Research Article

Giving Contexts Informative Value Makes Information Context-Specific

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Abstract. Contexts are sometimes informative about relationships that occur within them and sometimes not. The goal of this experiment was to determine the effect of that information value on the context-specificity of learning. Participants performed an instrumental task within a computer game in which they defended different Andalucía beaches (contexts) by destroying several attackers (planes or tanks) by clicking on them (responses) with the mouse. A colored sensor (discriminative stimulus) indicated to participants which attacker could be destroyed in a given trial – that is, which of the instrumental responses would be reinforced. Three groups of participants received training on a discrimination between two discriminative stimuli (X and Y) in Context A. The discrimination was reversed in Context B for Group I (informative). Group NI1 received the same X-Y discrimination in Context B. Group NI2 did not receive training with X and Y in Context B. Additionally, participants received training with cue Z in Context A, which consistently signaled the same outcome. A single test trial with Z revealed a lower response rate in Context B than in Context A in Group I, while no differences across contexts were found in Groups NI1 and NI2. Results suggest that when the context is informative about relationships within the experimental setting, even those relationships for which the context is not informative become context-dependent.

Keywords: attention, context-switch effect, discrimination, human beings, instrumental learning, renewal

Both human and nonhuman animal learning and memory literatures show that performance sometimes becomes impaired when information is learned and tested in different contexts, suggesting that the context in which the information is acquired may become a reference framework for its retrieval (e.g., Baddeley, 1992; Bouton, 1993; Tulving & Osler, 1968). For instance, in a typical renewal situation a cue is paired with an outcome in Context A (acquisition), and then the same cue is presented without the outcome in Context B (extinction). When either animals or participants are then evaluated about the relationship between the cue and the outcome, performance according to the cue-outcome relationship is greater in Context A than in Context B (ABA renewal, Bouton & Bolles, 1979; Rosas & Bouton, 1998; Rosas, Vila, Lugo, & López, 2001). Similar results have been reported when acquisition and extinction take place in Context A, and the test is conducted in Context B (AAB renewal, Bouton & Ricker, 1994; Rosas & Callejas-Aguilera, 2006; Rosas, García-Gutiérrez, & Callejas-Aguilera, 2007), and when acquisition, extinction, and testing are conducted in three different contexts (ABC renewal, e.g., Pineño & Miller, 2004; Thomas, Larsen, & Ayres, 2003), suggesting that extinction performance is more context-dependent than acquisition performance.

However, under many experimental conditions performance is often independent of the match between acquisition and testing contexts. For instance, in most cases of simple excitatory conditioning in animal learning literature, conditioned responding to the cue paired with the unconditioned stimulus is similar, regardless of whether the test takes place in the learning context or in a different but familiar context (see Bouton, 1993 for a review). Similar results have been found in human predictive and causal learning (e.g., Paredes-Olay & Rosas, 1999; Rosas et al., 2001).

Simple excitatory conditioning and predictive judgments about reliable cue-outcome relationships can also be made context-dependent in some situations (e.g., Bonardi, Honey & Hall, 1990; Hall & Honey, 1989, 1990; León, Abad, & Rosas, in press; Rosas & Callejas-Aguilera, 2006, 2007; Rosas, García-Gutiérrez, & Callejas-Aguilera, 2006). For instance, Rosas and Callejas-Aguilera (2006) conducted four experiments in human predictive learning and found that probability judgments about a cue-outcome relationship were impaired by a context-switch when such a relationship was learned while (or after) a different cue underwent extinction.

Given these mixed results, an important issue within the context-switch effect literature is to determine the conditions that lead to context-specificity of learned information. Bouton (1993) suggested that there are two types of information that become context-specific: Inhibitory information (i.e., cue-no outcome relationships) and the second information that it is learned about a cue (i.e., cue-outcome 2 after having learned that the cue was followed by outcome 1). Sometime later, Nelson (2002) showed that a key factor determining context-specificity of information was the order in which such information was learned. In a situation in which two different types of learning about the same cue were sequentially established, retrieval of second-learned

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information about a cue was found to be more context-dependent than retrieval of first-learned information, regardless of whether such information was excitatory (the cue is followed by the outcome) or inhibitory (the cue signals the absence of the outcome). When explaining why second-learned information is more context-specific than first-learned information, Bouton (1997) points out that giving the cue a second meaning makes the cue ambiguous. Ambiguity could lead participants to pay attention to the contexts so that ambiguous information is coded with the context in which it is presented.

Rosas and colleagues explored the idea that ambiguity may lead participants to pay attention to the contexts and further suggested that the main factor involved in making information context-specific is the attention participants (or animals) pay to the context during learning. That is, we assume that context-dependency does not depend on both attention and the ambiguity of the stimulus, but only on attention which is coincidentally aroused by ambiguity.

Attention is understood as a mechanism of cognitive control that is directed at processes that select information in support of efficient performance (Crump, Vaquero, & Milliken, 2008). If something in the situation makes participants orient to the context, performance will be context-dependent, regardless of the type of information involved (Rosas, Callejas-Aguilera, Ramos-Álvarez, & Abad, 2006; cf. Bouton, 1993, 1997; Nelson, 2002). Rosas, Callejas-Aguilera et al. (2006) assume that, once participants pay attention to the context, all the information in that context becomes context-specific. According to these authors, attention to the context may be modulated through five different factors: (1) Ambiguity in the meaning of the cues raises attention to the contexts leading to both ambiguous and nonambiguous information learned within those contexts to become context-specific (e.g., Rosas & Callejas-Aguilera, 2006, 2007; Rosas, García-Gutiérrez et al., 2006; but see Nelson & Callejas-Aguilera, 2007). (2) An increase in the relative salience of the context with respect to the cues should increase attention to the contexts and context-specificity of the information learned in them (see Abad, Ramos-Alvarez, & Rosas, 2009; Bouton & Sunsay, 2001). (3) It is assumed that attention to irrelevant contexts changes with experience. At the beginning of training participants in a new task do not have enough information as to discard contexts as potential predictors of the outcome (or of the cue-outcome relationships), so contexts will be attended to and information learned on them will become context-specific. However, as training progresses participants learn to discard irrelevant contexts and information will be coded, regardless of the context where it is learned (e.g., León et al., in press; Myers & Gluck, 1994). (4) It is assumed that attention to the contexts may be modulated by instructions in human participants where instructions that increase or decrease attention to the learning contexts would prompt or attenuate context-specificity of the information (e.g., Eich, 1985; see Bouton, 1993; but see also Neumann, 2007). Finally, (5) it is assumed that information learned in informative contexts will become context-specific, regardless of whether it is attached to an ambiguous stimulus, or first- or second-learned information.

There is at least one experiment in the animal learning literature which suggests that giving the contexts informative value may lead to context-switch effects on performance. Preston, Dickinson, and Mackintosh (1986, Experiment 2) trained two Groups of rats to discriminate between two cues in one context (Context A). In Context A rats received S1+ / S2− / S3+, where "+" and "−" represent the presence and the absence of the outcome, respectively. Groups differed in the treatment they received in Context B. In Group Cond (conditional discrimination), the S1-S2 discrimination was reversed in the alternative context (Context B), thus, Contexts A and B were informative with respect to the task; in Group Disc (discrimination), the discrimination between S1 and S2 was the same across contexts; thus, contexts were not informative about the task. S3 was not trained in Context B in any of the groups. Testing was conducted with S3 in Context A or B. During the test, extinction of S3 was faster in Context B in Group Cond, while no differences across contexts were found in Group Disc. This result suggests that the role of context on performance depends on the informative value of the context. S3 was consistently paired with the outcome and showed some context-dependency, but only when it was learned about in a context that was informative about another relationship. Unfortunately, the treatment received by Group Disc in the experiment conducted by Preston et al. (1986) allows for some ambiguity in the interpretation of the results. The context-switch effect may have been prompted by the informative value given to the contexts in Group Cond, or training the same S1-S2 discrimination in the two contexts may have led rats in Group Disc to ignore the contexts, reducing the context-switch effect that might have appeared had they used contexts that were informatively neutral.

The experiment reported here was conducted with the goal of exploring the role of manipulating the informative value of the context on the context-switch effect in human instrumental learning. Participants played a computer game (Gámez & Rosas, 2005, 2007; León et al., in press) in which they were requested to defend Andalusia against invasion by shooting missiles at tanks or planes by clicking on their respective pictures (R1 and R2). A colored sensor at the top of the screen played the role of a discriminative stimulus signaling which attacker could be destroyed in a given trial (see Figure 1). Training was conducted in different contexts provided by background images of natural scenery found in Andalusia.

The design of the experiment is presented in Table 1. Three Groups of participants were trained to discriminate between X and Y in Context A (X:R1-O1, Y:R2-O2). Additionally, in Context A, they received training with Z where R1 was followed by O1 (Z:R1-O1). For all groups Z was only experienced in Context A. For Group informative (I) the discrimination between X and Y was reversed in Context B (X:R2-O2, Y:R1-O1). Two noninformative (NI) control Groups were used. Group NI1 was similar to the control Group in the experiment conducted by Preston et al. (1986), with X and Y predicting the same outcomes in both Contexts A and B. Group NI2 was treated exactly as Group NI1, except that X and Y were presented only in Context A and the relevant response-outcome relationships in Context B were signaled by other cues. In all Groups filler cues were

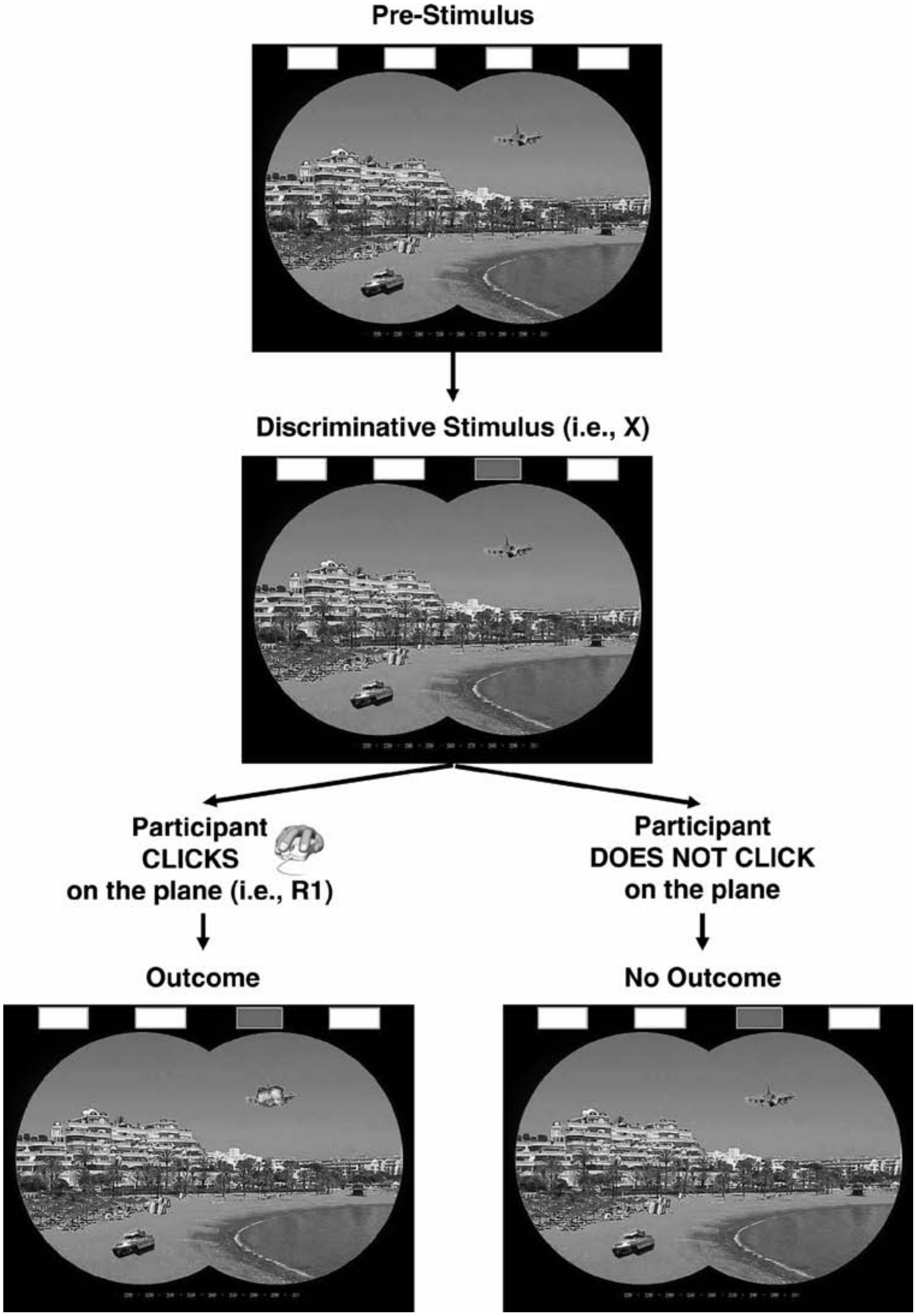

Figure 1. Example of stimuli on a trial. The top section presents the Prestimulus period. The plane and tank were presented on the context (the beach of Puerto Banús in this case) but no response was reinforced. The middle section presents the Stimulus period. Discriminative stimulus lights are on and responding to the correct attacker produces reinforcement, while no responding or responding to the alternate attacker does not lead to reinforcement (bottom).

presented to ensure that experience with the outcomes was the same across contexts and groups. Z was tested under extinction in both the training context (A) and the alternate context (B). The key issue in this experiment was to test whether context-specificity of Z (trained only in Context A) depended on whether the contexts in which Z was trained and tested were relevant to solve a task as Rosas, Callejas-Aguilera et al. (2006) suggest.

Table 1. Experimental design

Group	Training	Test
I	A: **X:R1-O1**, **Y:R2-O2**, F2:R2-O2, **Z:R1-O1** B: **X:R2-O2, Y:R1-O1**, F2:R2-O2, F1:R1-O1	
NI1	A: **X:R1-O1**, **Y:R2-O2**, F2:R2-O2, **Z:R1-O1** B: **X:R1-O1, Y:R2-O2**, F2:R2-O2, F1:R1-O1	A: Z:R1/R2-NO & B: Z:R1/R2-NO
NI2	A: **X:R1-O1**, **Y:R2-O2**, F2:R2-O2, **Z:R1-O1** B: **F3:R1-O1**, **F4:R2-O2**, F2:R2-O2, F1:R1-O1	

Note. Contexts A and B were different scenes of beaches of Puerto Banús and Tarifa, counterbalanced. Different discriminative stimuli were presented as colored rectangles in the top of the screen. Red, navy blue, and green colors were counterbalanced as discriminative stimuli X, Y, and Z. The identity of F1, F2, F3, and F4 was gray, light blue, yellow, and brown, respectively. Instrumental responses R1 and R2 were defined as clicking on the plane or the tank (attackers), counterbalanced. Destruction of the attackers, plane and tank, was counterbalanced as outcomes O1 and O2. NO represents the extinction situation, in which responses were not followed by outcomes. Target treatments are presented in bold font.

Method

Participants

Participants were 36 students from the University of Jaén (~ 65% were women). They were between 18 and 26 years and had no previous experience with this task.

Apparatus and Stimuli

Participants were trained individually in three adjacent isolated cubicles. Each cubicle had a Pentium PC with which the task was presented. The procedure was implemented using the program SuperLab Pro (Cedrus Corp.) software.

The task was a variation of the task used by Gámez and Rosas (2005, 2007). Participants played a computer game where they had to defend Andalusia from air and land attacks. The task is presented in Figure 1. The main screen presented a black view-screen simulating participant's control console. In the top of the screen there were four rectangles that could be colored. Red, navy blue, and green colors were counterbalanced as discriminative stimuli X, Y, and Z. Gray, light blue, yellow, and brown colors were used as fillers F1, F2, F3, and F4, respectively. Contexts were presented within the viewing area of the viewer. Scenes of different beaches of Andalusia, Puerto Banús (an urban beach), and Tarifa (a natural beach) were counterbalanced as Contexts A and B. The two attackers were a plane and a tank. The plane was presented on the sky, in the top right area of the context, while the tank was presented on the sand, in the bottom left area of the context. Both attackers could appear in one of two different positions within their respective areas on the context so that it would give the impression of movement to the participant. The position of the attacker within a trial changed immediately after the attacker was destroyed. The instrumental response was to click on either the plane or the tank (R1 and R2, counterbalanced). Destruction of the tank and the plane was counterbalanced as outcomes 1 and 2 (O1 and O2) across participants.

Procedure

All participants gave their informed consent to participate in the experiment. The instructions and all necessary information were presented on the computer screen. Participants interacted with the computer using the mouse (left button). Instructions were presented in five screens using a black Times New Roman 26 bold font against a light yellow background to simulate the appearance of an old document. To advance the instruction screens the participant had to click on a button labeled as "next" placed on the right bottom of the screen. Each participant was initially asked to read the following instructions (in Spanish):

> (Screen 1) Andalusia is being attacked. Different parts of Andalusia are being assaulted by land and air. You are placed in the only bunker able to face the attackers. Your work consists of defending Andalusia. Use the mouse to throw missiles to the targets. You should destroy the attackers before they take over Andalusia. (Screen 2) The monitor represents the bunker's viewer, and the different attackers you should face will appear on it. Your technology and weapons are older than theirs, so you will need to shoot several times to destroy them. To shoot, click with the left button of the mouse while the pointer is on top of the target. (Screen 3) On top of the viewer there are several sensors. Each of those sensors will indicate that only one of the attackers is within your shooting range and can be destroyed. If the sensors are off, none of the attackers will be within range. (Screen 4) The battle begins! Remember that you can destroy only one attacker at any given time, so you will have to discover which one is currently within the shooting range. Remember not to waste the ammunition on the attackers that are beyond the shooting range. Call the experimenter if you have any doubts. Otherwise, click with the mouse to begin. GOOD LUCK!

Participants were randomly assigned to one of the experimental Groups (I, NI1 or NI2; $n = 12$) upon their arrival to the laboratory. The experiment was conducted in two phases (see design in Table 1).

Discrimination Training

Two training blocks were conducted in each context. Four trials with each discriminative stimulus were presented in each block, leading to a total of eight trials with each discriminative stimulus in each context where it was presented. Trials within each block were randomly presented. The change of contexts was announced by a screen with the sentence "Your detachment has been posted to . . . (name of the beach where the battle continued)". This screen was presented for 2 s. The order in which those training blocks with each context were presented to participants was counterbalanced across participants (ABBA or BAAB). Each trial was divided in Pre and Stimulus periods (see Figure 1). During the Pre period, the tank and the plane were presented without the discriminative stimulus for 4 s (see top panel of Figure 1). Responding during this period was not reinforced. During the Stimulus period, the tank and the plane were presented accompanied by the relevant discriminative stimuli, depending on the trial (see middle panel of Figure 1). Giving the appropriate response for the present discriminative stimulus (e.g., clicking on the plane when color red was on) led to destruction of the attacker (reinforcer) under a VI2-s reinforcement schedule in which the availability of reinforcers varied randomly between 1 and 3 s. Once the reinforcer was available the trial ended only after the participant gave the correct response.

Each participant received X:R1-O1, Y:R2-O2, and Z:R1-O1 trials in Context A. Groups differed on the treatment participants received in Context B. In Group I, the discrimination between X and Y was reversed (X:R2-O2 and Y:R1-O1). In Group NI1, discrimination between X and Y was identical in Contexts B and A. Finally, in Group NI2 X and Y were replaced by F3 and F4 in Context B.

Fillers were included to equate outcome experience across groups and Contexts. Participants received F2:R2-O2 trials in Context A, and F1:R1-O1 and F2:R2-O2 trials in Context B.

Test

All participants received one trial with Z in each context. No reinforcement was available during test trials. Before the test trial the screen informing about the context was presented. Half of the participants in each group received the test with Z first in Context A and then in Context B, while the other half were tested first in Context B and then in Context A. Note that Z was not presented in Context B before testing. Accordingly, performance in Context A was labeled as "Same" and performance in Context B was labeled as "Different".

Dependent Variable and Statistical Analysis

Total mouse clicks on each target during the discriminative stimulus presentations were recorded and transformed to responses per minute. Clicks on the attacker signaled by the discriminative stimulus were labeled as correct responses, while clicks in the alternate attacker were labeled as incorrect responses. Responding was evaluated by analysis of variance (ANOVA). The rejection criterion was set at $p < .05$.

Results

Discriminative Training

With the goal of conducting a global analysis of performance across groups during discrimination training, X and

Table 2. Mean correct responses per minute to S1 and S2 in the first and last discriminative training trials in Groups I, NI1, and NI2 in Contexts A and B

			S1		S2	
Group		Context	First trial	Eighth trial	First trial	Eighth trial
I	R1	A	52.50 (5.69)	61.25 (8.94)	50.00 (20.17)	7.50 (5.38)
		B	22.50 (5.98)	2.50 (2.50)	48.75 (4.57)	61.25 (11.30)
	R2	A	15.00 (4.89)	3.75 (2.69)	47.50 (3.11)	70.00 (8.73)
		B	46.25 (5.04)	56.25 (7.64)	38.75 (15.93)	5.00 (3.37)
NI1	R1	A	61.25 (12.45)	85.00 (11.58)	56.25 (26.95)	12.50 (9.20)
		B	66.25 (9.68)	88.75 (13.63)	66.25 (26.66)	3.75 (3.75)
	R2	A	10.00 (3.37)	5.00 (3.84)	57.50 (9.91)	81.25 (10.00)
		B	10.00 (6.48)	1.25 (1.25)	61.25 (8.94)	83.75 (12.17)
NI2	R1	A	51.25 (4.31)	83.75 (12.85)	50.00 (19.91)	7.50 (7.50)
		B	63.75 (5.58)	65.00 (10.17)	47.50 (21.36)	2.50 (1.69)
	R2	A	6.25 (3.43)	0.00 (0.00)	52.50 (3.92)	82.50 (12.18)
		B	3.75 (1.69)	1.25 (1.25)	60.00 (4.52)	80.00 (8.92)

Note. S1 was X or F3, and S2 was Y or F4, depending on the Group and Context (see Table 1).

F3 were treated as target cue S1, while Y and F4 were treated as target cue S2 (see the stimuli role in Table 1). Table 2 shows mean responses per minute to S1 and S2 in the first and last discriminative training trials in Groups I, NI1, and NI2. A 3 (Group) × 2 (Context) × 2 (Response) × 2 (Stimuli) ANOVA conducted with data from the last discriminative training trial (eighth trial) found a significant four-way interaction, $F(2, 66) = 52.23$ ($MSE = 518.53$). Subsequent analyses found a three-way Context × Response × Stimulus interaction in Group I, $F(1, 22) = 80.67$ ($MSE = 983.52$). No interaction involving context was significant in Groups NI1 and NI2, largest $F(1, 44) = 1.41$ ($MSE = 364.87$). These results reveal that contexts were used to solve the discrimination only in Group I.

Mean correct and incorrect responses per minute in the last training trial for the target discriminative stimulus (Z) were, respectively, 67.50 (8.75) and 7.50 (7.50) in Group I, 80.00 (8.52) and 5.00 (5.00) in Group NI1, and 77.50 (9.74) and 0.00 (0.00) in Group NI2 (standard errors are presented within brackets). A 3 (Group) × 2 (Response) ANOVA found a significant main effect of response, $F(1, 33) = 132.67$ ($MSE = 680.68$). Neither the main effect of group nor the Group × Response interaction was significant, Fs < 1, showing that performance to Z was statistically equivalent across groups at the end of training. As would be expected, the final response to Z in Context A was not affected by the differential treatment received across the groups with the other stimuli in Context B.

Test

The most interesting results came from the test phase. Figure 2 depicts correct responding to Z in both, the context in which it was trained (Same) and the alternate context (Different) in Groups I, NI1, and NI2. A 3 (Group) × 2 (Test context) ANOVA found a significant two-way interaction, $F(2, 33) = 4.04$ ($MSE = 330.11$). Subsequent analyses found that the simple effect of context was significant only in Group I, $F(1, 11) = 7.24$ ($MSE = 104.83$), but it was not significant in Group NI1 or NI2, largest $F(1, 11) = 3.44$ ($MSE = 459.37$). Thus, the deleterious effect of context change on performance to a discriminative stimulus with consistent reinforcement history only appeared in those participants that were trained in a situation where the contexts were relevant to solving a different discrimination (Group I).

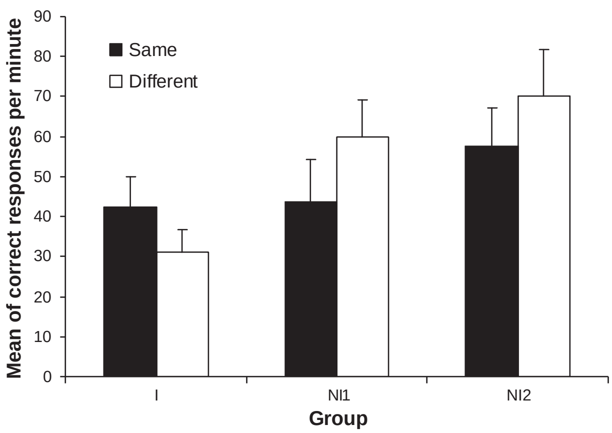

Figure 2. Mean correct responses per minute given to Z during the trial test in Groups I, NI1, and NI2 (from left to right) as a function of whether the test was conducted in the same context of training (Same) or the alternate context (Different).

Mean incorrect responses per minute on the test trial with the target discriminative stimulus (Z) in Contexts A (Same) and B (Different) were, respectively, 18.75 (3.75) and 16.25 (5.04) in Group I, 30.00 (9.41) and 27.50 (9.20) in Group NI1, and 17.50 (5.79) and 12.50 (5.79) in Group NI2 (standard errors are presented within brackets). A 3 (Group) × 2 (Test context) ANOVA found no significant main effects or interaction, Fs < 1.

Discussion

The present experiment was conducted to determine the role of the informative value of the context on the context-specificity of learning. When contexts were made informative by reversing a discrimination between two discriminative stimuli across contexts, expression of learning about a third discriminative stimulus with a consistent reinforcement history was context-specific (Group I). No reliable effects of context change were found when the discriminative stimulus with a consistent reinforcement history was trained in a context without informative value (Groups NI1 and NI2).

These results extend the results reported by Preston et al. (1986) using nonhuman animals. The experiment reported here included an additional control group in which different discriminations were trained in different contexts, so that the informative value of the contexts was neither increased (as in Group I) nor decreased (as in Group NI1). Finding a context-switch effect in the informative Group (Group I) and not finding it in the two noninformative control Groups (Groups NI1 and NI2) indicates that the informative value of the context may play an important role on context-dependency of the information.

The same first-learned discriminative stimulus-response-outcome relationship was found to be context-specific depending on whether the informative value of the context where such information was learned and tested was informative about the meaning of other cues trained there. This context-specific information was neither inhibitory, nor ambiguous, nor the second information learned about the cue (c.f. Bouton, 1993, 1997; Nelson, 2002).

This result is in agreement with the proposal of Rosas, Callejas-Aguilera et al. (2006) that context-switch effects will be obtained whenever participants pay attention to the context while the target information is learned. When attention to the contexts was increased by giving the contexts informative value, all the information learned in those contexts became context-specific. These results encourage the exploration of how different factors that increase or decrease attention to the contexts affect context-specificity of information.

Note that the results of this experiment do not allow for a direct measure of the attention that is supposed to be aroused by informative contexts. Attention to the contexts is indirectly deduced from context-specificity of the information. Similarly, the results of this experiment are silent with respect to the specific mechanism that regulates context-specificity of information once attention is paid to the context. Given that contexts are equally paired with both outcomes, a direct simple relationship between the context and the outcome seems unlikely to explain these results. Accordingly, it seems more likely that either contexts modulate discriminative-response-outcome relationships in this situation (e.g., Bouton & Swartzentruber, 1986), or they enter into a configuration with the discriminative stimulus (e.g., Pearce, 1987). Finally, in the present experiment both, training and test contexts, were informative in Group I. It remains to be seen whether the test context needs to be informative to find the context-switch effect, or it is enough with that of the training context to make information context-specific.

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References

Abad, M. J. F., Ramos-Álvarez, M. M., & Rosas, J. M. (2009). Partial reinforcement and context switch effects in human predictive learning. *The Quarterly Journal of Experimental Psychology, 62*, 174–188.

Baddeley, A. D. (1992). Domains of recollection. *Psychological Review, 89*, 708–792.

Bonardi, C., Honey, R. C., & Hall, G. (1990). Context specificity of conditioning in flavour-aversion learning: Extinction and blocking tests. *Animal Learning & Behavior, 18*, 229–237.

Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. *Psychological Bulletin, 114*, 80–99.

Bouton, M. E. (1997). Signals for whether versus when an event will occur. In M. E. Bouton & M. S. Fanselow (Eds.), *Learning, motivation and cognition: The functional behaviourism of Robert C. Bolles* (pp. 385–409). Washington, DC: American Psychological Association.

Bouton, M. E., & Bolles, R. C. (1979). Contextual control of the extinction of conditioned fear. *Learning and Motivation, 10*, 445–466.

Bouton, M. E., & Ricker, S. T. (1994). Renewal of extinguished responding in a second context. *Animal Learning & Behavior, 22*, 317–324.

Bouton, M. E., & Sunsay, C. (2001). Contextual control of appetitive conditioning: Influence of a contextual stimulus generated by a partial reinforcement procedure. *Quarterly Journal of Experimental Psychology, 54B*, 109–125.

Bouton, M. E., & Swartzentruber, D. (1986). Analysis of the associative and occasion-setting properties of contexts participating in a Pavlovian discrimination. *Journal of Experimental Psychology: Animal Behavior Processes, 12*, 333–350.

Crump, M. J. C., Vaquero, J. M. M., & Milliken, B. (2008). Context-specific learning and control: The roles of awareness, task relevance, and relative salience. *Consciousness and Cognition, 17*, 22–36.

Eich, J. E. (1985). Context, memory, and integrated item/context imagery. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*, 764–770.

Gámez, A. M., & Rosas, J. M. (2005). Transfer of stimulus control across instrumental responses is attenuated by extinction in human instrumental conditioning. *International Journal of Psychology and Psychological Therapy, 5*, 207–222.

Gámez, A., & Rosas, J. M. (2007). Associations in human instrumental conditioning. *Learning and Motivation, 38*(3), 242–261.

Hall, G., & Honey, R. C. (1989). Contextual effects in conditioning, latent inhibition, and habituation: Associative and retrieval functions of contextual cues. *Journal of Experimental Psychology: Animal Behavior Processes, 15*, 232–241.

Hall, G., & Honey, R. C. (1990). Context-specific conditioning in the conditioned-emotional-response procedure. *Journal of Experimental Psychology: Animal Behavior Processes, 16*, 271–278.

León, S. P., Abad, M. J. F., & Rosas, J. M. (in press). The effect of context change on simple acquisition disappears with increased training. *Psicológica*.

Myers, C., & Gluck, M. (1994). Context, conditioning and hippocampal re-representation. *Behavioral Neuroscience, 108*(5), 835–847.

Nelson, J. B. (2002). Context specificity of excitation and inhibition in ambiguous stimuli. *Learning and Motivation, 33*, 284–310.

Nelson, J. B., & Callejas-Aguilera, J. E. (2007). The role of interference produced by conflicting associations in contextual control. *Journal of Experimental Psychology: Animal Behavior Processes, 33*, 314–326.

Neumann, D. L. (2007). The resistance of renewal to instructions that devalue the role of contextual cues in a conditioned suppression task with humans. *Learning and Motivation, 38*, 105–127.

Paredes-Olay, C., & Rosas, J. M. (1999). Within-subjects extinction and renewal in predictive judgments. *Psicológica, 20*, 195–210.

Pearce, J. M. (1987). A model for stimulus generalization in Pavlovian conditioning. *Psychological Review, 94*, 61–73.

Pineño, O., & Miller, R. R. (2004). Signalling a change in cue-outcome relations in human associative learning. *Learning & Behavior, 32*, 360–375.

Preston, G. C., Dickinson, A., & Mackintosh, N. J. (1986). Contextual conditional discriminations. *Quarterly Journal of Experimental Psychology: Comparative and Physiological Psychology, 38B*, 217–237.

Rosas, J. M., & Bouton, M. E. (1998). Context change and retention interval have additive, rather than interactive, effects after taste aversion extinction. *Psychonomic Bulletin y Review, 5*, 79–83.

Rosas, J. M., & Callejas-Aguilera, J. E. (2006). Context switch effects on acquisition and extinction in human predictive learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 461–474.

Rosas, J. M., & Callejas-Aguilera, J. E. (2007). Acquisition of a conditioned taste aversion becomes context dependent when it is learned alter extinction. *Quarterly Journal of Experimental Psychology, 60*, 9–15.

Rosas, J. M., Callejas-Aguilera, J. E., Ramos-Álvarez, M. M., & Abad, M. J. F. (2006). Revision of retrieval theory of forgetting: What does make information context-specific? *International Journal of Psychology and Psychological Therapy, 6*, 147–166.

Rosas, J. M., García-Gutiérrez, A., & Callejas-Aguilera, J. E. (2006). Effects of context change upon retrieval of first and second-learned information in human predictive learning. *Psicológica, 27*, 35–56.

Rosas, J. M., García-Gutiérrez, A., & Callejas-Aguilera, J. E. (2007). AAB and ABA renewal as a function of the number of extinction trials in conditioned taste aversion. *Psicológica, 28*, 129–150.

Rosas, J. M., Vila, N. J., Lugo, M., & López, L. (2001). Combined effect of context change and retention interval upon interference in causality judgments. *Journal of Experimental Psychology: Animal Behavior Processes, 27*, 153–164.

Thomas, B. L., Larsen, N., & Ayres, J. J. B. (2003). Role of context similarity in ABA, ABC, and AAB renewal paradigms: Implications for theories of renewal and for treating human phobias. *Learning and Motivation, 34*, 410–436.

Tulving, E., & Osler, S. (1968). Effectiveness of retrieval cues in memory for words. *Journal of Psychology, 77*, 593–601.

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