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Time and context effects after discrimination reversal in human beings

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Two experiments were conducted using a discrimination reversal task in human beings with the aim of exploring the effects of time and context upon retrieval of a discrimination (S: C1+, C2-) that had been previously reversed (S: C1-, C2+). In Experiment 1, a 48-hr retention interval after reversal training led to spontaneous recovery of the original discrimination during the test. In Experiment 2, changing the context between reversal training and testing led to renewal of the original discrimination, independently of whether the context change involved returning to the acquisition context (121 renewal) or going to a different context (112 renewal). These results are in agreement with the predictions of Bouton's retrieval theory (Bouton, 1993).

In the first documented observation of extinction, Pavlov (1927) found that the presentation of a previously conditioned stimulus (CS) in the absence of the unconditioned stimulus (US) led to a gradual decrease on conditioned responding (CR). This decrease is known as the extinction effect, and can be found in a similar way on instrumental conditioning, when an originally reinforced response stops being followed by the reinforcer.

These results have been consistently found in animals (for a review see Bouton, 1993, and Mackintosh, 1974) and humans (Kahng, Iwata, Thompson & Hanley, 2000; Lerman, Iwata, y Wallace, 1999; Matute, Vegas & de Marez, 2002; Paredes-Olay & Rosas, 1999; Pineño & Matute, 2000; Vila, 2000; Vila & Rosas, 2001a, b). The increase in the CR observed during acquisition is taken as an index of the formation of a CS-US association (e.g., Rescorla, 1973). Consequently, a natural interpretation of the decrease in the CR observed during extinction could be to consider that the CS-US association has been eliminated. In fact, models as influential as Rescorla and Wagner's (1972) keep this kind of assumption.

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However, since the pioneer studies by Pavlov (1927) it is known that this interpretation has to be incorrect. The simple passage of time after extinction leads to spontaneous recovery of the extinguished CR (e.g., Brooks, 2000; Burdick & James, 1970; Rosas & Bouton, 1996, 1998), something that could never occur if extinction would have deleted the originally learned CS-US association. This phenomenon has been consistently replicated in different conditioning situations as taste aversion learning (Rosas & Bouton, 1996), appetitive conditioning (e.g., Bouton, 1993), and conditioned suppression (Bouton & Brooks, 1993; Burdick & James, 1970; Harris, Jones, Bailey, & Westbrooks, 2000), and also in causal learning (Vila & Rosas, 2001b).

In a complementary line of evidence, Bouton & Bolles (1979) reported that when learning of the CS-US association takes place in a context that we can call 1, and extinction takes place in a different context (context 2), returning to the acquisition context at testing led to renewal of the extinguished CR. This renewal effect has been consistently found in a wide range of tasks, including appetitive conditioning (Bouton & Peck, 1992; Bouton & Sunsay, 2001; Honey, Willis, & Hall, 1990), conditioned suppression (Bouton & Brooks, 1993; Bouton & King, 1983), taste aversion learning (Rosas & Bouton, 1997b), simple instrumental conditioning (Thomas, McKelvie, & Mah, 1985; Nakajima, Tanaka, Urushihara, & Imada, 2000), and human causal learning (Rosas, Vila, Lugo, & López, 2001; Vila & Rosas 2001b). Later work conduced mainly within Bouton's laboratory has shown that the critical aspect of renewal is leaving the extinction context, rather than returning to the acquisition context (e.g., Bouton y Ricker, 1994; Bouton & Swartzentruber, 1986, 1989).

Renewal and spontaneous recovery clearly demonstrate that extinction cannot be identified with unlearning of the CS-US association. Extinction has to involve new learning. What is learned during extinction is a matter of discussion. Some authors assume that extinction leads to the formation of some sort of inhibitory association between the CS and the US (e.g., Bouton, 1993; Konorsky, 1948), while others think that the inhibitory association is formed between the CS and the CR (Estes, 1955; Hull, 1943; Rescorla, 1997). Leaving aside the specific contents of extinction learning, spontaneous recovery and renewal show that they are stored independently of acquisition learning. Extinction inhibits expression of acquisition, but it does not eliminate acquisition.

To explain spontaneous recovery and renewal, Bouton (1993, 1994) points out that an extinguished CS becomes ambiguous after extinction (it is associated with both, the presence and the absence of the CS). The CS meaning is unique and consistent during acquisition, so the CS is coded independently of the context where it appears. However, the CS becomes ambiguous during extinction prompting an automatic search of something that eliminates the ambiguity, and leading the subject to code the extinction context. Extinction information becomes that way context dependent, so that when the subject leaves the extinction context, extinction will not be longer retrieved. The loss of extinction leads to retrieval of the acquisition information. This information, as the acquisition context was not coded, is not context dependent. Renewal fits naturally with this explanation. Renewal appears because the context change makes retrieval of extinction more difficult, and thus, extinction does not longer inhibit the expression of acquisition.

Bouton (1993) follows up an idea of Spear (1973), and points out that spontaneous recovery is a special case of renewal. The passage of time brings about a context change (physical, internal, temporal) that only affects contextually coded information, that is, extinction. Thus, renewal and spontaneous recovery would be just two different aspects of the same mechanism for retrieval of the information (see also Bouton, Nelson, & Rosas, 1999a, 1999b; Rosas, 2000; Rosas & Bouton, 1997a, 1998).

The interpretation of extinction as inhibition makes extinction akin to other interference paradigms like counterconditioning, lists learning, latent inhibition etc. (e.g., Bouton, 1993). The role of time and context upon retrieval of the information has also been studied in these situations with results akin to the ones reported with extinction. For instance, Thomas et al. (1985), used an operant task to explore the effects of context change upon discrimination reversal. They trained pigeons to discriminate between two coloured keys within context 1 (X+, Y-). Then, they reversed discrimination in context 2 (X-, Y+). When pigeons were subsequently tested in both contexts, generalization gradient peaked around X in context 1, and around Y in context 2.

Time and context effects also have been found in humans using interference procedures different from extinction. Rosas, Vila, Lugo, & López (2001) established a causal relationship between a fictitious medicine and a side effect. Subsequently, the same medicine was related to a different side effect (side effect 2). They found that a retention interval, a context change, or the combination of these two factors after interference training led to retrieval of the original relationship between the medicine and side effect 1, attenuating retroactive interference. This study used a situation akin to Pavlovian conditioning where the dependent variable was a judgment emitted by participants. This is a feature of most of the studies that have explored renewal in human beings (e.g., Baker, Murphy, & Vallée-Tourangeau, 1996; Paredes-Olay & Rosas, 1999; Vila & Rosas, 2001a; 2001b).

The aim of the two experiments presented here was to evaluate the effects of time and context change upon interference in a situation of discrimination reversal in human instrumental learning where participants' performance is recorded behaviourally. As far as we know, there are just a few reports of behavioural evaluation of context and time effects upon interference in human literature (Pineño & Matute, 2000; Pineño, Ortega, & Matute, 2000). The experiments presented here extended the behavioural evaluation to the effects of context change and time upon discrimination reversal in an instrumental learning situation. After establishing a relationship between two stimuli and two outcomes (e.g., A+, B-), the relationship is reversed (A-, B+). Reversal training interferes retroactively with the original training, so that participants end responding to B as if it was followed by "+", rather than

"-". This paradigm has been extensively studied in avoidance learning (e.g., Gordon, Frank, & Hamperg, 1979; Gordon & Spear, 1973; Spear, Smith, Bryan, Gordon, Timmons, & Chiszar, 1980), in appetitive conditioning (e.g., Spear, 1971), and conditioned suppression (e.g., Bouton & Brooks, 1993).

Here, we trained participants in a discrimination where choosing a stimulus C1 in the presence of another stimulus (S) was reinforced, while choosing the alternate stimulus C2 was not reinforced (S: C1+, C2-). Following this training, the relationship between S and C1-C2 was reversed. Choosing C2 was reinforced while choosing C1 was not reinforced (S: C1-, C2+). This treatment produces retroactive interference. Experiment 1 evaluated the effects of a retention interval interposed between reversal training and testing upon retroactive interference. Experiment 2 evaluated the effects of changing the context before the test.

EXPERIMENT 1

As noted in the introduction, the decrease on retroactive interference with the retention interval has been shown in different interference paradigms within animal classical and instrumental conditioning (e.g., Bouton, 1993), and in human causal learning (e.g., Rosas et al, 2001; Vila & Rosas, 2001b). The aim of this experiment was to evaluate the effects of a retention interval upon retroactive interference in a human instrumental task. Participants were trained in a discrimination where they had to choose between two different stimuli in the presence of another one. Choosing one of the stimuli was reinforced during the first phase of training (S: C1+, C2-). During the second phase, the relationship was reversed (S: C1-, C2+). Half of the participants were tested immediately after retroactive interference (group 0). The other half was tested 48 hours later (group 48). According to previous results in the literature (e.g., Rosas et al. 2001; Vila & Rosas 2001b) we expected the 48-hr retention interval to decrease retroactive interference, so that participants in that group would perform closer to the information received during acquisition.

METHOD

Participants. Twenty students of Psychology at the Universidad Nacional Autónoma de México, FES Iztacala participated in the experiment. They were between 19 and 24 years old without previous experience with the task. Seventy per cent of them were women. Their participation in the experiment was voluntary.

Apparatus. The experiment was conducted in a room where a standard IBM compatible computer with a pair of speakers was placed. Procedure was implemented using the program Clipper for Windows (Diseño y desarrollo de Sistemas, Co.).

Stimuli were presented on the computer screen against a 100 x 100 pixels white background within a 540 x 332 pixels grey background. As can be seen in Figure 1, one of the white backgrounds was placed in the top centre of the screen. Sample stimuli were presented always there. The white backgrounds where comparison stimuli were presented were placed at the bottom right and left quadrants of the screen, equidistant from the sample stimulus.

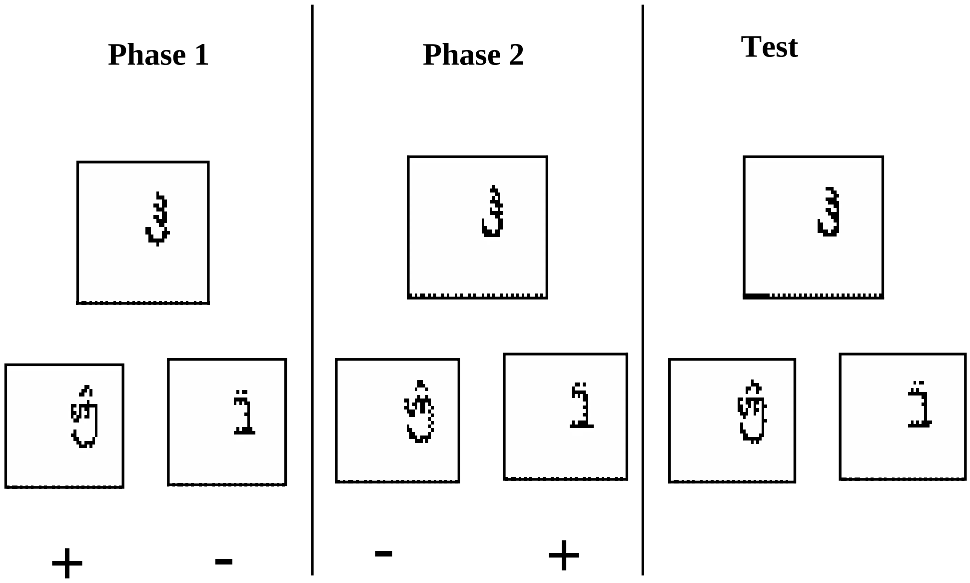

Figure 1. Example of the experimental task used in this experiment.

Two symbols roughly similar to characters of the Chinese alphabet, without meaning for participants, were used as sample stimuli (S1 and S2), counterbalanced across participants. Two different symbols were used as comparison stimuli C1 and C2, counterbalancing between trials the place where they appeared on the screen. Participants gave their response by clicking with the mouse within the area of the comparison stimuli.

Procedure. Participants were run one by one. They were placed in front of the computer and the following instructions appeared on the screen (the actual instructions were presented in Spanish):

Welcome!

There will appear three symbols on the screen, one at the top, and the other two at the bottom of the screen. Your task will consist on choosing the bottom symbol that you think keeps a relationship with the *top symbol. To pick a symbol press the left button of the mouse when the pointer is on top of the symbol that you believe is the correct one. Whenever you are ready press the left button to begin.*

Each trial begun with a warning noise (a "ding") presented through the speakers. The sample stimuli and the two comparison stimuli appeared immediately afterwards. When the sample stimulus was S1, comparison stimuli were C1 and C2. Choosing one of the comparison stimuli was followed by feedback in red capital letters. Feedback was the word "right" accompanied with the sound Tada.wav (Microsoft co.) if the choice was the correct one, and the word "wrong" accompanied with the sound Chord.wav (Microsoft co.) if the choice had been incorrect. If the participant did not make a choice within 15 seconds the trial ended, and the sentence "no response" appeared on the screen. When S2 was the sample stimulus there were no comparison stimuli, and the choice of any of the white backgrounds was not followed by feedback. S2 was irrelevant and included solely as a distracter stimulus, with the only aim of making the task slightly more complex for participants. Without the use of the distracter stimulus, acquisition is so fast that makes difficult to detect any effect upon it. A 3 seconds intertrial interval was used.

Participants were randomly assigned to one of the two experimental groups (0 and 48) before the beginning of the experiment. The experiment lasted 3 days and was run in three phases. The design of the experiment is presented in Table 1.

Table 1. Design of Experiment 1.

Group	Acquisition	Reversal training	Retention interval	Test
0			0 hours	
	S: C1+, C2-	S: C1-, C2 +		S: C1, C2
48			48 hours	

Note. S: Sample stimulus. C1 & C2: Comparison stimuli, counterbalanced across participants. +: correct. -: incorrect.

Acquisition: Twelve trials with S1, and 12 trials with S2 were randomly intermixed. The correct choice for S1 was the comparison stimulus C1 in both groups.

Reversal: It was identical to the acquisition phase, with the exception that the correct choice for S1 was the comparison stimulus C2.

Test: There were 4 trials with S1 and 4 trials with S2 randomly intermixed. Participants did not have feedback on any of these trials. Participants in group 0 received the test immediately after reversal training, without any sign that the test was going to take place. Participants in group 48 left the laboratory after reversal training and were requested to come back 48 hours later for the test (the instruction was e.g., “please, come back next Wednesday at 10:30 to finish the experiment”). The test was presented then immediately with participants receiving the instruction “you are going to finish the task that you begun two days before.” Thus, groups were equated with respect to the time they received acquisition and reversal training.

Dependent variable and statistical analysis. Response in each test trial was recorded, and percentage of response was calculated by taking as reference the correct combination during acquisition (S1-C1). That is, a value of 100% in our dependent variable reflects performance perfectly adjusted to the acquisition phase. A value of 0% reflects performance perfectly adjusted to the reversal phase, while a value of 50% reflects random performance, intermediate between the two phases. Percentages were evaluated with analysis of variance (ANOVA). The rejection criterion was set at $p < .05$.

RESULTS AND DISCUSSION

Figure 2 presents the percentage of response to S1-C1 relationship at the end of acquisition, reversal, and testing for Groups 0 and 48 (four-trial blocks). Acquisition and reversal proceeded uneventfully, and without differences between groups. Percentage of correct responses was high by the end of acquisition, and low by the end of reversal in both groups, reflecting performance appropriate to acquisition and reversal training, respectively. At testing, the 48-hr retention interval spontaneously recovered acquisition performance. Statistical analysis confirmed these impressions. A 2 (group) x 3 (phase) found a significant main effect of group [$F(1, 18) = 76.41$], and phase [$F(2, 36) = 463.30$]. Most importantly, there was a significant group by phase interaction [$F(2, 36) = 126.61$].

Subsequent analysis to explore the group by phase interaction found that the simple effect of group, that it was not significant during acquisition and reversal training [$Fs < 1$], it was significant at testing [$F(1, 18) = 147.28$]. The simple effect of test was significant in both groups [$Fs(2, 18) \geq 186.91$]. Thus, both groups acquired and reversed the discrimination equally well. However, a 48-hr retention interval led to performance close to the acquisition information, with a higher percentage of responses to S1-C1 in that group than in group 0. Response to S2 remained random throughout the experiment.

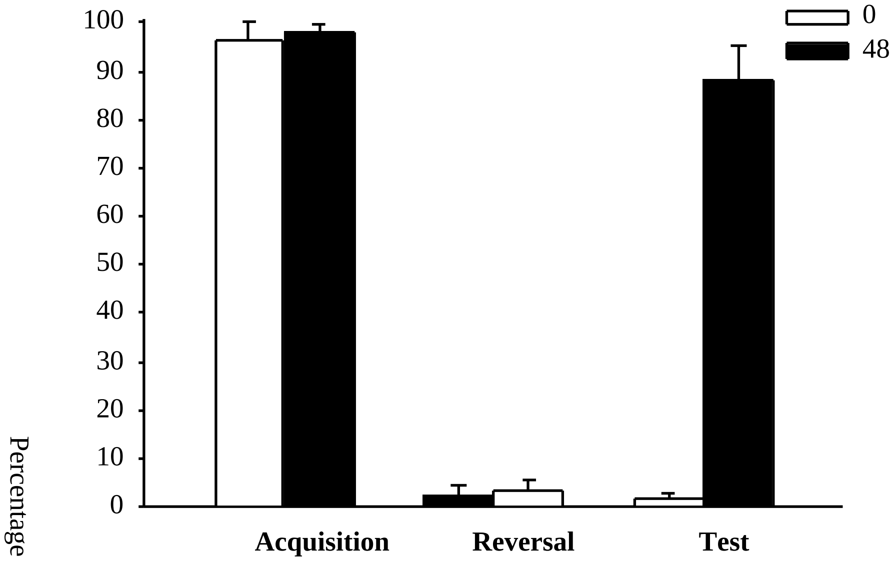

Figure 2. Percentage of response to S1-C1 relationship at the end of acquisition, reversal training, and testing (4-trial blocks), for groups 0 and 48 in Experiment 1. Error bars denote standard error of the mean.

The increase in percentage of response observed with the 48-hr retention interval suggests that the passage of time leads to a decrease in retroactive interference similar to the one previously found with other procedures in animals (e.g., Burdick & James, 1970; Harris et al., 2000; Rosas & Bouton, 1996) and human beings (Rosas et al., 2001; Vila & Rosas, 2001b). This result clearly suggests that reversing the discrimination does not eliminate the originally learned response in a matched to sample task, a result that resembles those previously found with reversal of the discrimination in animals (Bouton & Brooks, 1993; Gordon et al., 1979; Spear et al., 1980).

EXPERIMENT 2

Experiment 1 found spontaneous recovery of the originally learned discrimination 48 hours after learning the reverse discrimination. According to Bouton's theory (1993) time effect upon retrieval of the information is just a special case of contextual change. In fact, there are many demonstrations where a physical context change resembles the effects of a retention interval (e.g., Bouton & Peck , 1992; Rosas & Bouton, 1998; Rosas et al, 2001).

The aim of Experiment 2 was to explore the effects of a context change upon retrieval of the information in a matched to sample task. We expected that a change of context between reversing the discrimination and testing would lead to renewal of the originally learned discrimination. According to Bouton's theory (1993), renewal should occur independently of whether the context change after acquisition implies returning to the original acquisition context, or going to a new context.

We used the four-group design presented in table 2. All participants were trained in discrimination between two comparison stimuli (S: C1+, C2-). Then, the relationship was reversed (S: C1-, C2+). Finally, they received a test with C1 and C2 in the presence of S. Groups 111, and 112 received acquisition and reversal in context 1. Groups 122 and 121 received acquisition in context 1, and reversal in context 2. Groups 111 and 122 received the test in the same context where they had received reversal training. Groups 121 and 112 received the test in a context different from the context where reversal training took place. We expected that the change of context between reversal training and testing would produce renewal of the originally learned discrimination, so that groups 112 and 121 would retrieve acquisition performance at testing.

METHOD

Participants and apparatus. Forty students with similar characteristics to the ones that participated in Experiment 1 participated in this experiment. Apparatus were the same used in Experiment 1, except for what follows. Contexts were two different computers. One of the computers had a screen configuration of 640 x 480 pixels, and the other had a screen configuration of 800 x 600 pixels. Computers were partially counterbalanced as contexts 1 and 2 across participants. Of the 5 participants that were trained with symbol 1 reinforced, 3 were trained in computer 1 and 2 in computer 2, while the reverse was true for the 5 participants trained with symbol 2 reinforced. Counterbalancing could not be completed because 2 participants failed to attend their appointment.

Procedure. The design of the experiment is presented in table 2. Procedure was identical to the one described in Experiment 1 except for what follows. Participants were randomly ascribed to 4 groups before the beginning of the experiment (Groups 111, 122, 112, and 121). All groups received training in context 1. Groups 111 and 112 received reversal training in context 1, while groups 122 and 121 received reversal training in context 2. Finally, groups 111 and 121 received the test in context 1, while groups 122 and 112 received the training in context 2. Thus, groups 121 and 112 received the test in a context different from the reversal-training context, while groups 111 and 122 received the test in the same context where they had received reversal training. All groups were tested immediately after reversal training. Participants that change the context were conducted to the new context with the instruction “lets continue with the experiment on this computer.” No other instruction was given to participants to indicate that phases changed.

Table 2. Design of Experiment 2.

<table>
<tr><th>Group</th><th>Acquisition</th><th>Reversal training</th><th>Test</th></tr>
<tr><td>111</td><td rowspan="4">Ctx 1 S: C1+, C2-</td><td rowspan="2">Ctx 1 S: C1-, C2 +</td><td>Ctx 1 S: C1, C2</td></tr>
<tr><td>112</td><td>Ctx 2 S: C1, C2</td></tr>
<tr><td>122</td><td rowspan="2">Ctx 2 S: C1-, C2 +</td><td>Ctx 2 S: C1, C2</td></tr>
<tr><td>121</td><td>Ctx 1 S: C1, C2</td></tr>
</table>

Note. S: Sample stimulus. C1 & C2: Comparison stimuli, counterbalanced across participants. +: correct. -: incorrect.

RESULTS AND DISCUSSION

Acquisition and reversal training proceeded normally. Mean percentage of response to S1-C1 for groups 111, 122, 112, and 121 was, respectively, 98.33, 98.33, 94.99, and 93.32 at the end of acquisition (4-trial block), 29.97, 41.57, 38.27, and 33.30 at the beginning of reversal, and 3.33, 8.30, 8.30, and 1.66 at the end of reversal. A 2 (context change) x 2 (test context) x 3 (phase) ANOVA only found a significant main effect of phase [$F(2, 72) = 404.63$]. No other main effects or interactions were statistically significant [$Fs(1, 36) \leq 2.26$]. Thus, context change after acquisition did not affect participants’ performance. Response to S2 remained at random level throughout the experiment.

Figure 3 shows mean percentage of response to S1-C1 during the test for groups 111, 122, 112, and 121. Percentage of response in groups 111 and 122 was low, reflecting performance according to the information learned during reversal training. However, percentage of correct responses was increasingly greater in groups 112 and 121. These impressions were confirmed by statistical analysis. A 2 (context change) x 2 (test context) found a significant main effect of context change [$F(1, 36) = 52.35$]. The main effect of test context fell just short of significance [$F(1, 36) = 3.50$, $p = .69$].

Most important, the interaction between context change and test context was statistically significant [F(1, 36) = 10.70].

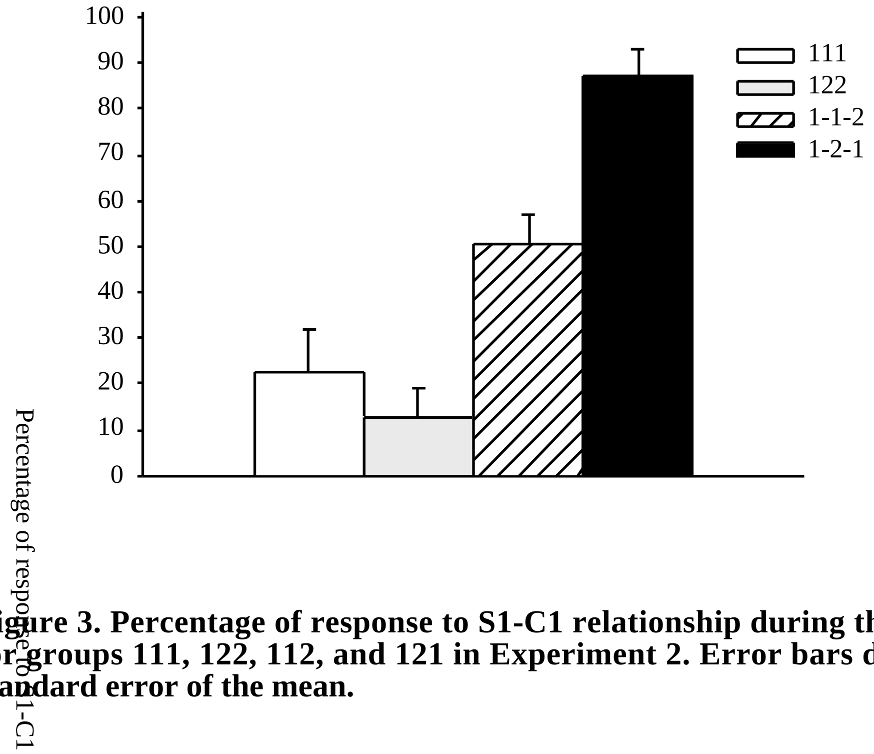

Figure 3. Percentage of response to S1-C1 relationship during the test for groups 111, 122, 112, and 121 in Experiment 2. Error bars denote standard error of the mean.

Planned comparisons run to explore the test context by context change interaction found that the simple effect of context change was significant independently of the test context [Fs(1, 18) ≥ 6.28]. Thus, changing the context produced a decrease in retroactive interference independently of whether this change placed participants in the acquisition context, or took them to a different context. On the other hand, the effect of test context was significant when the test context was different from the reversal-training context [Fs(1, 18) = 19.49], but it was not significant when there was not a context change between reversal training and testing [F<1]. Thus, the context change effect was bigger in the group that returned to the original context during the test (group 121) than in the group that received the test in a context different from the acquisition and reversal contexts (group 112).

Taken together, these results found renewal of the originally learned discrimination when the context was changed after reversal training. As noted in the introduction, this is the kind of result predicted by Bouton’s retrieval theory (Bouton, 1993). These results replicate previous results in humans where retroactive interference decreased when the context was changed before the test (Rosas et al. 2001), extending them to a situation of discrimination reversal where a behavioural measure of performance is taken (see Pineño & Matute, 2000; Pineño et al., 2000).

Performance in group 112 was random, leaving open the question of whether this effect reflects true partial recovery of the originally learned discrimination or it simply reflects random performance of confounded participants because of the change of context. However, it should be noted that the same context change did not affect performance when it took place before reversal training (groups 121 and 122). If the change of context by itself would have made participants to respond random, then a similar effect should have been found in the first four trials of reversal for groups 121 and 122 with respect to the other two groups. The fact that the context effect appeared only at testing suggests that random performance in group 112 reflects partial recovery of the first learned discrimination, rather than a hypothetical spurious effect of changing contexts.

Though renewal appears independently of the test context, renewal was bigger when participants were taken to the acquisition context, than when they were taken to a different context. We are not aware of any experiment in the causal learning literature where these two types of context change are compared. Rosas et al (2001) reported similar context change effects using 121 and 112 designs, but the comparison should be established across experiments. In any case, finding a lower effect of context change after a 112 design than after a 121 design is not so rare in the animal literature (e.g. Bouton & Swartzentruber, 1986; Nakajima et al., 2000; Tamai & Nakajima, 2000). The difference between the two procedures probably indicates that some kind of features of the originally trained context are coded, but that either they are not enough as to make context-dependent the originally trained information, or training context is coded retroactively during the reversal phase when this one takes place in a different context. This idea poses a problem for Bouton's (1993) retrieval theory. In such a theory, it is assumed that context is not coded until information becomes ambiguous. This assumption is based on the finding that context change does not usually affect acquisition (see groups 122 and 121 above). Then, retrieval of the first-learned information would exclusively depend on leaving the interference context. Therefore, the theory predicts a similar effect of 112 and 121 renewal. The fact that 121 renewal shows to be stronger suggests that returning to the acquisition context is important, even though the lack of context change effect upon acquisition suggests that context was not coded before interference, and that retrieval theory should be modified to include this characteristic.

GENERAL DISCUSSION

Experiment 1 found that a retention interval placed between reversal training and testing led to retrieval of the originally trained discrimination. Experiment 2 found that the same results could be found when participants are tested outside the reversal context. These results replicate and extend previous results found with animals (e.g., Bouton & Brooks, 1993), and humans (e.g., Rosas et al., 2001), suggesting that reversal training does not erase the originally learned acquisition.

The effects of retention interval and context change were quite similar between them. This similarity opens the possibility of using the same explanation for both effects. According to Bouton (1993), when the information becomes ambiguous during the reversal-training phase, the new information is coded together with the context. According to this author (see also Bouton et al., 1999a, 1999b), the passage of time after reversal training may produce by itself a gradual change in the context where reversal training took place. This change of context would affect exclusively second-learned information that enters in competition with the information originally learned; that is, it would impair retrieval of the information about reversal training. Interpreted this way, spontaneous recovery is considered a special case of renewal, specifically, a special case of 112, or 123 renewal, depending on the length of training and interference.

Of course, the fact that two different manipulations produce equivalent effects upon the same dependent variable is not enough by itself to conclude that both manipulations are affecting the same underlying mechanism. However, similarity between context and time effects upon retrieval of the information is only one of the results suggesting that both effects may be reflecting the same underlying mechanism. Additional evidence for the interpretation of time effects in terms of a context change comes from the fact that those situations where retention intervals do not seem to have effects, as simple conditioning (e.g., Hendersen, 1985) or long term habituation (e.g., Csànyi, Csizmadia, & Miklosi, 1989) does not seem to be affected by the context change either (for a review see Bouton, 1993; Bouton et al. 1999a). Similarly, both, spontaneous recovery and renewal can be attenuated by the presentation of a cue that reminds the animals of the context where interference took place (Brooks & Bouton, 1993; 1994). Within the same line of evidence, it has been found recently that the effects of a context change and a retention interval upon retrieval of the information can be additive (Rosas & Bouton, 1997a; 1998; Rosas et al., 2001). In fact, in one experiment conducted shortly after the ones reported here, additivity between context and time effect was also found with the task used in these experiments (Vila, Romero, & Rosas, 2002). Taken all together this evidence suggests that the effects of time and context change may be reflecting the action of the same underlying mechanism, namely, a context change.

In summary, the experiments reported in this paper extend time and context change effects to an interference paradigm in human instrumental learning where participant's performance is behaviourally recorded. Both manipulations seem to have parallel effects, decreasing retroactive interference. The results of these experiments add to the evidence in the literature that suggests that time and context effects appear similarly within different task and species, suggesting that some basic memory mechanisms may by shared by different animal species, including human beings.

RESUMEN

Efectos del tiempo y del contexto tras la inversión de una discriminación en seres humanos. Los presentes experimentos utilizaron una tarea de inversión en la discriminación para examinar en seres humanos los efectos del paso del tiempo y el cambio de contexto sobre la recuperación de una discriminación [S: C1+, C2-] una vez que ésta ha sido invertida [S: C1-, C2+]. En el Experimento 1, un intervalo de retención de 48 horas tras la fase de inversión dio lugar la recuperación espontánea de la discriminación original durante la prueba. En el Experimento 2, el cambio de contexto entre la fase de inversión y la prueba dio lugar a una renovación de la discriminación original, independientemente de si este cambio de contexto suponía el regreso al contexto de adquisición (renovación 121) o pasar a un contexto distinto (renovación 112). Estos resultados se ajustan a lo predicho desde la teoría de la recuperación de la información de Bouton (1993).

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