IMPROVEMENT OF SHUTTLE AVOIDANCE BY HANDLING DURING THE INTERTRIAL INTERVAL

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Abstract:

Rats handled between trials during shuttle avoidance training were superior to those not handled on several measures of avoidance learning; handled rats were nonetheless inferior to those receiving one-way training. A second experiment clearly demonstrated that differences between shuttle and one-way avoidance could not be attributed to differences in handling. Furthermore, hypotheses which explained poor shuttle avoidance by reference to either competing freezing responses or the necessity of entering a previously shocked compartment were by themselves unable to account for the present findings. A modification and synthesis of these hypotheses was proposed to provide a better account of the present data. It was suggested that freezing will occur only in the presence of fear-motivated conflict and that conflict is present only when a new response is required which is opposed to a previously successful response.

Article:

The one-way avoidance training procedure, which always requires *S* to run from the same starting box to the same safe box, leads to much more rapid learning than does the shuttle (two-way) avoidance procedure, which requires *S* to reenter the box it left on the previous trial (Theios & Dunaway, 1964). Unlike Ss receiving shuttle training, an *S* receiving one-way training must be returned to the same location prior to each trial, and is thus handled by *E* on each trial. A recent study has demonstrated that performance of rats in the bar-press avoidance task may be greatly improved by handling during the intertrial interval (Wahlsten, Cole, Sharp, & Fantino, 1968). Thus, the one-way training procedure might lead to more rapid learning simply because it requires handling of *S* between trials.

Theios, Lynch, and Lowe (1966) included a control group which received handling during shuttle training in their study of one-way and shuttle avoidance. When trained to a learning criterion of 10 consecutive avoidances, the control made approximately half as many errors as did the unhandled shuttle grow, but was, nevertheless, inferior to the one-way group. On the other hand, Krieckhaus and Kenyon[3] failed to observe any improvement owing to handling during shuttle avoidance training. Because of these conflicting results and because previous experiments have reported little data relevant to the effects of handling, the present experiments were performed to gather more detailed information on the effects of handling upon shuttle and one-way avoidance learning. It was also intended to relate the effects of handling to hypotheses concerning the superiority of one-way over shuttle training.

One hypothesis currently entertained is that shuttle learning is more difficult because it requires the subject to run back into a box which was paired with shock on the previous trial (Denny, Koons, & Mason, 1959). This failure to return to the opposite side before shock occurs has been termed the "staying" response (Theios et al., 1966), so this explanation of poor shuttle avoidance may be termed the staying hypothesis. Several studies have found that strong shocks disrupt shuttle avoidance while they have little effect on one-way avoidance (Krieckhaus & Kenyon, see Footnote 3; Moyer & Korn, 1964, 1966; Theois et al., 1966). These findings suggest that strong shock increases the strength of the conflict between avoiding the shock and entering a place where *S*s had previously been shocked. Knapp (1965) has found impeded jump-out avoidance when the shock and safe boxes are similar; likewise, preshocks in the safe box have been shown to retard one-way avoidance learning (de Toledo & Black, 1967). Thus, when the avoidance response involves approaching cues previously paired with shock, anticipatory avoidances are generally less likely to occur.

Other researchers have concluded that shuttle avoidance is impaired by the presence of competing freezing responses conditioned to the CS by the shock. Shuttle avoidance has been facilitated by *d*-amphetamine (Krieckhaus, Miller, & Zimmerman, 1965), adrenalin (Latané & Schachter, 1962), septal lesions (Trafton, 1967), hippocampal lesions (Isaacson, Douglas, & Moore, 1961), and electroconvulsive shock (Vanderwolf, 1963). Shuttle avoidance decrements have resulted from cingulate lesions (Lubar & Perachio, 1965; Trafton, 1967). The effects of the various manipulations were presumably mediated by direct psychological changes in the tendency to freeze in the presence of aversive cues.

The freezing hypothesis differs from the staying hypothesis in that freezing is said to be specific crouching response which is conditioned to the CS by aversive stimulation (Blanchard, Dielman, & Blanchard, 1968a, 1968b), while staying is said to result from conflicting tendencies to enter and not to enter the opposite box. Freezing implies staying and nonavoidance, but nonavoidance by staying does not imply freezing.

In the case of handling as an independent variable, the freezing hypothesis predicts facilitation of shuttle avoidance, since freezing has been reduced by handling in bar-press avoidance (Wahlsten et al., 1968). The staying hypothesis, however does not clearly predict improvement, for *S* is still required to enter a place where it had previously been shocked.

EXPERIMENT 1

In the present experiment *S*s were trained using either the one-way, shuttle, or shuttle-with-handling procedure. In addition to a measure of response latency, a record of *S*'s location in the box was recorded on each trial in order to obtain a more complete description of performance under each condition. The distance of *S* from the center door at CS onset was believed to be relevant to the contention of Theios et al. (1966) that the development of orienting toward the door following handling could account for the observed facilitation resulting from handling. Furthermore, *S*s in a pilot study were observed to occupy quite dissimilar positions in the starting box at CS onset under the different training procedures.

Method

Subjects. Thirty male Sprague-Dawley albino rats, weighing 300-500 gm. and with no previous experience with electric shock, were used as subjects. They were assigned to groups equated for weight.

Apparatus. The training apparatus was a shuttle box consisting of two similar 15 × 6 × 7 in. compartments (A and B) separated by a motor-driven guillotine door. The sides and top were gray wood, while the front was clear Plexiglas. The grid floor was made of $\frac{1}{8}$-in.-diameter steel bars $\frac{5}{8}$ in. apart; it pivoted at the middle and rested on snap-action switches at each end. Centered on the back wall of each compartment 6 in. from the grid was a 15-w. frosted light bulb, whose light served as the CS in conjunction with the raising of the door. The US was a 650-v. ac shock through a 1-megohm resistor to give .65 ma. The current was applied in pulses at the rate of 100 per minute. Programming was done with operant relay equipment. Latencies were measured with a Standard Electric timer to the nearest .01 sec., and distances were measured to the nearest inch using a scale printed on the Plexiglas front.

Procedure. Ten *S*s each in Group OW (one-way), Group SH (shuttle), and Group 511-HA (shuttle-handle) received 50 trials per day for 4 days with a CS-US interval of 5 sec. and an inter-trial interval (ITI) of 30 sec.

Group OW received standard one-way training. The *S* was placed in the start box facing away from the door and with its head about 10 in. from the door. After 15 sec. the CS light came on and the door was raised. When

S ran far enough into the safe box to operate the switch under the grid floor, the CS (or CS and US) was terminated and the door was lowered. The *8* was returned to the start box by *E's* ungloved hand 10 *sec.* after crossing. Since the handling operation required about 5 sec., the next trial began about 15 *sec.* after *S* was returned, to the start box. Every trial on a particular day began in the same start box and required running into the same safe box. The compartment used as start box (A or B) was counterbalanced across *Ss* and days.

Group SH received shuttle training. The *S* was required to run into the opposite box (safe box) either to avoid or escape shock. That box then became the start box for the next trial. The box (A or B) used as start box on the first trial was counterbalanced across *Ss* and days.

Group SH-HA was similar to Group SH. except *S* was removed from the box 10 sec. following each trial and immediately returned to that same box 15 sec. prior to the start of the next trial. The *S* was always placed with its head about 10 in. from the door and facing away from it. Thus, *S* was handled like Group OW, but required to shuttle like Group SH.

On each trial measures were taken of response latency and distance of *S's* head from the door at CS onset.

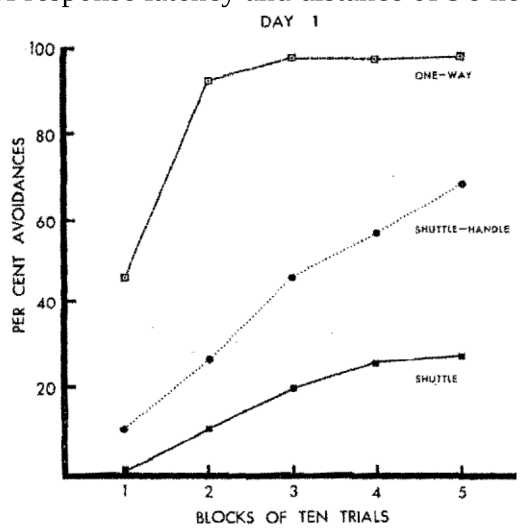

Fig. 1. Percentage of avoidance responses across five blocks of 10 trials each on Day 1 for Groups OW, SH, and SH-HA.

Results

The number of avoidances for each *S* in 10 trial blocks on the 4 days was subjected to an analysis of variance on groups, days, and trials. The statistical analysis indicated very large effects for groups ($F = 54.9$, $df = 2/27$, $p < .001$) and trials ($F = 61.3$, $df = 4/108$, $p < .001$). The Groups × Trials interaction was also significant ($F = 5.30$, $df = 8/108$, $p < .001$). Comparing mean avoidances for the three groups using the Tukey procedure with $\alpha = .05$ indicated that Group OW was superior to Group SH-HA and Group SH-HA was superior to Group SH. Neither the main effect for days nor the Days × Groups or Days × Trials interactions were significant (all ps > .05). This meant that the avoidances on Day 1, shown in Figure 1, were representative of the 3 subsequent days. No further improvement was evident after Day 1.

Mean avoidance latencies pooled over the 4 days gave a significant groups effect ($F = 23.2$, $df = 2/27$, $p < .001$). Using the Tukey test with $\alpha = .05$, Group OW mean avoidance latency (1.67 sec.) was less than that of Group SH-HA (2.10 sec.), and Group SH-HA was less than Group SH (2.78 sec.). Escape latencies for the three groups did not differ significantly ($F < 1.0$).

The, groups also differed with respect to their average position in the box at the start of a trial when the distance scores were pooled over the 4 days ($F = 4.40$, $df = 2/27$, $p < .025$). Using orthogent contrasts, Groups SH (8.60 in.) and OW (7.76 in.) did not differ significantly ($F < 1.0$); Group SH and Group OW mean distances were less than the 10.42 in. for Group SH-HA ($F = 7.57$, $df = 1/27$, $p < .025$). The frequency distributions of distances from the door at CS onset, shown in Figure 2, are actually more indicative of group differences. The frequency of occurrence of each distance score was found during the 200 trials over the 4 days for each *S*. The median frequency of 10 *S*s at each distance yielded the group-frequency distributions. Converting the frequencies to proportions and applying the Kolmogorov-Smirnov two-sample test (Siegel, 1956), Group OW was found to have stochastically shorter distances than Group SH ($\chi^2 = 27.7$, $df = 2$, $p < .001$), while distances of Group SH were shorter than those of Group SH-HA ($\chi^2 = 42.2$, $df = 2$, $p < .001$). The discrepancy between the analyses of mean-distance scores and the distributions of distances was apparently due to the bimodal distribution for Group OW. Clearly, *S*s in Group OW were often very near the door at CS onset, while those in Group SH tended to remain in the middle and those in Group SH-HA moved to the far end following handling and prior to CS onset. The *S*s in Group SH-HA did not turn around and orient towards the center door as reported by Theios et al., 1966), but instead they retreated to the far end and turned about halfway around. The *S*s in Group SH, however, very often did make such an orientation after crossing and then remained immobile in that position until the next trial. The *S*s in Group OW often turned around and approached the door, darting across as soon as it opened. The distance data also indicated that group differences in avoidances and avoidance latency could not be attributed to the shorter runs required of some groups. Although Group SH-HA was generally further from the center door than Group SH, it avoided more often and with shorter avoidance latency than did Group Sh.

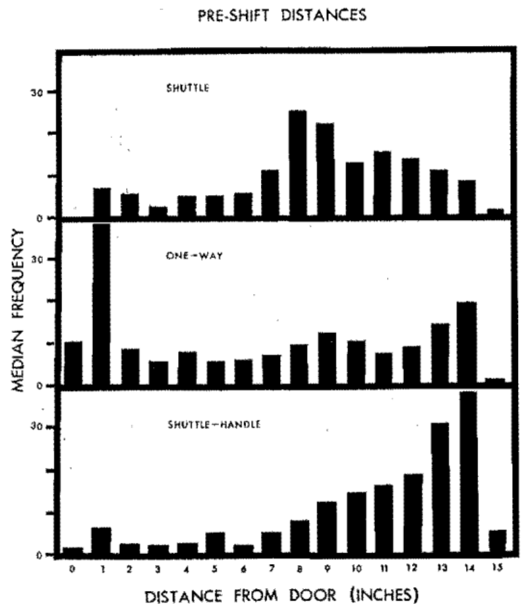

FIG. 2. Median frequencies of various distances from the door at CS onset for Groups OW, SH, and SH-HA.

Discussion

The present results are consistent with those of Theios et al. (1966). Handling during intertrial intervals improves shuttle avoidance learning, but handled Ss are nonetheless inferior to Ss given one-way training. The failure of Krieckhaus and Kenyon (see Footnote 3) to observe facilitation cannot be explained by the present results; clearly, additional study of the components of the handling operation which improve learning is needed.

The explanation by Theios et al. (1966) of the effect of handling, namely that handling provides stimuli to which an orienting response is conditioned, is found to be inadequate. Directly measured orientation towards the door occurred frequently for Group OW, occasionally for Group SH, and almost never for Group SH-HA. The freezing hypothesis, which maintains that the tendency to freeze during the CS is attenuated by the handling operation and that avoidance is thereby improved, is more compatible with these data. The only difficulty for the freezing hypothesis is that, although both Groups OW and SH-HA receive handling, Group OW performs better. Some factor in addition to handling must be operating to account for this difference.

The staying hypothesis does not adequately account for the present results. As in studies using drugs and brain lesions, handling improves shuttle avoidance, even though handled Ss are required to enter a box in which they had previously received shock. Perhaps handling somehow reduces the staying response. If this were true, then

Group SH-HA ought to have made more anticipations and orientations towards the opposite box, as in Group OW, than did Group SH. However, Group SH-HA actually made fewer such responses than Group SH; nevertheless, more avoidance responses were made by Group SH-HA.

EXPERIMENT 2

In Experiment 1 *S*s were required to cross to a box in which they had previously been shocked only during shuttle training. The second experiment was designed to separate further the factors of handling and type of training by requiring *S*s to cross to a place where they had previously been shocked during both one-way and shuttle avoidance training. Utilizing a three-compartment shuttle box, one group was required to run from one end box to the middle box on the first trial. On the next 'trial *S*s ran from the middle box to the other end box without being handled prior to the trial. On the third trial they were returned by hand to the first end box to repeat the sequence. Thus, if an *S* received shock in the middle box on the second trial, it would have to enter a box where it had been previously shocked on the third trial in order to avoid, although it was nevertheless running one way. This technique also permits an examination of the importance of handling for one-way avoidance because on all even-numbered trials *S* would have to run one way without receiving handling prior to the trial. A group given shuttle training in the three-compartment shuttle box ran alternately from the first end box to the middle box and then from the middle box back to the first end box on the next trial, receiving handling only on the trials beginning in the first end box. Control groups which ran one way between only two boxes were also included. In addition, a measure of freezing was obtained by noting whenever *S*'s head was in the same position at both CS and US onsets.

Method

Subjects. Forty-eight male Sprague-Dawley albino rats, weighing 300-400 gm. and with no previous experience with electric shock, were used as subjects. The Ss were assigned to groups equated for weight.

Apparatus. The shuttle box *was* composed of the two boxes (A and B) with grid floors, as in Experiment 1, and a third box (C) adjacent to Box B which was only 12 in. long and had a wooden floor covered with sawdust. A photocell, used to detect S's entrance into Box C, was located 5 in. from the door and 1 in. from the floor. Raising of the door between either Box A and Box B or Box B and Box C started a trial. All other supporting equipment was the same as in Experiment 1.

Design and procedure. The 48 *Ss* were divided into four groups of 12 *Ss* each. All *S*s received trials in a single session with a CS-US interval 5 sec. and a 30-sec. ITI.

Group ABA was required to shuttle between Boxes A and B. The *Ss* were handled 15 sec. prior to each trial starting in Box A and were never handled while they were in Box B.

The *Ss* in Group ABC ran one way from Box A to Box B on one trial and then one way from Box B to Box C on the next trial. They were returned from Box C to Box A by *E* 15 sec. before the start of the trial in Box A. They were never handled while in Box B. Thus, Groups ABA and ABC differed only with respect to the safe box when starting a trial in Box B.

Two one-way control groups were included for purposes of comparison with the two experimental groups. Group AB ran one way from Box A to Box B, while Group BC ran one way from Box B to Box C. The procedures were the same as for Group OW in Experiment 1. These two groups also provided a test of possible faster learning for *Ss* running to a safe box unlike the shock box (Group BC) than for those having similar shock and safe boxes (Group AB).

An indicator of freezing, as in Wahlsten et al. (1968), was obtained by measuring the distance of *S's* head from the door at CS onset (D1) and US onset (D2), If *S* avoided, D2 was set equal to 0 in. Freezing was said to occur when D1 equaled D2.

TABLE 1
Mean Scores for Experiment 2

Group	Avoidance In 50 trials	Trial of first avoidance	Trials to five straight avoidances	Avoidance latency (in sec.)	Escape latency (in sec.)	Distance at CS onset (in in.)
ABA	20.17	16.67	_____a	2.87	7.12	9.98
ABC	42.25	5.42	8.25	1.54	7.31	3.75
AB	39.58	5.67	6.83	1.87	6.56	3.64
BC	39.92	4.58	11.42	1.39	6.90	3.78

a Four *S*s not at criterion

Results

Mean scores for the four groups are presented in Table 1. Inspection of these data suggests that Shuttling Group ABA was retarded in every measure of avoidance learning compared with the other three groups which received one-way training. Orthogonal contrasts (all *dfs* = 1/44) based upon one-way analyses of variance revealed that Group ABA had fewer avoidances ($F = 49.0$), later trial of the first avoidance ($F = 36.9$), longer avoidance latencies ($F = 35.9$), and larger distances from the door at CS onset ($F = 128.9$) than did the three one-way groups (all ps < .01). Group ABA did not differ from the other groups in escape latency ($F < 1.0$). Contrasts (all *dfs* = 2/44) based upon the same analyses of variance showed that Groups ABC, AB, and BC did not differ significantly in either number of avoidance responses ($F < 1.0$), trial of first avoidance ($F < 1.0$), or distance at CS onset ($F < 1.0$). Group AB had shorter escape latencies ($F = 5.69$, $df = 44$, $p < .025$) than Groups ABC and BC. Since four *S*s in Group ABA did not reach even the weak criterion of five consecutive avoidance responses, and thus had indeterminate scores, evaluations were made using a Kruskal-Wallis *H* test. The *S*s in Group ABA met the criterion later than Ss in the other three groups ($H = 25$, $df = 1$, $p < .001$), whereas Groups ABC, AB, and BC did not differ ($H = 2.57$, $df = 2$, $p > .10$).

Comparisons were also made between these various measures on trials when *S* was handled (Box A) and not handled (Box B). Using a *t* test on paired observations, for Group ABA there were no significant differences between trials beginning in Boxes A and B for avoidance responses, avoidance latency, escape latency, or distance at CS onset (all ps > .10). Using the definition of a freezing response as D1 = D2, there was weak evidence of less freezing when *S*s were handled than when not handled ($t = 1.68$, $df = 11$, $p < .10$). For Group ABC neither avoidances, distances, freezes, avoidance latencies, nor escape latencies differed on trials from Box A and Box B.

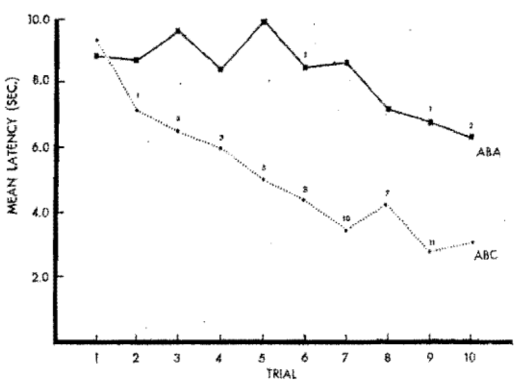

FIG. 3. Mean response latency, including both avoidance and escape responses, during the first 10 trials for Groups ABA and ABC. (The small numbers above each point indicate the number of *S*s out of 12 in each group which avoided the shock on that trial.)

The large difference between Groups ABA and ABC developed within the first 10 trials, as shown in Figure 3. The two groups did not differ in response latency on the first trial ($t < 1.0$), while Group ABC was faster on the second trial ($t = 1.79$, $df = 22$, $p < .05$). Group ABA did not change from Trial 1 to 2 ($t < 1.0$), while Group ABC was faster on the second trial than the first ($t = 2.43$, $df = 11$, $p < .025$). Following Trial 2, the differences in both latency and avoidances were obvious. The groups also differed with respect to the freezing measure. Since not freezing was confounded with avoiding, a more meaningful score was the proportion of instances of freezing on trials when Ss did not avoid. On Trials 3-10 the proportions of freezes, .84 and .61 for Groups ABA and ABC, respectively, were significantly different (χ^2 = 7,07, *df* = 1, *p* < ,01). Thus, freezing was more likely to be observed for the shuttle group than the one-way group when there was no avoidance. Comparisons among Groups ABC, AB, and BC over the first 10 trials revealed no significant differences.

Discussion

Altogether these results indicate that Group ABC performed essentially the same as One-Way Groups AB and BC. The large difference in performance between Groups ABA and ABC cannot be attributed to running to a dissimilar box (C) on every other trial in Group ABC, since Groups AB and BC exhibited nearly equivalent performance.

The high level of avoidance shown by Group ABC on trials starting in Box B demonstrates that handling prior to a trial is not necessary to establish excellent avoidance as in the usual one-way training with handling. This finding is consistent with studies reporting good avoidance in a one-way apparatus not requiring handling (Baum & Bobrow, 1966; Davis, Babbini, & Huneycutt, 1967). Thus, even though the present experiments demonstrate that handling improves shuttle avoidance, the difference between shuttle and one-way avoidance cannot be attributed to differences in handling.

The freezing hypothesis can explain only the improvement in shuttle avoidance due to handling. Freezing was slightly less likely following handling only for Group ABA, In addition, freezing was more likely to occur when an *S* of the Shuttle Group ABA failed to avoid. The freezing hypothesis cannot, however, explain the superiority of the one-way over the shuttle with-handling procedure in either Experiment 1 or 2.

As in Experiment 1, the staying hypothesis alone cannot account for the data. Although Group ABC was expected to be superior to Group ABA because it required *Ss* to enter a place where they had previously been shocked on only half of the trials, two findings contradict the staying hypothesis. First, performance was equivalent for Group ABC on trials starting in Boxes A and B, although trials from Box A required running to a box in which *S* had previously been shocked, Second, Group ABC performed as well as Groups AB and BC which never entered a shock box at all.

Before dismissing the staying hypothesis, it must be noted that, heretofore, staying has been said to result from interference due to the aversive properties of the box previously associated with shock. However, it is reasonable to propose that the relation between the response and extra-apparatus cues might be of importance, since *S* could see *E* and room cues through the Plexiglas front in the present apparatus. With abundant extra-apparatus cues available, Groups ABC, AB, and BC always ran in the same direction, while Group ABA constantly reversed direction. The usual shuttle and one-way procedures confound the extra-apparatus cues and the properties of the start and safe boxes. However, training with the shuttle procedure and rotating the boxes by 180° between trials, thus reversing their positions with respect to extra-apparatus cues give good avoidance (Baum & Bobrow 1966), while one-way avoidance is sometimes disrupted if the relative position of the start and safe boxes are reversed (Lambert & Gorfein, 1958). Thus, *S*s may utilize directional cues to determine the proper response. Of course, an *S* in any given situation may respond primarily to either extra- or intra-apparatus cues or both, depending upon the precise nature of the apparatus and training technique (Restle, 1957). The important consideration for this alternate hypothesis is that performance will be disrupted if a task requires *S* to make a response contrary to a previous successful response, be it based on absolute or relational cues.

Although this revised hypothesis concerning response conflict adequately explains the differences between one-way and shuttle training in the present experiments, it still fails to predict clearly the facilitation of shuttle avoidance by handling, drugs, and brain lesions. The freezing hypothesis, on the other hand, more adequately accounts for such effects. Since freezing does not occur in one-way avoidance, it may be suggested that freezing is significant only when strong fear motivated conflict exists. For such a scheme, freezing, like grooming in other situations (Zeigler, 1964), functions as a displacement response. Likewise, handling, if it does indeed reduce freezing as is indicated by the results for Group ABA in Experiment 2 and those of Wahlsten et al. (1968) is effective only in situations where conflict occurs. Thus, handling is not a critical factor in one-way avoidance, since conflict and freezing are not present, whereas it improves shuttle avoidance by reducing the freezing due to conflicting responses.

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