

# *FIXED-RATIO SCHEDULES OF CONDITIONED REINFORCEMENT WITH CHIMPANZEES<sup>1</sup>*

ROGER T. KELLEHER<sup>2</sup>

YERKES LABORATORIES OF PRIMATE BIOLOGY

In earlier studies of conditioned reinforcement, I investigated both fixed-interval and multiple schedules with fixed-interval and fixed-ratio components (2, 3, 4). These studies demonstrated several similarities between the characteristics of behavior maintained by conditioned reinforcers and behavior maintained by food reinforcers. However, one consistent difference was found in the general trend toward higher response rates as the time approached when the conditioned reinforcers could be exchanged for food. The purpose of this experiment was to extend the results of these earlier studies by elucidating the characteristics of performance maintained by fixed-ratio schedules of conditioned reinforcement.

## SUBJECTS

The two *Ss* were 7-year-old chimpanzees (Yerkes Laboratories, No. 117 and 119) maintained at about 80 per cent of normal body weight. The experimental histories of these animals, which included thousands of hours on schedules of conditioned reinforcement, have been presented previously (2, 3, 4).

## APPARATUS AND PROCEDURE

The animals had been trained to obtain poker chips (conditioned reinforcers) by pressing a telephone key in the presence of a white light. When 60 poker chips had been delivered or when 8 hours had elapsed, the white light went off and a red light appeared. When the white light was off, presses on the telephone key were ineffective. The animals had been trained to obtain food by inserting the poker chips through a slotted Plexiglas window in the presence of the red light. When the red light was off, poker-chip insertions were recorded but were otherwise ineffective. The animals were not physically restrained from inserting poker chips at any time. Further details concerning apparatus and procedure are presented elsewhere (2,3,4).

A 30-response, fixed-ratio schedule (FR 30) of conditioned reinforcement was in effect for 30 sessions. Under this schedule, one poker chip was delivered for every 30 presses on the telephone key. Over the next 10 sessions, the response requirement was gradually increased from FR 30 to FR 100. Each *S* had three sessions on FR 100. Following these three sessions, multiple schedules and variable-interval schedules were investigated for 3 months. The *Ss* were then returned to FR 60, and the response requirement was gradually increased to FR 125 over 10 sessions. On FR 125 the *Ss* were required to obtain only 50 poker chips before the red light appeared to indicate that exchange for food was possible. After 20 sessions on FR 125, the poker-chip magazine was disconnected for a 6-hour extinction ses-

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<sup>2</sup>Present address: Department of Pharmacology, Smith, Kline and French Laboratories, Philadelphia, Pa.

sion. Each *S* was given 50 poker chips at the start of both the fortieth and fiftieth sessions on 125, but was still required to work for another 50 poker chips before exchange for food was possible. Each *S* had 60 sessions on FR 125.

#### RESULTS

The individual rates of responding were bi-valued; that is, *S* was either not responding (pausing) or responding at a high, stable rate (the running rate). Figure 1 shows records on FR 30 for each *S*. Brief pauses usually occurred following poker-chip deliveries, but became less frequent in the later part of each session. The running rates were stable at 2 responses per second for No. 117 and 3 responses per second for No. 119.

Figure 2 shows the effects of increasing the response requirement to FR 100. The pauses in the early portions of each session became more prolonged, and the running rates were higher than at FR 30. Running rates were 3 responses per second for No. 117 and 4 responses per second for No. 119.

When the animals were returned from the variable-interval schedule to the FR 60 schedule of conditioned reinforcement, they rapidly recovered performances similar to those shown in Fig. 2. Once again, as the response requirement was increased, the initial pauses became more prolonged and the running rates higher. Figure 3 shows a representative session on FR 125. One new characteristic of performance emerged clearly after experience on FR 125. The prolonged pauses which continued to occur in the early portions of each session were often initiated after responding had begun; that is, the running rates were interrupted by pauses. After several poker

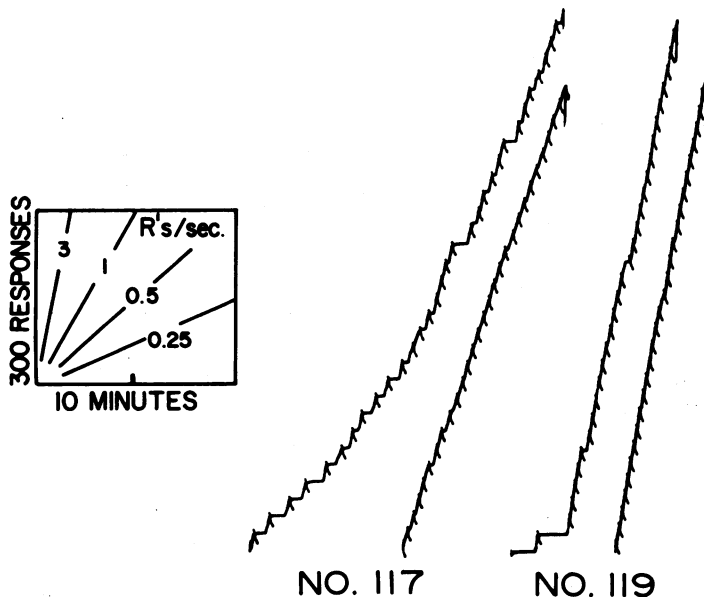


Figure 1. Final performances on the FR 30 schedule of conditioned reinforcement. The cumulative-response records have been telescoped along the abscissa as described by Ferster and Skinner (1, pg. 27). The short diagonal lines indicate the deliveries of poker chips which were exchanged for food at the end of each session. Coordinates and representative response rates are presented at the left of the figure.

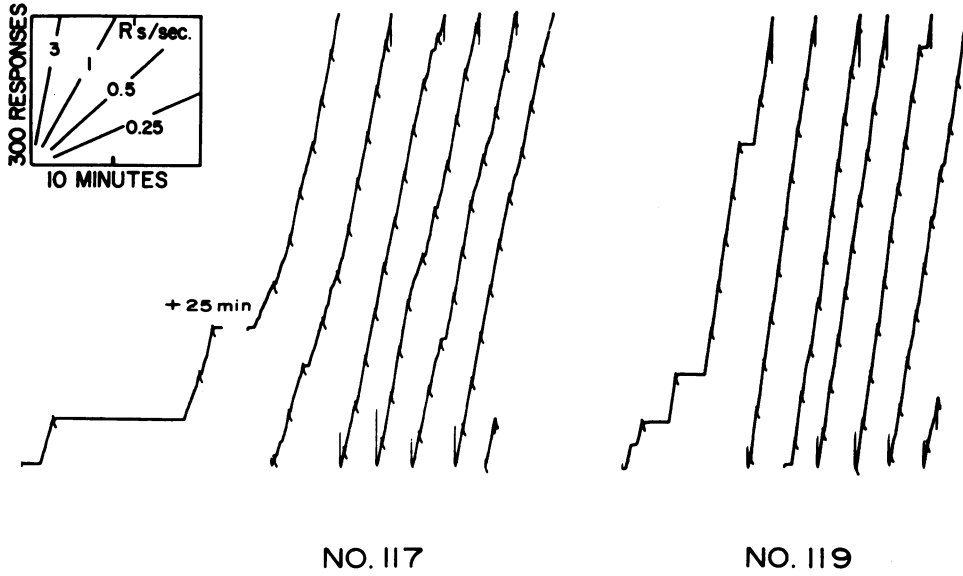


Figure 2. Complete sessions on an FR 100 schedule of conditioned reinforcement. A 25-minute pause was omitted from the record of No. 117 as indicated by the break in the record.

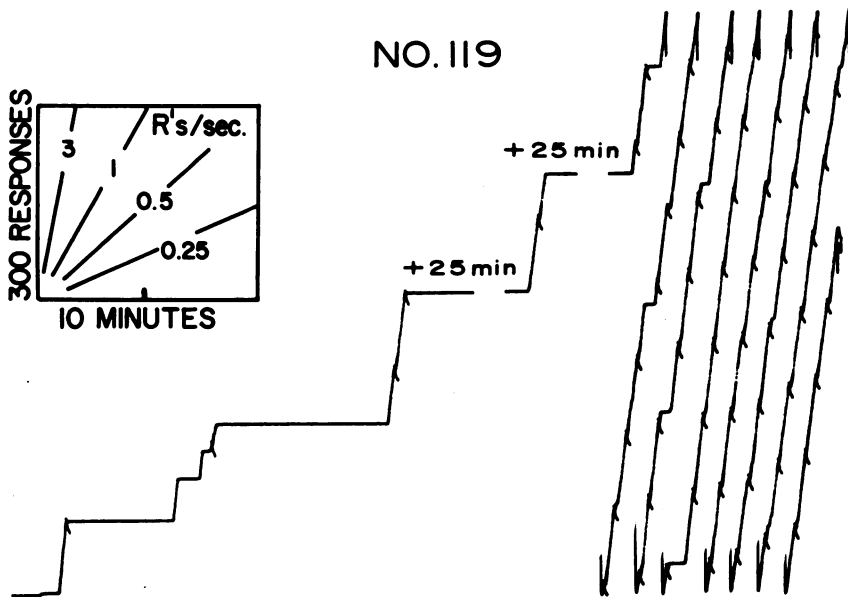


Figure 3. Record of the tenth session for No. 119 on FR 125. Periods of pausing were omitted as indicated.

chips had been obtained, these running rates were sustained for the remainder of the session. When occasional brief pauses did occur, they usually followed poker-chip deliveries. The running rate of No. 117 was 3 responses per second, but in every other way the records of No. 117 at FR 125 were similar to those of No. 119. If the running rates which prevailed near the end of each session had been sustained throughout, each session would have ended within 35 minutes.

Segments from the first two hours of the extinction sessions are presented in Fig. 4. The pausing at the start of the session was followed by an abrupt shift to the running rates which had prevailed in the later portions of each session on FR 125. Number 117 sustained this running rate until about 1200 responses had been emitted, and No. 119 alternated bursts of responding with increasing pauses until about 750 responses had been emitted. Both Ss responded only sporadically over the remainder of the extinction session. Except for the initial pauses, these extinction records are similar to those obtained after comparable schedules of food reinforcement; that is, most responding occurred at the running rates which had prevailed on FR 125.

Because of an apparatus failure in a subsequent session, the red light did not appear when 60 poker chips had been delivered. In fact, it appeared only after 8 hours had elapsed. The white light remained on for these 8 hours, and poker chips inserted during this time were wasted. The performances of both Ss were similar in this session, and only the records of No. 119 are presented in Fig. 5. The poker-chip magazine, which held approximately 103 poker chips, was emptied at about A. In

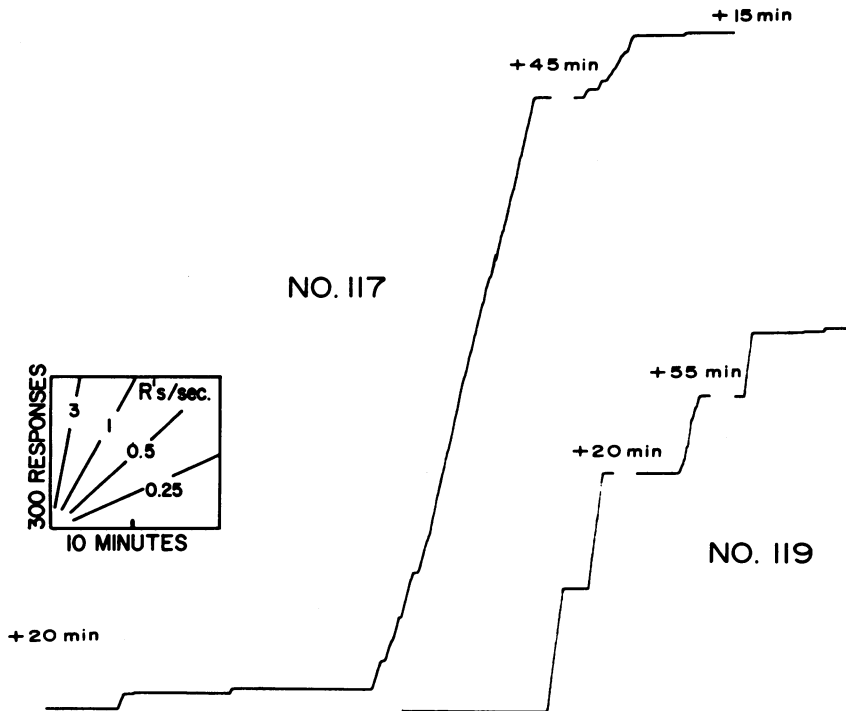


Figure 4. Records of the first two hours of extinction following FR 125. Periods of pausing were omitted as indicated, and the last four hours of the session were omitted.

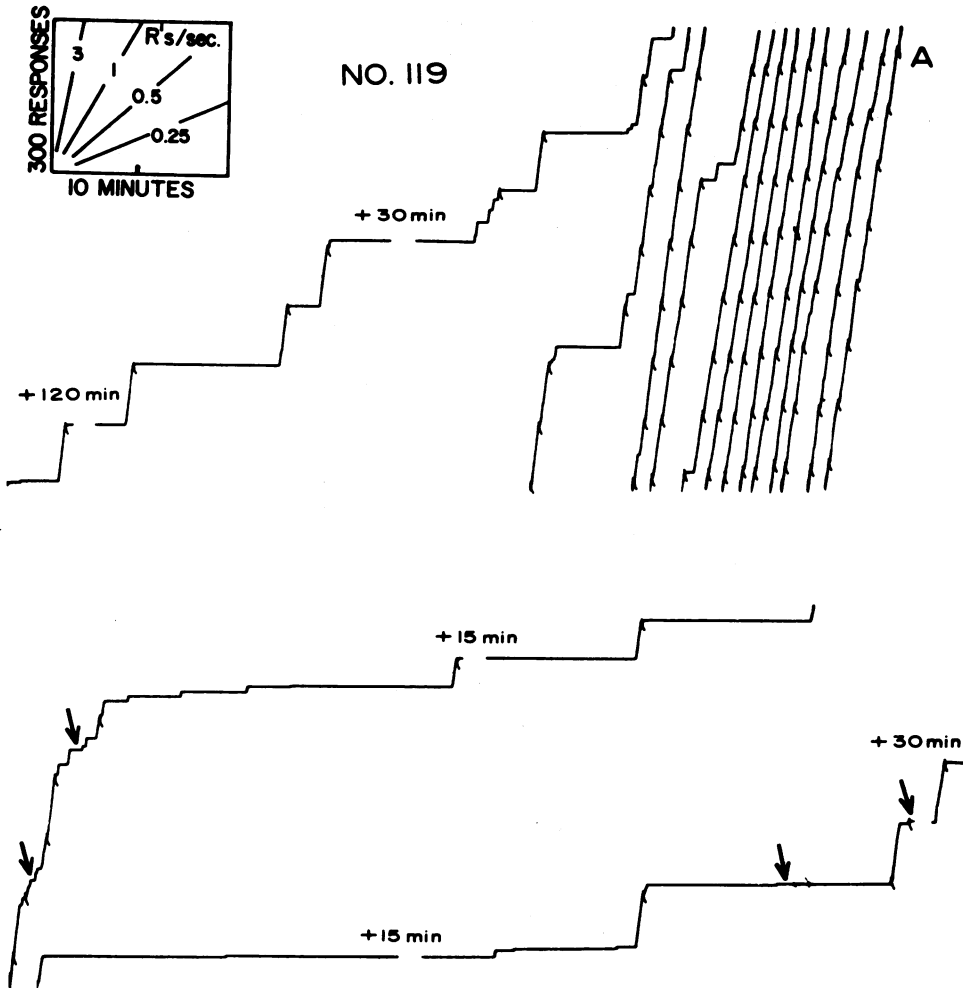


Figure 5. Cumulative-response records from a session in which poker chips could not be exchanged for food until 8 hours had elapsed. The two curves at the bottom of the figure are a continuation of the curves at the top. Periods of pausing were omitted as indicated, and the last part of this session was omitted.

the records just before A, No. 119 emitted 9000 responses at a rate of more than 3 responses per second. It is clear that *S* could sustain this high rate for at least 50 minutes. The two curves in the lower portion of Fig. 5 can be considered as another period of extinction, differing in at least two ways from the extinction curves of Fig. 4. During the session shown in Fig. 5, the poker-chip magazine continued to operate and *S* had in its possession the poker chips obtained in the first portion of the session. This extinction curve is, however, similar to those shown in Fig. 4. That No. 117 wasted only two and No. 119 only four poker chips indicates the extent to which the red light controlled poker-chip insertions.

The A records in Fig. 6 and 7 show representative performances on FR 125. Prolonged pauses prevailed for at least 2 hours at the start of each session. Once

responding began, however, it was sustained except for brief pauses usually following poker-chip deliveries. The B records in Fig. 6 and 7 show the cumulative-response records from the following session in which each S was given 50 poker chips at the start of the session. The initial periods of pausing, which usually totalled more than 2 hours, were almost completely abolished. The 5- to 10- minute pauses

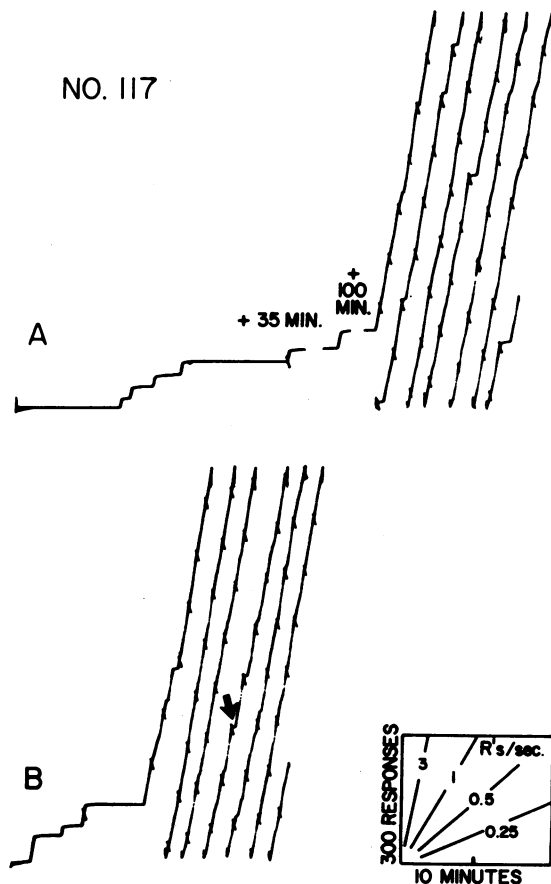


Figure 6. A: FR 125; B: the effect of delivering 50 poker chips at the start of a session. Arrows indicate poker-chip insertions.

that did occur at the start of this session were accompanied by hyperactivity, handling the poker chips, and vocalizations. In this session, No. 117 wasted one poker chip and No. 119, four. Occasionally, No. 119 wasted one or two poker chips late in control sessions, as shown in Fig. 7A; however, No. 117 never wasted poker chips in control sessions. In the sessions following those shown in the B records, both Ss again showed prolonged initial pausing. This procedure was repeated in a later session, and the same effects were observed with both animals.

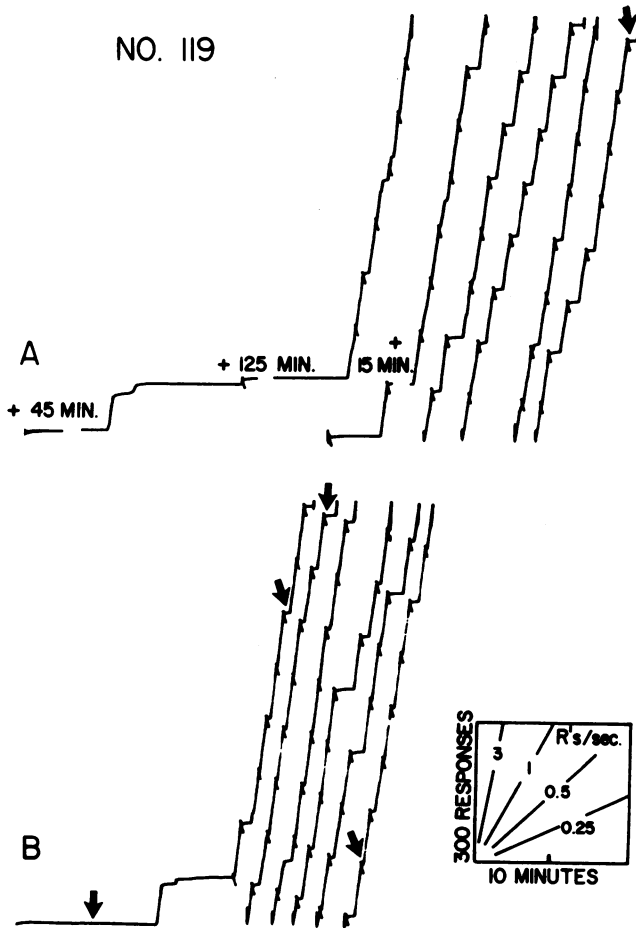


Figure 7. A: FR 125; B: the effect of delivering 50 poker chips at the start of a session. Arrows indicate poker-chip insertions.

#### DISCUSSION

Performance on FR schedules of food reinforcement is characterized by high, stable rates of responding. Pauses may occur before responding begins if the response requirement is high (1, 6) or if sessions are prolonged (5). The frequency with which these pauses occur and their duration tend to increase as each session proceeds. These general characteristics were confirmed in the present investigation of FR schedules of conditioned reinforcement; however, the pauses in the first few FR segments of each session were extremely prolonged, and the animals often stopped responding before completing a ratio at FR 125. This general trend toward more sustained responding late in each session confirms the results found with other schedules of conditioned reinforcement.

The results demonstrate that the animals could sustain high response rates long enough to obtain more than 50 poker chips. (See Fig. 5.) Indeed, they could have

obtained 50 poker chips on FR 125 within 35 minutes if they had started responding at the start of each session. Thus, the prolonged initial pauses, which substantially delayed the receipt of food, are due to some aspect of conditioned reinforcement.

Informal observations indicated that the Ss were very inactive at the start of each session. They became extremely active when they had numerous poker chips, and continually manipulated several poker chips with one hand. Often, they held several poker chips in their mouths and rattled these against their teeth by vigorous head movements. All this activity was accompanied by high rates of responding as well as the screaming and barking which usually occurred during daily feedings in the home cages.

The formal as well as the informal observations suggested the feasibility of interpreting the FR schedule of conditioned reinforcement as a *chained FR schedule* (1). The delivery of each poker chip serves as a conditioned reinforcer for the preceding FR and increases the number of poker chips in the animal's possession. Since the number of poker chips in the animal's possession varies directly with the number of FR segments that have been completed, these poker chips could act as discriminative stimuli indicating the approach of the period of exchange for food. In the study of chained FR schedules with pigeons, for example, a different stimulus is associated with each component of the chain, and the response rates in each component vary directly with the proximity of food delivery. These differential response rates can be temporarily reversed by reversing the sequence of stimuli. If the chaining interpretation is applicable to the present procedure, high response rates might possibly be produced at the start of a session by when the stimuli are introduced which are usually present near the end of the session. This was accomplished by providing each animal with 50 poker chips at the start of a session. This change in procedure did generate high response rates and hyperactivity at the start of the session. Although this procedure was not repeated over several sessions in succession, the change in performance probably would last only until the animals formed a new discrimination. The stimulus control of the initial pausing, which could be characterized as a sort of psychological strain (6), is apparently quite powerful. Variables which would attenuate this control, especially those which might have more lasting effects, would certainly be of interest.

The development and maintenance of behavior by effective conditioned reinforcers is important for gaining an understanding of the behavioral processes involved in conditioned reinforcement *per se*; however, the technical advantages of having effective conditioned reinforcers should not be overlooked. Many reinforcers have immediate physiological effects which have a strong influence on subsequent behavior. For example, if food is the reinforcer, there may be progressive satiation as each session proceeds. The present method would enable one to investigate behavioral processes independently of the effects of food ingestion during a session. Such considerations could be crucial if one were attempting to use a drug as a reinforcer. For example, animals might work for ethyl alcohol, but progressive intoxication would influence results. With the use of poker chips which could be exchanged for alcohol, the reinforcing properties of the drug could be assessed in the absence of these side effects.



## SUMMARY

Ss pressed a telephone key to obtain conditioned reinforcers (poker chips) which could be exchanged for food at the end of each session. Fixed-ratio schedules of conditioned reinforcement ranging from FR 30 to FR 125 were investigated. The results were comparable to results obtained with FR schedules of food reinforcement except for prolonged pauses at the start of each session at the higher FR values. These prolonged pauses were eliminated when each S was given 50 poker chips at the start of a session. The results were discussed with respect to previous studies of conditioned reinforcement.

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