OPERANT PREFERENCE FOR STEREOPHONIC OVER MONOPHONIC MUSIC[1]

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In conjugate reinforcement, the intensity of a continuously available reinforcing consequence is directly controlled by the subject's rate of responding. This immediate and direct relationship between response rate and reinforcer intensity makes the conjugate an ideal contingency for comparing the strength of different reinforcers. This experiment demonstrates the advantages of conjugate reinforcement in measuring preferences for narrative reinforcers, which lose much of their strength when presented on an episodic schedule. One-operandum and two-operanda preference techniques are compared.

Analysis of four normal adults' preferences for stereophonic over monophonic music demonstrated: (1) Conjugately contingent music is a reinforcer of sufficient strength to maintain responding and shows considerable resistance to satiation. (2) Although stereophonic music was discriminated from and verbally preferred to monophonic music by all four subjects, stereophonic music was operantly preferred by only two of the four. Two stimuli which can be discriminated and for which subjects verbally indicate differential preference do not necessarily have differential reinforcing powers.

IN this study, free-operant preference was compared with both free-operant discrimination of, and verbal preference for, stereophonic over monophonic music in the same four human subjects.

Operant Preference

Studies of preference for one stimulus over another involve procedures in which an organism is given an opportunity to select one from two or more stimuli. In operant terms, the stimuli are reinforcers for the "choice" or "selection" response of the subject. Operant preference is defined as differential responding for one reinforcing stimulus as opposed to another reinforcing stimulus. In a free-operant situation, since the subject's response rate is not limited by trials or any other aspect of the experimental procedure, preference can be defined in terms of differential response rate. That is, the preferred stimulus is that which, when presented as a reinforcing consequence of a response, results in the highest frequency of free-operant responding.

Verbal Preference

Preference studies with humans are often limited to verbal responses. The subject cannot actually obtain the stimuli, but is asked which he would chose if he could obtain them. In operant terms, the names of the stimuli are given as discriminative stimuli for a verbal response. Although the reinforcement for this verbal response is not usually specified, it presumably involves pleasing the experimenter.

Music as a Reinforcer

Operant preference testing requires that the comparison stimuli be reinforcers of sufficient strength to maintain the operant preference responses at useful rates. Observation of the great extent to which music is used in everyday life suggests that music can operate as a reinforcer. There is also some experimental evidence of its reinforcing properties. Jeffrey (1955) was able to increase responding in children with music, and Barrett (1962) found that interruption of music can attenuate an undesired response. Fane (1955), however, was unable to accelerate responding in psychotics with ten-second bursts of music presented on a one-minute variable-interval schedule. The reinforcing effects of the music were probably minimized in these experiments

 This research was conducted by the Behavior Research Company, Belmont 78, Mass., and was partially supported by special research funds from Colorado College. Reprinted by permission.

because the music was presented in disjointed segments (Fane, 1955) or interrupted periodically (Jeffrey, 1955; Barrett, 1962). The conjugate contingency, in which the intensity of the reinforcing stimulus is contingent on the rate of responding, overcomes this difficulty (Lindsley, 1957; Lindsley, 1961; Lindsley, Hobika, and Etsten, 1961). Conjugate contingencies have been used to determine separately the moment-to-moment changes in the reinforcing power of the audio and video portions of television programs (Lindsley, 1962). By responding at a preset rate, the subject can maintain the program at full volume. As his rate of responding decreases, the volume of the program decreases. As his response rate slows to zero, the program fades to silence. As his response rate increases, the program increases in volume. Thus the conjugate contingency directly feeds back the program volume as a function of the rate of responding without interrupting the program narration.

In the present study we measured preference for stereophonic as opposed to monophonic music. The stereophonic-monophonic dimension was selected because it seemed to be a very subtle dimension that would provide a good test of the sensitivity of operant preference testing methods. Also, it permitted us to equate the reinforcing stimuli in all other dimensions. The subjects were given a choice between hearing music monophonically and hearing the same music played stereophonically from the same tape, at the same time, and at the same volume. Thus, we were able to equate parameters (such as rhythm, harmony, tone, and instrumentation) which vary between musical selections or even from one part of a selection to another. This minimized the likelihood that any preferences shown would be attributable to other than the stereophonic-monophonic dimension of the music.

METHOD

Subjects

The four subjects were one male (N31) and one female (NCF7) high school students and two female student nurses (NF8, NF9), ages 15 to 21.[2] Each subject participated in four to five daily sessions of 45 minutes to two hours duration. The preference of each subject was studied with both techniques described below, each technique being used in alternate sessions. With two of the subjects, the two-operanda technique was used first, and with the other two, the one-operandum technique was used first.

Apparatus

Each subject sat in a small-attenuated room furnished only with a comfortable chair, a pair of earphones, and one or two operanda (see Skinner, 1962). The operanda were handswitches on the ends of cords.[3] The subjects were told that they would be listening to music through the earphones and that they could press the switch (or switches) whenever they wanted. Nothing was said about the reinforcement contingencies, nor was it indicated that it would be necessary to keep responding. Response rates were recorded on cumulative recorders. Recording and programming apparatus was fully automatic and located in a separate room.

The reinforcement was programmed through a conjugate reinforcement servo[4] which converted the rate of electrical pulses from the handswitches into changes in electrical resistance in the sound circuit. The maximum volume of the music was preset at a comfortable level. The rate of responding required to maintain maximum volume was 60 responses per minute for all subjects throughout the study.

The music was a stereophonic tape recording of Gershwin's *Rhapsody in Blue* and *American in Paris*.[5] Pilot studies had indicated that these were selections which were not aversive to people of most musical tastes.

The music was presented through stereophonic earphones. When stereophonic music was presented, both channels of the stereophonic tape were fed separately into the two earphones. When monophonic music was presented, the sound from only one channel

[2] The cooperation of students from New England Baptist Hospital Nursing School and Saint Mary's High School, Waltham, Mass., in serving as subjects is greatly appreciated.

[3] Handswitches #E-800-6 manufactured by Grason-Stadler Company, West Concord, Mass., were modified to require 350 grams of force through 3 mm. for each operation.

[4] Conjugate reinforcement servo #CR2S manufactured by Behavior Research Company, Belmont 78, Mass.

[5] Stereo tape MQ322, Columbia Masterworks Series.

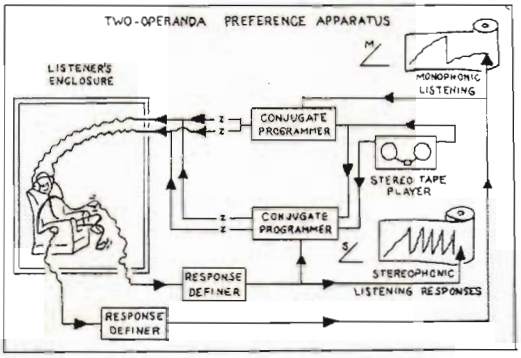

FIG. 1. Apparatus schema for two-operanda operant preference testing. The subject can hear stereophonic music by pressing one operandum and monophonic music by pressing the other at rates of 40 to 60 responses per minute.

was fed into both earphones. The tape was continuously in motion, so that, if the subject did not respond, he missed part of the music. Because of the conjugate contingency, it was possible for the subject to switch back and forth between stereophonic and monophonic music without any interruptions or changes in the volume of the music.

PROCEDURE AND RESULTS

Two-Operanda Technique

Each subject was given two switches, one to hold in each hand. Responding on one of the switches produced the music stereophonically; responding on the other switch produced the music monophonically. Responding on neither switch resulted in silence. The contingencies were switched back and forth between the two operanda to control for position or operandum bias. A schematic diagram of the apparatus is given in Figure 1.

Figure 2 shows a cumulative record of the fourth session of a subject who showed a preference for stereophonic music. During the first segment, responding on the left operandum produced stereophonic music (STEREO INC) and responding on the right operandum produced monophonic music (MONO INC). Responding for stereophonic music was about three times as great as responding for monophonic music. When the contingencies were switched to the opposite operanda in the second segment and then back again in the third, the response rates on the two operanda

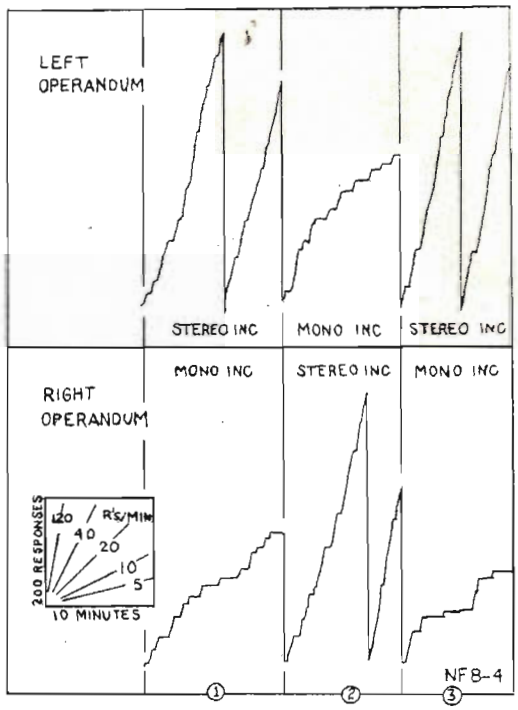

FIG. 2. Operant preference for stereophonic music over monophonic music shown by the two-operanda technique. Responding on one operandum produces stereophonic music (STEREO INC) and responding on the other operandum produces monophonic music (MONO INC). The two response contingencies are switched back and forth between the two operanda during a single session. This subject was more reinforced by stereophonic than by monophonic music.

were reversed, indicating that the differential responding was not due to position preference or operandum bias. The short bursts of responding which occurred on the operandum producing monophonic music can be interpreted as the subject's testing for contingency changes.

Figure 3 is a record taken under identical conditions in the third session of a subject who showed no preference for either stereophonic or monophonic music. Responding was first divided between the two operanda and gradually shifted to the left operandum, indicating left operandum preference in this left-handed subject. The maintenance of a high rate of responding on the left operandum indicated that the musical selection was reinforcing to this subject. Reversals of reinforcement contingency between the two operanda

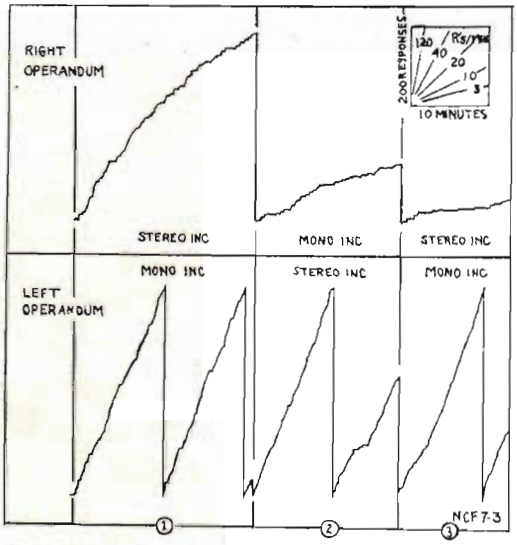

FIG. 3. Lack of preference for either stereophonic or monophonic music shown by the two-operanda technique. The experimental conditions are the same as in Figure 2. This subject was not differentially reinforced by the stereophonic property of the music.

had no effect, indicating that although the music was reinforcing, its stereophonic property was not.

Two of the four subjects showed two-operanda operant preference for stereophonic music, and two showed no preference for either stereophonic or monophonic music. The records given in Figures 2 and 3 are very similar to the records of the other two subjects.

One-Operandum Technique

Each subject was given only one handswitch. When not responding, the subject heard monophonic music. An increase in response rate produced a decrease in monophonic music and a concurrent increase in stereophonic music, so that rates from 10 to 40 per minute produced mixtures of stereophonic and monophonic music. The higher the rate of responding, the purer was the stereophony. By responding at 60 responses or more per minute, the subject could produce purely stereophonic music. This contingency was reversed during each session so that stereophonic music was produced by not responding and monophonic music was produced by responding. This reversal controlled

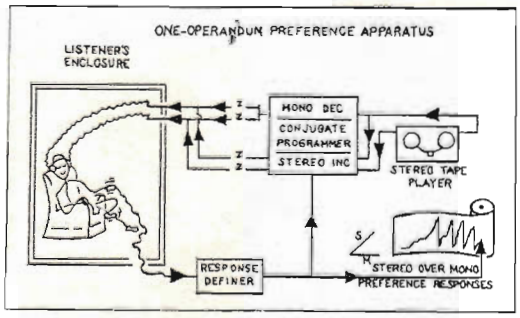

FIG. 4. Apparatus schema for one-operandum operant preference testing. The subject can change monophonic music to stereophonic music by responding at rates above 60 responses per minute.

for the additional response cost necessarily added to the response-contingent stimulus in the one-operandum technique. The apparatus is diagrammed in Figure 4.

With the one-operandum technique it was necessary to give each subject pretraining in a situation in which responding was reinforced by increases in music volume and no music could be heard without responding. When put directly into the one-operandum situation without any pretraining, the subjects did not learn to respond for the stereophonic property of the music. Possibly the monophonic music was reinforcing enough to satiate the subjects, so they would not respond.

Figure 5 is the record of the fifth session of a subject (NF8) who showed preference for stereophonic music with the one-operandum technique. (Her two-operanda preference in the preceding session is shown in Figure 2.) In Segments 1, 3, and 5, the subject responded at rates above 100 per minute to maintain stereophonic music when monophonic music was available for not responding ($^{S}/_{M}$). When the contingencies were reversed so that responding produced monophonic music and not responding produced stereophonic music (segment 2: $^{M}/_{S}$), the subject stopped responding. In segment 4, when monophonic music was heard regardless of responding, the rate of responding was higher (10 responses per minute) than in segment 2 when stereophonic music was heard when not responding. This higher rate indicates "searching" for the preferred stereophonic quality which disappeared.

Figure 6 is a record of the second session of a subject who did not show operant pref-

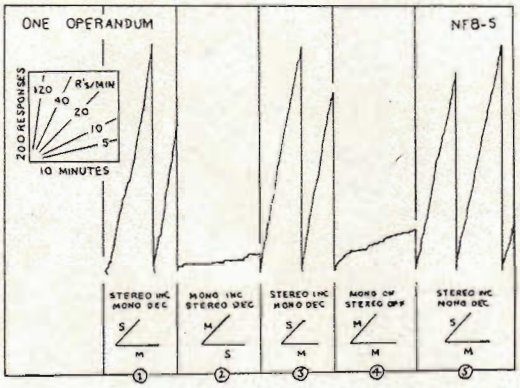

FIG. 5. Operant preference for stereophonic music over monophonic music shown by the one-operandum technique. This subject responded at a high rate to produce stereophonic music when he could hear monophonic music by not responding (STEREO INC, MONO DEC), and made few responses when responding produced monophonic music and he could hear stereophonic music by not responding (MONO INC, STEREO DEC). Responding at an irregular, low rate was recorded when monophonic music was heard regardless of response rate and stereophonic music could not be obtained (MONO ON, STEREO OFF).

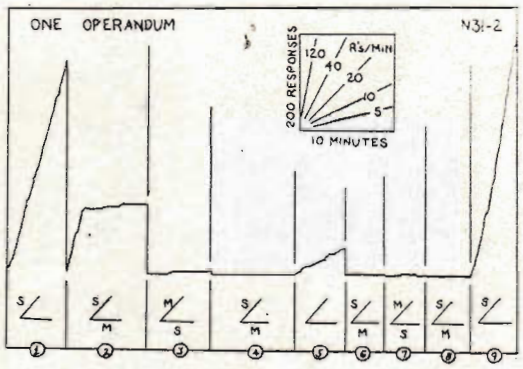

FIG. 6. Lack of preference for stereophonic music or monophonic music shown by the one-operandum technique. The subject responded to obtain stereophonic music when no music was obtained by not responding ($^{S}\angle$). When monophonic music was made available for not responding ($^{S}\angle_{M}$), responding ceased almost entirely. Neither did the subject respond when stereophonic music was produced by not responding and responding produced monophonic music ($^{M}\angle_{S}$). Intermittent responding was recorded when no music could be obtained either by responding or not responding ($\angle$).

erence for stereophony. Responding was produced only when not responding resulted in silence and responding produced music, in the first and last segments ($^{S}\angle$). When monophonic music was made available for not responding in segment 2 ($^{S}\angle_{M}$), responding ceased as soon as the subject had stopped long enough to discover that the conditions had been changed and that he could now get music for nothing. Reversal of contingencies so that stereophonic music was heard for not responding and monophonic music could be produced by responding (segments 3 and 7: $^{M}\angle_{S}$) did not produce responding. This showed that the lack of responding under the previous conditions was not an indication of preference for monophonic music. Under extinction procedures, when no music was available for either responding or not responding (segment 5: $\angle$), responding occurred at a higher rate (10 responses per minute) than when under monophonic or stereophonic satiation.

Operant preference for stereophonic music over monophonic music was shown in the same two subjects with this technique as with the two-operanda technique. The other two subjects, who lacked two-operanda operant preference, also lacked one-operandum preference for either stereophonic or monophonic music. The response records for the other two subjects are very similar to those shown in Figures 5 and 6.

Operant Preference versus Operant Discrimination[6]

The performance of one of the four subjects (N31) raised a question of the relation of the mechanisms of stimulus discrimination and response differentiation to preference as we have defined it. When presented with the two-operanda situation, this subject, developed a stereotyped pattern of responding in which he pushed both operanda simultaneously or in rapid alternation. The subject expressed superstition in stating that it was necessary to push the two operanda in combination in this way in order to produce music in both earphones. This failure to differentiate between the two responses was highly resistant to experimental sharpening. The stereotyped double responding was not broken when music was presented for responding on just

[6] The advice and assistance of Donald Cohen during this part of the study is gratefully acknowledged.

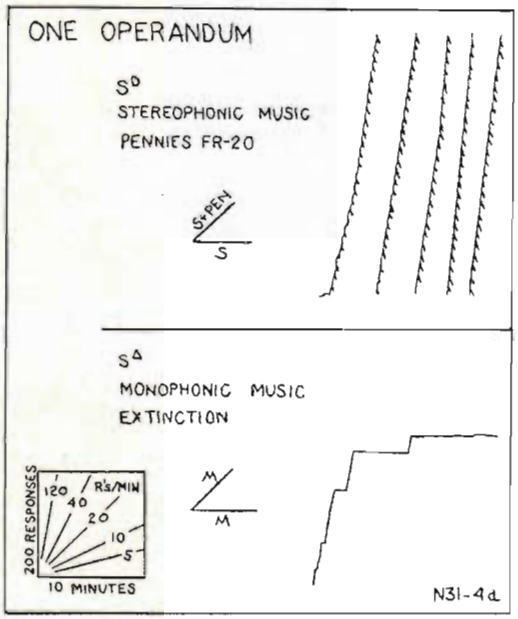

FIG. 7. Stereophonic music operating as a positive discriminative stimulus for penny-reinforced responding. Responding on the single operandum during S^D (stereophonic music) for penny reinforcement is recorded on the upper curve. Hatch marks indicate presentations of pennies. Responding during S^Δ (monophonic music) periods is recorded on the lower curve.

one of the operanda and no reinforcement was contingent on the other. The stereotyped pattern was broken only when white noise was made contingent on responding on one operandum and music was made contingent on the other. Following this white-noise punishment procedure, the stereotyped double responding did not recur. However, when monophonic and stereophonic music were again made separately contingent on the two operanda, responding remained about equal on both. This suggested that N31 could not differentiate the two responses unless one were punished.[7] The question was raised as to whether the lack of two-operanda preference shown by this subject's responding was a result of failure to discriminate between the two stimuli, a failure to differentiate between the two responses, or equal reinforcing powers of the two stimuli.

We decided to test N31's ability to discriminate between the two musical stimuli by presenting them as S^D and S^Δ for responding on one operandum for a different reinforcer. A penny dispenser was installed in the experimental room. The subject was given one operandum, and music which was not in any way contingent on his responding was played to him through the earphones. The music was switched back and forth between stereophonic and monophonic at intervals varying from one to three minutes in length, without interrupting the course of the music. When the music was stereophonic (S^D), the subject's responding was reinforced with pennies on a fixed-ratio of 20. When the music was monophonic (S^Δ) responding was not reinforced. The subject's responding under these conditions is shown in Figure 7. A high response rate was maintained under stereophonic stimulation and the rate decreased to zero under monophonic stimulation, indicating that the subject could indeed discriminate stereophonic from monophonic music, even though neither was operantly preferred.

Operant Differentiation Deficit Analysis

Since we had shown that N31 could operantly discriminate stereophonic from monophonic music, we returned to the two-operanda preference technique to test for the suspected differentiation deficit. The response record from this session is given in Figure 8. Response rates on the two operanda for stereophonic and monophonic music remained about equal (segment 1). To determine whether N31 could differentiate the two operanda using consequences with greater differences in reinforcing power, pennies were added as reinforcement to the left operandum (segment 2). Differential responding apparently occurred. However, when the monetary reinforcement was switched to the other operandum, responding was not confined to the operandum reinforced with pennies (segment 3). A pattern of long bursts of responding alternated between the two operanda. The differential responding in the brief segment 2 may have been a portion of this alternating pattern. Although there was a higher overall

[7] Barrett and Lindsley (1962) have shown failure to differentiate responses in retarded children. Suggestions for locating and prosthetizing differentiation and other operant component deficits were recently made (Lindsley, 1964).

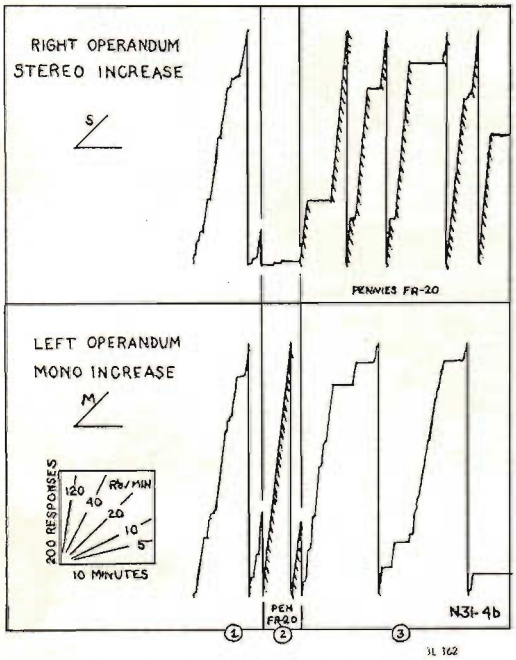

FIG. 8. Lack of differentiation between responses differentially reinforced by stimuli which are discriminated. No difference in response rate is recorded between the operandum reinforced with stereophonic music ($^{S}\angle$) and the operandum reinforced with monophonic music ($^{M}\angle$). Pennies on an FR-20 schedule, added first to the reinforcement of the left operandum and then to the reinforcement of the right operandum, failed to produce complete differentiation. Each presentation of a penny is indicated by a hatch mark on the records.

rate for the penny-reinforced response, differentiation was not complete.

In summary, our analysis of N31's behavior yielded eleven conclusions. The one-operandum preference technique showed: (1) Music was an adequate operant positive reinforcer. (2) The handswitch defined a useful operant response. (3) The conjugate contingency was effective (comparison of segments 1, 5, and 9 of Figure 6). (4) Stereophonic music was not operantly preferred over monophonic music (segments 2, 3, 4, 6, 7, and 8 of Figure 6).

The one-operandum discrimination test using pennies as a reinforcer showed: (5) N31 could easily discriminate stereophonic music from monophonic music. (6) Pennies were an adequate reinforcer. (7) Fixed-ratio 20 was an effective reinforcing contingency (Figure 7).

The two-operanda preference technique showed: (8) Stereotyped responding occurred first as simultaneous pressing of both switches, second as rapid single alternation of pressing, and later as irregular alternation of long bursts of responding. (9) Differential reinforcement with music alone did not break this pattern, but (10) punishment of one response with white noise did break the pattern and produce a full response differentiation.

Use of pennies to positively reinforce differentiation showed (11) only partial differentiation (Figure 8).

Therefore, N31 adequately discriminated stereophonic from monophonic music, but both were equally reinforcing to him. He showed a partial differentiation deficit when only one response was reinforced, characteristically alternating between separate bursts of reinforced and non-reinforced responding; but when one response was reinforced and the other was punished, his partial differentiation deficit was overcome.

Operant Preference versus Verbal Preference

When questioned, all four subjects verbally stated that they preferred stereophonic to monophonic music. However, only two out of the four showed operant preference for stereophonic over monophonic music. Their operant preference was displayed using both the one-operandum and two-operanda techniques. This difference between operant and verbal preference clearly shows that verbally preferred items may not have reinforcing power and may not be worth working for. Therefore, the results of verbal preference studies should not be used to predict reinforcement value or media consumption.

DISCUSSION

The experimental comparison of operant stimulus discrimination and preference shown in Figures 6 and 7 proves that discrimination between two stimuli does not necessarily indicate preference between them, *as we have defined preference*. Thus, preference defined as a response to a discriminative stimulus is different from preference defined as a response to obtain a stimulus as a reinforcer. This observation is further supported by the discrepancy between operant and verbal preference reported above.

Therefore, a method of preference testing in which the stimuli are presented and the subject is asked to make a response, but the stimuli are not actually obtained or consumed, may produce different results from a method in which the subject consumes the stimuli. For example, a person may respond differently if he is asked to choose between two objects, one which he may have, than if he is asked which of the two is better or prettier.

Conjugately contingent music proved to reinforce response rates above 100 responses per minute in all four subjects. No satiation effects were observed to the same musical selections used during as many as seven experimental hours. The verbally stated musical tastes of these subjects ranged from rock-and-roll to classical music.

Using both one-operandum and two-operanda techniques, operant preferences of the four subjects for stereophonic over monophonic music were easily measured. The preference or lack of preference was clearly indicated by markedly different response rates (100 compared with 20 responses per minute) for each of the subjects. The development of the preference was clearly observed in the first 30 minutes as the response rates separated. Two of the four subjects showed operant preference for stereophonic music and the other two showed no preference for either. The two subjects who did not show operant preference for stereophonic over monophonic music were the high school students. The two student nurses clearly preferred the stereophonic music with both the one-operandum and two-operanda techniques. Since the nurses were older than the high school students, it is possible that the reinforcing power of stereophony is acquired through experience, training, and sophistication.

Some of the relative merits of the one-operandum and two-operanda techniques can be suggested. The one-operandum technique has the disadvantage of requiring pretraining with a single strong reinforcer before it can be used to evaluate preferences between two nearly equal reinforcers. It should be noted that we did not instruct our subjects as to the type of responding necessary to maintain the music. Precise instruction would have eliminated the need for such pretraining for most normal subjects.[8] The one-operandum technique also has the disadvantage of unequal response costs for the two comparison stimuli. These unequal response costs require more experimental time in sequential reversing of the response contingencies in order to counterbalance the research design.

The usefulness of the two-operanda technique may be limited by its dependence on accurate and full response differentiation be- a given reinforcer at full strength. Response The differentiation between responding and not responding required by the one-operandum technique apparently did not cause any difficulties for the subject (N31) who did have difficulty differentiating between the two responses in the two-operanda situation.

FURTHER APPLICATIONS

Absolute measurements of preference or value might be made by measuring the cost of responses emitted to produce and maintain a given reinforcer at full strength. Responses costs can be manipulated by changing the amount of force necessary to operate the handswitch, by changing the rate of responding necessary to maintain the music at full volume, or by imposing response fines or penalties (Weiner, 1962).

Aspects of music and dimensions of instrumental and theatrical program other than degree of stereophony could be easily compared with this new method. Preferences for subtle and fleeting differences between continuous taped or live entertainment narrations can be accurately and objectively recorded in single consumers.

Operant preference testing with conjugate contingencies shows promise as a new measurement technique in communication research and experimental aesthetics.

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[8] Operant methods do not require verbal instructions. It is valuable to show this in initial demonstrations of a new method to prove that the method can be used with subjects who cannot comprehend the instructional language (e.g.: infants, foreign speaking, psychotic, or inattentive individuals). In later practical applications of the method, the behavioral measurement can be greatly speeded up by eliminating the time-consuming response acquisition period with precise verbal instructions. Weiner (1961) has also and independently come to use these time-saving instructions with human subjects when their acquisition data are not required for experimental analysis.

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