrast clearly appears to be an aftereffect; Malone and Staddon found no evidence for changes in responding attributable to the following component. However, their method made it extremely unlikely that such effects could appear; the sequences they used were arranged in such a way that it was difficult, if not impossible, to predict what component would follow a given component. There is some evidence suggesting that when the coming component is predictable it may exert an influence on responding in the preceding component (*e.g.,* Pliskoff, 1961, 1963; Williams, 1976; Wilton and Gay, 1969). Such effects could very easily occur in two-component multiple schedules, where the components simply alternate and the sequence is therefore predictable. Whether such effects, if present, would be noticed requires that a change be made in the presentation sequence and that controls be made for aftereffects, such as local contrast that could be occurring at the same time.

The procedure in the present experiment involved presentation of seven line-orientation stimuli with reinforcement provided in only the two extreme orientations [90° (vertical) and 0°]. A decrease in the duration of the 0° component and an increase in the duration of the 90° component led to large, stable, and recoverable increases in response rate in the presence of the 0° stimulus. When the direction of the transition between the two components was varied (*i.e.,* 90° to 0° *versus* 0° to 90°) increases and decreases in response rate occurred in the first component of each pair. These changes were independent of effects attributable to component length alone. In addition, positive and negative local contrast effects observed among components suggested that component length alone may produce effects similar to those produced by differences in frequency of reinforcement.

METHOD

Subjects

Five White Carneaux pigeons were reduced to 80% of their free-feeding weights and remained at that weight throughout the experiment. All birds were experienced in pecking wall-and-floor-mounted keys illuminated with white light on various fixed-ratio (FR) and differential-reinforcement-of-other-behavior (DRO) schedules; none was experienced with multiple schedules.

Apparatus

The experimental chamber was a 33- by 33- by 40-cm steel and Plexiglas box wholly enclosed in a larger sound-proofed box. A Grason-Stadler stimulus projector mounted behind the transparent response key provided line-orientation stimuli; the key was centered over the 3-cm by 2.4-cm magazine aperture; the 6-W houselight and the stimulus on the key were extinguished during reinforcement (3-sec access to mixed grain). The soundproofed box and a large ventilation fan masked extraneous noises. All programming and recording equipment was located in an adjoining room.

Procedure

Seven line-orientation stimuli [0° (horizontal), 15°, 30°, 45°, 60°, 75°, 90°, (vertical)] appeared during successive 30-sec presentations. Responses in 0° and in 90° were reinforced according to a variable-interval (VI) 30-sec schedule; all other orientations appeared without food reinforcement. Each session consisted of 106 components arranged in eight blocks of either 13 or 14 components each. Components were randomized, with the restriction that each stimulus preceded and followed each other stimulus (and itself) equally often. To facilitate control by stimuli on the key, no-stimulus periods were inserted at the end of each block. During these periods, no stimulus appeared on the key and food reinforcement was never delivered. Each key peck reset a 3-sec timer, which controlled the length of the period; thus, steady responding prolonged the period indefinitely. This contingency was in effect only during no-stimulus periods.

During the experiment, the only changes made were in the length of the 90° and the 0° components and in the order of the presentation sequence. Conditions were changed when the performance of most birds seemed stable. The order of conditions was:

(1) *Baseline.* (32 sessions). All stimulus presentations were 30 sec long and each component preceded itself and each other component equally often (twice). The 90° and 0° components appeared with VI 30-sec reinforcement; other components appeared in extinction. Seven "no-stimulus" periods were inserted after blocks of either 13 or 14 stimuli.

(2) *Length change only.* (15 sessions). Presentations of 0° were shortened to 10 sec and presentations of 90° were lengthened to 50 sec. VI 30-sec reinforcement remained in force during both 90° and 0°, and all other components still appeared for 30 sec. Since the decrease in the presentation length of 0° equalled the increase in presentation length of 90° (*i.e.,* 20 sec), the total session time in which VI 30-sec was in effect was unchanged from the baseline condition. The sequence of components remained unchanged.

(3) *Baseline.* (30 sessions). As in (1) above.

(4) *Length change only.* (10 sessions). As in (2) above; presentations of 90° were lengthened to 50 sec and presentations of 0° were shortened to 10 sec.

(5) *Long-to-short transition.* (14 sessions). During this condition, 50-sec presentations of 90° were always followed by 10-sec presentations of 0°. The sequence remained unchanged, except that wherever 0° appeared in the sequence, a 90° component was inserted preceding it. Scheduled presentations of 90° elsewhere were deleted. No other orientation preceded 0° during this condition and 90° was preceded equally often by every other orientation, except 0° and itself. Other aspects of the sequence remained the same as in the previous conditions, with the restrictions necessary to ensure that 90° was always followed by 0°. The 90°-to-0° transition appeared 16 times per session.

(6) *Length change only.* (15 sessions). The sequence of presentations was returned to that of conditions (1) through (4). Presentations of 90° remained 50 sec long and those of 0° were 10 sec long.

(7) *Short-to-long transitions.* (Nine sessions). Ten-second presentations of 0° were always followed by 50-sec presentations of 90°. To accomplish this, the positions of 0° and 90° in the sequence used in condition (5) were reversed. No other orientation preceded 90° during this condition, and 0° was preceded equally often by every other orientation, except 90° and itself. Other aspects of the sequence remained the same as in conditions (1) through (4) and (6). The 0°-to-90° transition appeared 16 times per session.

(8) *Length change only.* (10 sessions). The presentation sequence was returned to the baseline sequence of conditions (1) through (4) and (6). Presentations of 90° remained 50 sec long and those of 0° remained 10 sec.

Thus, the only manipulations were the change in the durations of 90° and 0°, those orientations in which food reinforcement was received, and in the transition between these two components (*i.e.,* long 90° to short 0° in condition 5 and the reverse transition in condition 7).

RESULTS

Figures 1 and 2 show average daily response rates during 90° and 0° for the five subjects. Response rates remained low in the other orientations throughout the experiment and are not directly relevant to the data described here. Aside from the first few sessions, there was virtually no responding during "no-stimulus" periods.

Effect of Changes in Component Length

The left panel of each figure shows response rates in 90° (filled circles) and in 0° (open circles) during the last 10 days of the baseline sequence. As is to be expected, there were no systematic differences during this condition; Birds 52, 67, and 61 responded at

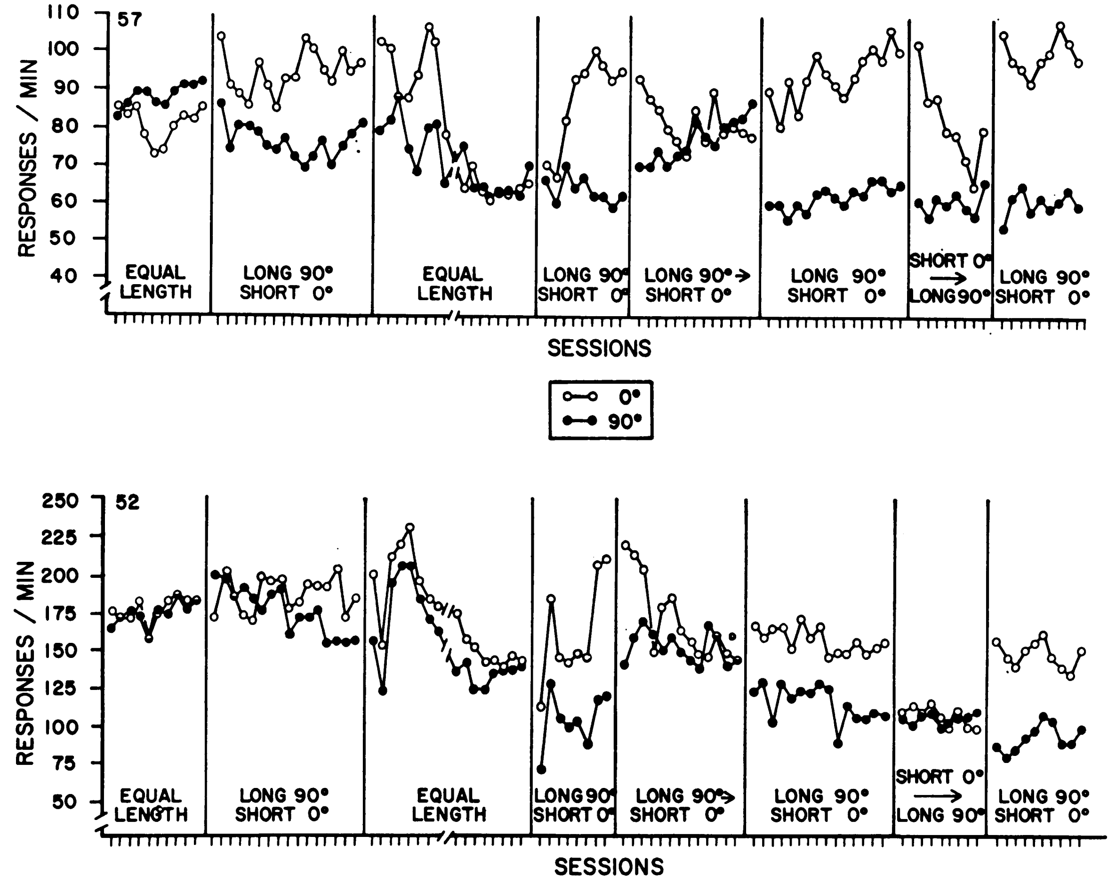

Fig. 1. Response rates during 90° and 0° for Birds 57 and 52 during each phase of the experiment. The third panels show only the first and last eight sessions of that condition.

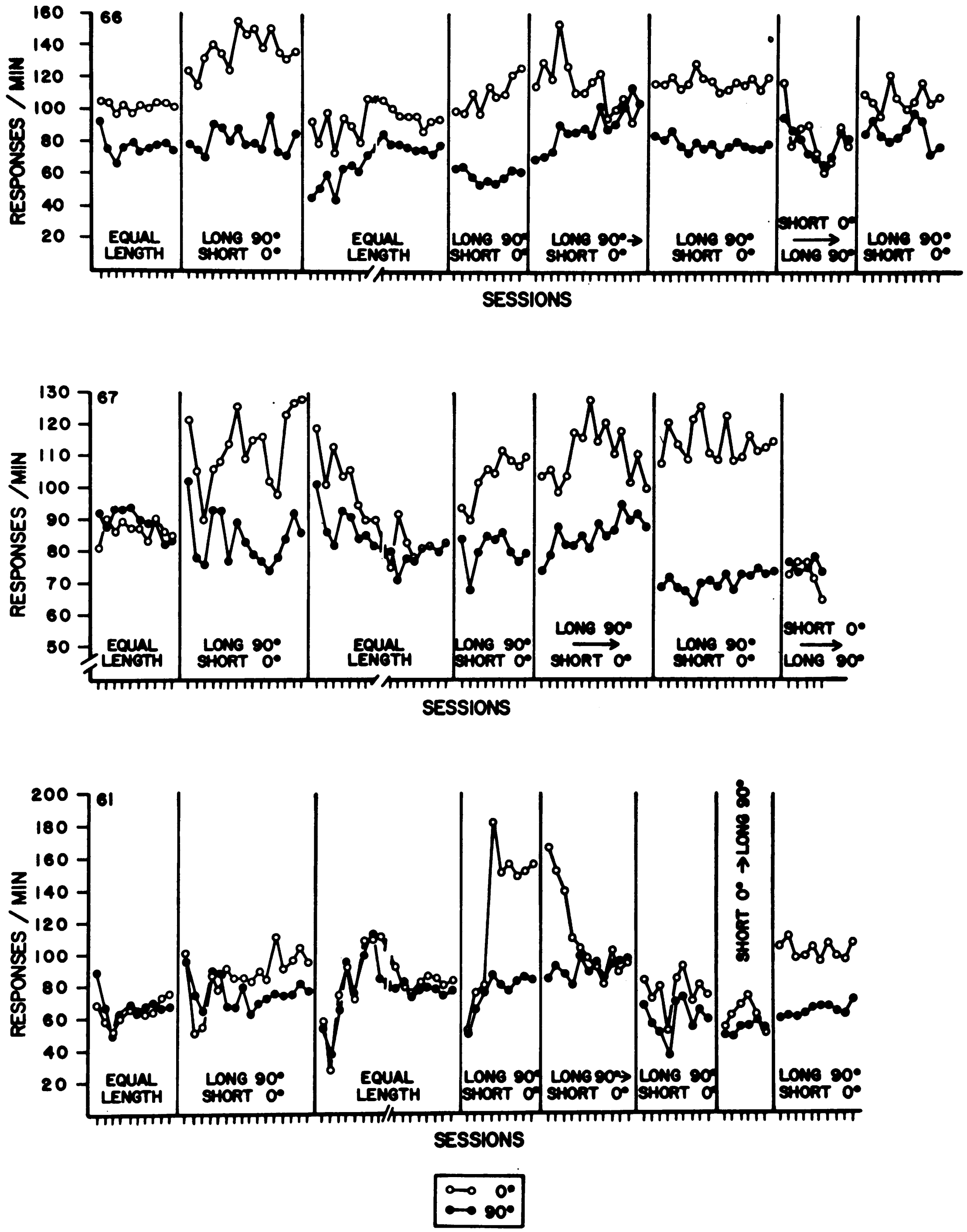

Fig. 2. Response rates during 90° and 0° for Birds 66, 67, and 61 during each phase of the experiment. The third panels show only the first and last eight sessions of that condition.

roughly the same rate in both stimuli; Birds 57 and 66 showed higher rates in 90° and 0°, respectively.

The change in length of the two components (second panel) led to large differences in response rates for all animals. In every case, re-

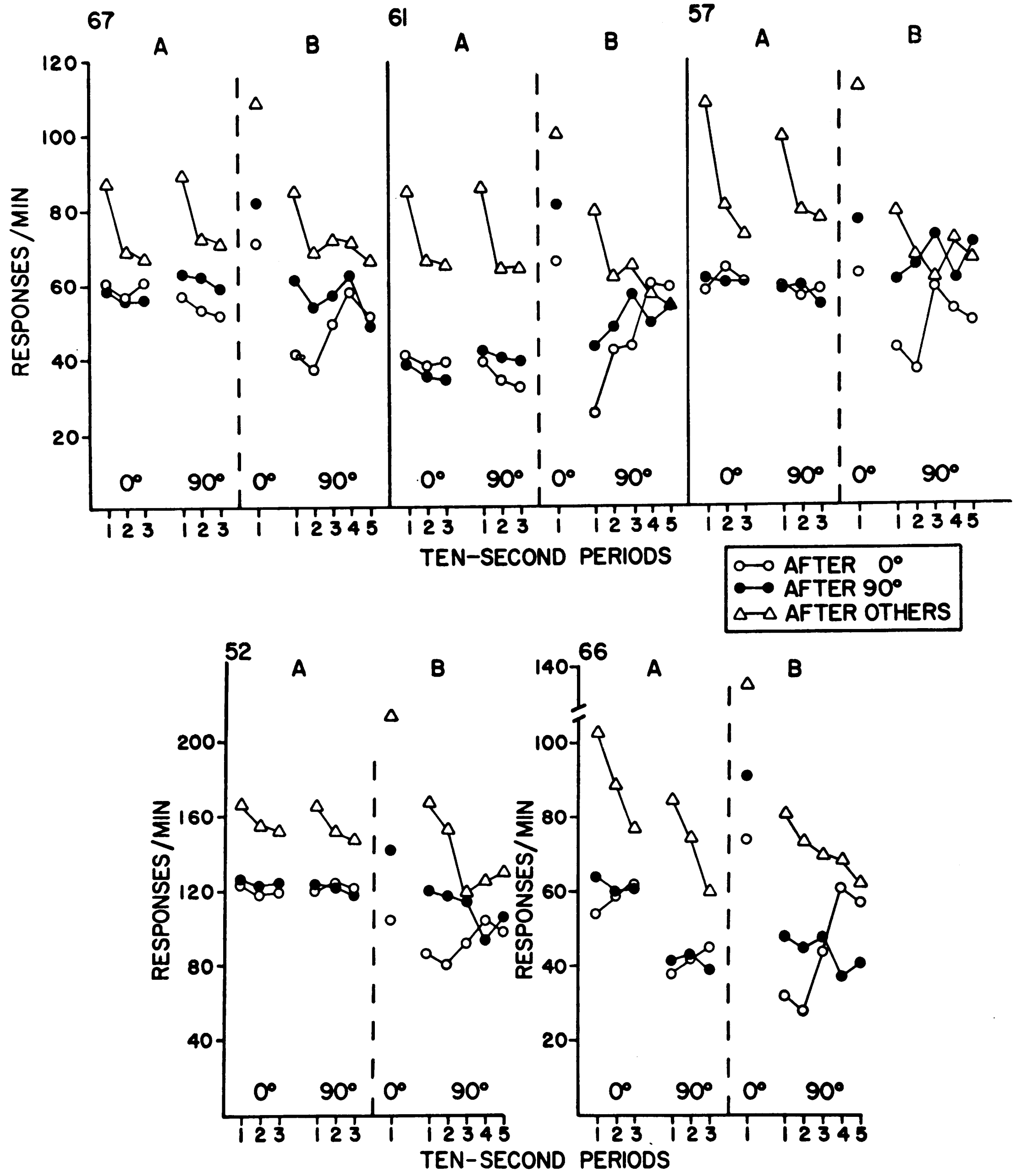

Fig. 3. Response rates during successive 10-sec periods of presentations of 90° and 0°, averaged over the last 10 sessions of the first condition (panels A, equal length) and the second condition (panels B). Open circles show responding when the preceding component was 0°, filled circles show responding when the preceding component was 90%. Triangles show average responding when the preceding component was one of the five extinction components.

sponding in 0°, which had been shortened to 10 sec, increased above the baseline (equal length) level. This increased response rate was quite marked in some cases (*i.e.*, increases of 60 responses per minute for Bird 66) and remained throughout the condition. The rate of responding during 90° remained unchanged with the increase in length from 30 to 50 sec; only Bird 57 showed a clear decrease in response rate.

Local Contrast

Along with the changes in response rate accompanying the change in component length, changes also appeared in local contrast effects occurring between presentations of 90° and 0°. Figure 3 shows responding during 10-sec periods of the presentations of the two stimuli during the last 10 days of baseline (equal length) and of the first changed-length condition.

Open circles show responding in 90° or 0° when the preceding component was 0°, while filled circles show responding when the preceding component was 90°. For simplicity, the effects of those components appearing in extinction were pooled; the triangles represent average response rate in 90° or 0° when preceded by any of the five extinction components.

Panel A for each bird shows local contrast effects during the baseline (equal length) condition. Response rates during 90° and 0° were generally the same and were independent of whether the preceding stimulus was 90° or 0°. When the preceding component was one of the extinction components (triangles), clear positive local contrast appeared in both 90° and 0°. The increase in response rate was normally the same in both components, but Birds 66 and 57 showed a greater effect in 0°.

Panel B for each bird shows the changes in local contrast during the second condition (changed length). Response rate during the 10-sec 0° component was elevated in virtually every case; the highest response rates occurred when the preceding orientation was one of the extinction components and the next highest rates of responding occurred when the preceding component was the 50-sec 90° component. Comparing these response rates to response rates during the first 10 sec of the 30-sec 0° component in panel A (equal length) shows that positive local contrast produced by components other than 0° increased. Though the highest absolute response rates occurred when the preceding orientation was one of the extinction components, the amount of increase over response rates in panel A was usually greater following the now-lengthened 90° VI component. Thus, response rate for Bird 61 during the first 10 sec of 0° in the equal-length condition was 38 responses per minute when the preceding component was 90° and 87 responses per minute when the preceding component was one of the extinction components. These response rates increased to 82 and 108 responses per minute when the duration of the VI components was changed. This means that the 50-sec VI component produced even greater positive local contrast during subsequent presentations of 0° than did the components presented in extinction. Local contrast in 0° following 90° was not always greater than local contrast following the extinction components (it was not true for Birds 67 and 52), but in all cases, substantial increases in response rate appeared when the preceding component was 90°. Since such effects did not appear in panel A, it must be concluded that the change in the duration of the VI components produced local contrast effects as would be expected to occur if 0° had been associated with more frequent reinforcement and 90° with less frequent reinforcement.

Aside from the increased positive local contrast during 0°, there was an increase in response rate in 0° when preceded by another 0° component for three of the five animals. For Bird 52, response rate was somewhat lower, and for Bird 57 it remained approximately the same.

Local contrast during the 50-sec 90° component also differed from the equal-length condition. Responding following the 10-sec 0° component (open circles) showed clear negative local contrast, as would be expected if the preceding component (*i.e.,* 0°) were associated with more frequent reinforcement. In all cases, response rates were lower during the first 30 sec of the component than when another 90° component preceded it. When the preceding component was one of those appearing in extinction, positive local contrast appeared. Considering only the first 30 sec of the 50-sec component, it appears that the degree of positive local contrast was virtually the same as that appearing during the equal-length condition. This was generally the case, except for Bird 57.

In summary, the data of Figure 3 suggest that the change in component duration produced changes in both positive and negative local contrast, which would be expected if 0° were associated with a higher frequency and 90° with a lower frequency of reinforcement.

Return to Equal Component Lengths

The third panels of Figures 1 and 2 show the first and last eight sessions after the return to the baseline (equal-length) condition. With 90° and 0° both appearing for 30-sec periods, response rates returned to approximately equal levels. The decrease in 0° was not immediate (except for Bird 61) but occurred only after a considerable number of sessions. Thus, the effects of changes in component length on overall response rates were completely reversible.

Second Change in Component Length

Once again, lengthening presentations of 90° to 50 sec and shortening 0° to 10 sec (Figures 1 and 2, panel 4) produced the same changes shown in panel 2. Response rate increased in 0° for all animals and Birds 52 and 66 showed some decrease in response rate in 90°.

Transition: Long 90°-to-Short 0°

When the sequence was changed so that 50-sec presentations of 90° were always followed by 10-sec presentations of 0° (panel 5), response rate in 90° clearly increased for all birds except Bird 61 (and perhaps Bird 67). For Bird 67, responding in 0° remained at approximately the level prevailing in the previous condition; response rate decreased in 0° for the remaining birds.

Return to Baseline Sequence

The sixth panels of Figures 1 and 2 show the effects of reinstating the baseline sequence, in which each orientation preceded and followed each other equally often. As in panel four, presentations of 90° remained 50 sec long and 0° appeared for 10-sec periods. It is important to note that when 90° was no longer always followed by 0°, response rate in 90° decreased considerably for all birds. Response rate in 0° remained at approximately that level prevailing in the prior condition for Birds 66 and 67, and increased for Birds 57 and 52.

Thus, panels, 4, 5, and 6 show that the effects of the long 90° to short 0° transition occurred in addition to the effects of length change alone. Moreover, the effects of the transition were not simply to produce equal response rates in 90° and 0°, though this occurred for all birds but 67. The main effect was increased responding in 90°, presumably due to the invariant 90° to 0° transition. The decrease in responding during 90° following this condition (sixth panel) supports this interpretation.

Transition: Short 0°-to-Long 90°

When 10-sec presentations of 0° were always followed by 50-sec presentations of 90° (panel 7), response rate decreased during 0° for all birds but 61. Once again, it is important to note that responding during 90° remained at that level prevailing in the previous (length difference only) condition; each bird showed no change in 90° as the result of the change in presentation sequence. Thus, the effect is not simply to produce equal response rates in the two components; the effect of the 0°-to-90° transition was to decrease response rate in 0°.

Return to Baseline Sequence

The last (far right) panel shows the return to the baseline sequence, in which each orientation precedes and follows each other equally often, and 90° and 0° still appear for 50- and 10-sec periods respectively. Birds 57, 52, 66, and 61 all show increased response rates in 0° and virtually no change in 90°. This indicates that the effect of the 0°-to-90° transition was indeed a decrease in response rate in 0°, rather than simply the production of equal response rates in the two components. When the transition was no longer invariant, response rate in 0° returned to its baseline level. Due to illness, Bird 67 was excluded from this final condition.

EXPERIMENT II

This experiment replicated the effects of altered component duration, using considerably longer components.

METHOD

Subjects

Three of the subjects from the first experiment and an additional Silver King pigeon (Bird 06) served. The latter bird had a varied training history. As in the first experiment, the birds were maintained at 80% of their free-feeding weights.

Apparatus

As in Experiment I.

Procedure

Four line-orientation stimuli [0°, 30°, 60°, and 90°, (vertical)] appeared during successive 150-sec presentations. Reinforcement was provided during 90° and 0° according to a VI 30-sec schedule, while 60° and 30° appeared in extinction. A session was composed of 25 components, randomized, with the restriction that each stimulus preceded and followed each other stimulus equally often (twice). Ninety degrees appeared seven times per session, while the remaining stimuli each appeared six times. Unlike the first experiment, no timeout (no-stimulus) periods were used.

For approximately the first 30 sessions, all birds showed extremely erratic behavior, which was attributable to a failure by a new experimenter to maintain the animals at their 80% weights. The following conditions exclude those data.

(1) *Baseline.* (44 sessions). All stimulus presentations were 150 sec long; the 90° and 0° components appeared with VI 30-sec reinforcement; the 60° and 30° components appeared in extinction.

(2) *Length change.* (17 sessions). Presentations of 90° were shortened to 50 sec and presentations of 0° were lengthened to 250 sec. This procedure differs from the first experiment, in which presentations of 0° were shortened and 90° lengthened. Variable-interval reinforcement remained in effect during both components and the two extinction components still appeared for 150 sec. The total session time during which VI reinforcement was available remained the same as during the baseline condition.

(3) *Baseline.* (16 sessions). As in (1).

(4) *Length change.* (16 sessions). As in (2).

RESULTS

Figure 4 shows daily average response rates during 90° and 0° for the four subjects. As in the first experiment, responding during the extinction components (60° and 30°) was not relevant to the data described here.

When the durations of the 90° and the 0° components were changed from 150 sec each to 50 sec (90°) and 250 sec (0°), clear differences in response rates soon appeared. Though the magnitude of the difference in response rate was less than that in the first experiment, responding during the shorter (90°) component was clearly greater than it was during 0°. With the return to equal component durations (third panel from left), response rates returned to approximately equal levels within a few sessions. When component durations were again altered (right panel) response rates again diverged, and again the higher response rates occurred during the shorter (90°) component.

In the first experiment, differences in response rates when components were of unequal duration seemed attributable to increases in responding in the shorter component, rather than to decreased responding in the component of longer duration. This was not clearly the case here; panel two shows several cases (*e.g.*, 06, 52, and 57) in which the difference in response rates seems to derive both from increases in responding during 90° and decreases during 0°. Yet, the effect in the right panel seems in all cases to be due to increased response rates during the shorter component, as was the case in the first experiment.

It is important to note that, as in the first experiment, changes in response rate normally appeared only several sessions after alterations in component duration. Thus, response rates did not immediately return to equal levels when components were returned to equal durations in the third panel. This suggests once again that the differences in responding during the preceding unequal duration condition were not simply the result of unequal weighting of local contrast effects during the two components. If local contrast were responsible for the differences in response rates, one would expect the immediate disappearance of such effects, once components were of equal duration.

DISCUSSION

The present data show that component length can differentially affect response rate in a multiple schedule even when the reinforcement schedule in each component is the same. Figures 1 and 2, panels 2, 4, 6, and 8, and Figure 4 show that this effect was large and stable and was recoverable after interpolated conditions. The major effect was increased responding in the shortened compo-

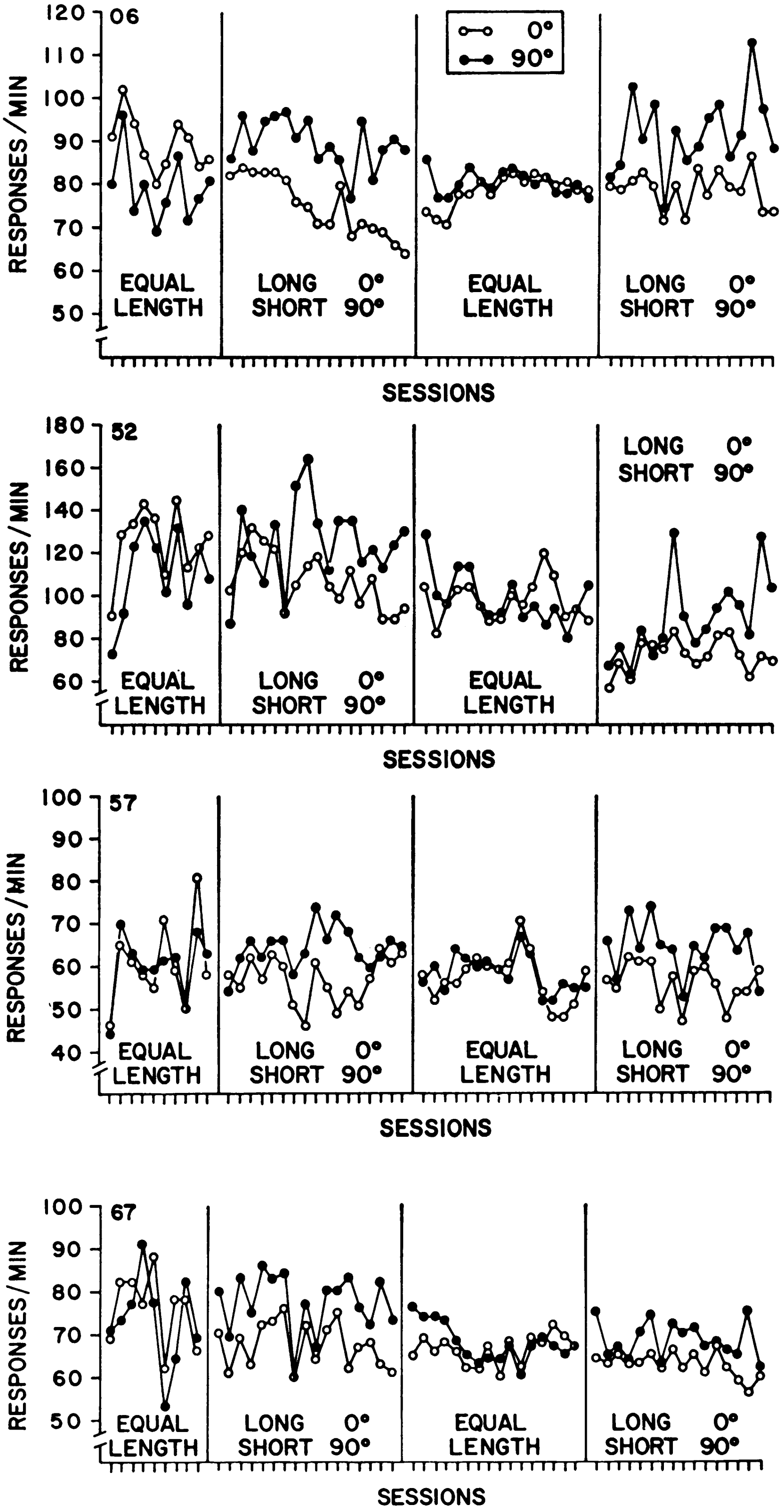

Fig. 4. Response rates in 90° and 0° for each animal during Experiment II.

nent, though in some cases response rate decreased in the lengthened component. Experiment II showed that these effects appear when component durations of 150 sec are altered to 50 and 250 sec; thus, the effect does not depend on the use of extremely short (*i.e.,* 10 sec) components.

Other research investigating the effects of component length, such as Shimp and Wheatley (1971) and Todorov (1972), are not relevant to these data, since different reinforcement schedules were in effect in their components and their components were never differentially lengthened or shortened; during any given condition, components were of the same duration. However, Wilton and Clements (1969) and Kodera and Rilling (1976) reported that response rate in a VI component increased when the duration of an accompanying extinction component was increased. In these cases, components were of unequal length but, as in the studies above, reinforcement frequency in the two components differed.

The present experiments imposed a restriction on the time that could be spent responding for VI reinforcement in one component. The total time per session in which a stimulus associated with VI reinforcement was present in each experiment remained constant, since the presentation length of one component was increased to offset the decrease of time in the other.

It could be argued that the increased responding in the briefer component was the result of local contrast and the altered component durations. For example, in Experiment I, the 0° component was preceded by the five orientations appearing in extinction 10 times per session; this would produce positive local contrast in the 0° component (*e.g.,* Malone, 1976; Malone and Staddon, 1973; Nevin and Shettleworth, 1966) reflected in increased response rates during the initial part of the 30-sec presentation. Similar effects would occur during the 90° component, while presentations of 0° and 90° components would produce negative local contrast in the presence of the remaining five orientations.

If the presentation length of 0° were shortened, response rate could therefore *appear* elevated, since only the initial part of the component (*i.e.,* that part most influenced by positive local contrast) would be considered. Any decrease in response rate in the presence of the 90° stimulus (such as occurred for Birds 57 and 52) could be due to the same factor; lengthening the component gives that much less weight in determining overall response rate to the initial part of the component, which is the part most influenced by positive local contrast. Thus, it is only the relative "weighting" of the effects of local contrast that produced differences in response rate.

This interpretation seems extremely plausible, but it cannot account for several aspects of the data. Figure 3 shows that when presentations of 0° were shortened and those of 90° were lengthened, negative local contrast occurred in the presence of the 90° stimulus when the preceding stimulus was 0°. Therefore, it is not the case that the "value" of the two components remained identical and that the change in component length simply magnified the effects of positive local contrast on the 0° component. The 0° component produced negative local contrast in the 90° component, just as would a component correlated with more frequent food reinforcement. In addition, response rate in the presence of the 0° stimulus remained elevated for some time after the return to equal component durations (Figures 1 and 2, third panels). If the increase in responding produced by the shortened component duration simply gave more weight to local contrast, the return to equal component durations should have immediately abolished the effect.

Aside from the effects of component length, Experiment I shows that once reliable differences in response rate have been established, responding in one component may be influenced by the *following* component. When 90°, in the presence of which response rate was lower, was invariably followed by 0° (higher response rate), responding in 90° increased (Figures 1 and 2, panel 5). When the reverse transition occurred and 0° was always followed by 90°, response rate in the presence of 0° decreased. In at least six of nine cases where increases and decreases occurred, the effect was clearly on the initial member of the pair. Panel seven shows that the 0°-to-90° transition led to decreased responding in the presence of 0°, rather than to changes in both components. In addition, it was responding in the initial member that fell (panel 6) or rose (panel 8) when the sequence no longer included the 90°-to-0° or 0°-to-90° transitions. Therefore, the effect may be viewed as the influence of one component on the preceding component.

Here again, however, it is possible that a local contrast interpretation could apply; perhaps aspects of the change in the sequence of components allowed for local contrast "aftereffects" to produce the changes in panels five and seven. This could have produced the increase in response rate in the presence of 90° during the 90°-to-0° transition, since the sequence change that ensured that 90° was always followed by 0° also meant that 90° was never preceded by 0°. This in turn means that 90° was more often preceded by orientations presented in extinction, and therefore that the positive local contrast produced by these components could result in increased response rates in 90°.

Similarly, the decrease in response rate during 0° in this condition could be due to local contrast. Since 0° was always preceded by 90°, positive local contrast previously produced in 0° by the five extinction components could not occur. Though the 50-sec 90° component could be expected to produce positive local contrast during 0°, the degree of local contrast would not be as great as that produced by the extinction components (see Figure 3). Therefore, response rate in 0° would be expected to decrease (as it often did) relative to its level during the preceding condition.

Such an account does not apply, however, to the effects of the 0°-to-90° transition. Since 90° was always preceded by 0°, positive local contrast previously produced in 90° by the extinction components would not occur and response rate in 90° should therefore decrease. This did not occur. Moreover, since 0° was always preceded by an extinction component, rather than sometimes by the 90° component or another 0° component, one would expect response rates to increase during 0°. Since responding clearly decreased in 0°, there seems no alternative but to assume that this effect was not due to local contrast, but depended on the 0°-to-90° transition.

Another difficulty in attempting to attribute the effects of altered component duration or of the transitions among components to local contrast lies in the fact that local contrast does not always lead to large differences in overall response rates (*cf.* Malone, 1976). For example, Figure 3 shows large differences in the pattern of responding during the 50-sec 90° component, which constitute positive and negative local contrast. Yet, in several cases the difference in overall response rate is slight. For example, Bird 66 shows negative local contrast following 0°, but the net effect on overall response rate is virtually identical to that appearing when the 90° component was preceded by another 90° component (filled circles). Malone (1976) showed that local contrast seems inadequate to account fully for differences in overall response rates, though its effects may still be considerable.

The reason that local contrast (an aftereffect; see Malone, 1976) should sometimes occur, and that effects due to the following component should occur at other times, may seem a problem. But the solution is not difficult to find. Persistent local contrast, such as that reported by Malone and Staddon (1973), occurs when stable differences in response rates have been established and the sequence of components is unpredictable. When the sequence of components is predictable, such as is the case when only two components alternate, local contrast "aftereffects" appear for a few sessions and then disappear (Malone, 1976; Nevin and Shettleworth, 1966). Once local contrast has subsided, effects of the component-to-come could account in part for the typical tendency toward convergence in response rates, which accompanies prolonged discrimination training (*e.g.*, Malone, 1976). When the component-to-come is predictable, effects such as those described here should occur. In a typical multiple schedule, both types of effects normally pass unnoticed, though local contrast may be more obvious because it appears as a change in the pattern, as well as in the overall rate of responding.

Previous reports have described the effects of one component on behavior in a preceding component as opposite in direction to the effects found in Experiment I. Thus, Wilton and Gay (1969) replicated Pliskoff's (1961; 1963) finding that a signal preceding the transition from more to less frequent reinforcement produces higher rates of responding than does a signal preceding the opposite transition. Pliskoff's original demonstrations involved the addition of what he called warning stimuli to components that provided different frequencies of reinforcement. The procedure was different enough from that used here to account for the discrepancies in results, and Kello, Innis, and Staddon (1975) cast doubt on the assumption that stimuli added in that way really serve a "warning" function. Wilton and Gay, however, used a procedure more similar to the one used here; components providing equal frequencies of reinforcement were regularly followed by components associated with more or less frequent reinforcement. Though their data were not clear-cut, they certainly conformed more to Pliskoff's effect than to the present data.

The most salient procedural difference between this study and that of Wilton and Gay is that the present study examined the effects of transitions among components in which performance was clearly asymptotic; the first manipulation of the transitions among components occurred only after 69 sessions of training. Most of Wilton and Gay's subjects were experienced with the components in which effects were observed for only 15 sessions. The effects they described appeared only after eight to 10 sessions of training and vanished in the one case in which training was carried out for an extended period. Thus, the "Pliskoff Effect", represented by Wilton and Gay's data, may appear transiently, before response rates stabilize, while the effects reported here occur among components in which responding has had sufficient time to stabilize.

Interestingly, Pliskoff (1961) reported "numerous cases" in which effects similar to those reported here occurred: "Several aspects of the data support the quite reasonable assumption that the transition from VI one to VI ten had negative reinforcement properties (sic) whereas the transition from VI ten to VI one had positive reinforcement properties."

The changes in response rates in 90° and in 0° may best be described as effects of reinforcing and punishing transitions, in the sense that Baum (1973) used these terms. He described reinforcement and punishment as transitions among situations differing in value, an interpretation similar to Premack's (*e.g.*, 1971) analysis. There are many ways to manipulate value (or response strength) aside from varying the frequency of food reinforcement; our data show that under some circumstances, the use of unequal component lengths is sufficient. Given that stable differences in response rates exist, both local contrast and reinforcing and punishing effects may occur; as suggested above (*cf.* Malone, 1976), it is likely that the predictability of the sequence of components will determine which of these effects appear.

The effects that are here called reinforcing and punishing occur in the absence of an explicit response requirement; components change independently of the subject's behavior. This is probably not terribly important, though both Premack and Baum assume that situation change normally is response produced (but see Premack, 1965). In the present experiment, response rates were typically high in both components, and though no explicit response requirement was imposed, it is altogether possible that from the subject's point of view an implicit response contingency was in effect. Surely the effects of adventitious reinforcement are well enough known to make such a possibility plausible.

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