The Role of Situations in Concept Learning

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Abstract

This study examines how situation information is incorporated in concept learning and representation. Unlike most concept learning studies, this study includes situation information during concept learning. Unlike most studies about the influence of situations on episodic memory, this study investigates how situations affects conceptual processing. Experiment 1 demonstrates that people rely on situation information when processing concepts. Subjects verified a concept's property more quickly if the property was learned and tested in the same situation. Experiment 2 shows that in order for a situation to produce priming, the situation must be related to the property in a meaningful manner. Mere cooccurrence between a property and a situation is not sufficient.

Introduction

Though models of concept learning vary considerably, they often assume that concept structure remains the same across contexts. People encounter the same kind of objects in various situations, but they have the ability to extract these objects out of contexts, and represent concepts as isolated entities. The situation information either cancels itself out or is simply not represented together with a concept. Researchers adopting such theories have focused more on the internal structure of the concepts, and have almost always used isolated concepts as stimuli in their experiments, not addressing the effect of situations (e.g., Estes, 1986; Hayes-Roth & Hayes-Roth, 1977; Hintzman, 1986; Homa & Vosburgh, 1976; Katz & Postal, 1964; Kruschke, 1992; Medin & Schaffer, 1978; Nosofsky, 1986; Posner & Keele, 1968; Reed, 1972; Rosch, 1975; Rosch & Mervis, 1975).

In ordinary life, objects almost never occur in isolation, and people seldom learn concepts out of particular contexts, with the possible exception of formal education. Rather, it seems that people encounter objects in typical situations. Flowers usually appear on plants, are bundled as a bouquet, or sit in a vase. Cars are observed running on streets or highways, parked in garages or parking lots, or are being filled with gas at gas stations. Moreover, different aspects of an object seem to be more salient in different situations, and thereby associated with them. For instance, people might be aware of a car's fuel tank and how to fill it at a gas station, but may pay more attention to the car's speed on a highway. It is thus possible that people associate a gas station with a car's fuel tank, while a highway with the car's speed.

Contrary to the orientation of current concept theories, empirical studies outside the concept learning literature suggest that people do incorporate situation information in concept representations. Context effects have been widely demonstrated in episodic memory (see Davies, 1986 for a review). People encode physical environmental context together with the to-be-remembered words, and therefore restating the environment facilitates the recall of the words (Eich, 1985; Godden and Baddeley, 1975; Smith, Glenberg, & Bjork, 1978; Smith, 1979). Furthermore, research on scene processing suggests that people have a schema about the situation in which an object typically occurs, and therefore they expect to see certain objects when given a scene. Subjects recognize objects faster in a typical scene than in an atypical scene or in isolation, and they memorize objects better when they form a meaningful and coherent scene (Biederman, 1972, 1981; Mandler & Parker, 1976; Palmer, 1975). In addition, research using words or sentences as semantic contexts suggests that a concept is not only associated with a typical situation, but also might be associated with more than one typical situation. As the situation varies, people retrieve different information about the same concept. Therefore, when given different sentence contexts for the same concept, subjects activate different properties or different instances of the concept (Barsalou, 1982; Conrad, 1978; Greenspan, 1986; Roth & Shoben, 1983; Tabossi & Johnson-Laird, 1980; Tabossi, 1988; Whitney, McKay, Kellas, and Emerson, 1985; Wisniewski, 1995). Finally, most connectionist's models are based on the idea that if two events cooccur frequently, the link between them will be strengthened (Rumelhart, Smolensky, McClelland, & Hinton, 1986). Therefore, if a property of a concept always occurs in one situation, the link between the property and the situation should be stronger than those between the property and other situations.

The purpose of this study is to examine how situation information is incorporated in concept learning. A situation is defined as a relatively well-bounded region of space that contains a coherent activity. For example, sitting in a living room is a situation in which a chair typically occurs, and parking in a garage is a situation that typically contains a car. Unlike most concept learning studies, this study includes situation information during concept learning. Furthermore, unlike most studies reviewed in the previous section, which examine the influence of situations on episodic memory, this study investigates how situations affects conceptual processing.

Experiment 1

Experiment 1 examines whether retrieving information about a concept is affected by situations. Subjects learned a new concept in two situations, with some of the concept's properties occurring in one situation, and with other properties occurring in the other situation. After learning the novel concept's properties in the two situations, subjects verified the properties in either the same or the alternative situation in which they learned the properties. Subjects also performed a property listing task, in which they were given one of the learning situations and had to list all the concept's properties.

According to a Situation-Independent Hypothesis, people extract what they learn about a concept across situations, and represent the concept in an abstract way, not incorporating any specific situation information. Therefore, priming subjects with a scene of a situation will not help retrieving the properties learned that in situation. Subjects should verify properties learned in the same situation as quickly as those learned in a different situation. Subjects should also list the properties for the two kinds of situations in no particular order.

In contrast, a Situation-Dependent Hypothesis holds that people store, together with a concept, the situations in which they typically encounter it. Therefore a concept is not an isolated entity, but rather, includes the situations in which it typically occurs. Furthermore, since people attend to different properties in different situations, they associate different properties with different situations. Hence, the Situation-Dependent Hypothesis predicts that subjects will verify properties learned in the same situation more quickly than those learned in a different situation, and they will also list properties learned in the test situation earlier than those learned in the other situation.

Method

Materials. Four novel concepts were used in this experiment, two of them being animals, another a plant, and the other an artifact. A cover story was created for each concept to explain how a new concept was discovered and observed, and also to describe the two situations where the concept is normally observed. Each concept had six properties, each being instantiated by four instances. Three of a concept's properties always occurred in one location (usually the plant or animal's natural habitat), and the other three in another location (usually the human context where the animals/plants are studied, see Table 1 for examples of the materials). For example, subjects observed 24 instances of a new kind of animal, a "zod," either 1000 feet under the Pacific Ocean, or in a zoology laboratory where zods were raised. Zods observed in the ocean exhibited the property of *elastic, blind,* or *sticky* (four zods each). Zods observed in

Table 1. Examples of learning materials in Experiment 1.

Concept	Situation	Property
zod (an animal)	the Pacific Ocean	elastic blind sticky
	zoology laboratory	yellow hops carnivorous
foush (a plant)	small village	bluish velvety odorless
	greenhouse	flowering succulent medicinal

the laboratory were *carnivorous, yellow,* or *hops* (four zods each). For each instance and its property, subjects read a sentence instructing them how to imagine the property in the situation. The four instances that shared a common property also shared a common sentence with minor modifications. For example, the sentences describing the four *elastic* zods went like this, "Imagine that a zod *under/beside/between/behind* the rocks is stretching its ELASTIC body..." and the sentences for the four carnivorous zods were "Imagine that the zoologist gives the CARNIVOROUS zod *a fish/a clam/some squid/some shrimp*, and the zod eats it..."

In the property verification test, each concept was tested by six true trials and nine false trials. The six true properties were those learned in the learning phase. The nine false properties were chosen from the other three concepts' properties. Therefore, subjects were equally familiar with the true and false properties, and had to respond by retrieving information from the correct concept. Each concept was tested in only one of the two learning situations (e.g., 1000 feet under the Pacific Ocean), and thus half of the properties were learned and tested in the same situation (e.g., *elastic* was learned and tested in the Pacific Ocean scene), while the other half were tested in a different situation (e.g., *carnivorous* was learned in the zoology laboratory scene, but was tested in the Pacific Ocean scene). The combined set of 60 test properties were presented in a random order to subjects.

In the property listing test, each concept was tested in the learning scene that was not shown in the property verification test. For example, if zods were tested in the Pacific Ocean scene in the property verification test, they were tested in the zoology laboratory scene in the property listing test.

Procedure. In the learning phase of the experiment, subjects first read a cover story about a novel concept, then they saw 24 pictures, each depicting an instance of this concept in a scene. Half of the instances occurred in one scene and the other half in the other. For each instance, subjects read a verbal description of the instance's property in the center of the picture for 2 seconds, and a description about the role of the property in the scene for 7 seconds.

After seeing four such concepts and their properties, subjects performed a property verification task and a property listing task. In the verification task, subjects were primed with one of the two scenes and decided whether a property was true of a concept or not. To verify a property, subjects first saw a picture of a situation on a computer screen for 1.5 seconds. Then, the concept's name appeared in the center of the picture for another 1 second. After a 1 second interval, a fixation point appeared in the center of the picture for 500 msec, followed by a 250 msec interval. Then a possible property appeared, and subjects had to verify as quickly and as accurately as possible whether the property was true of the probed concept by pressing one of the buttons on a button box. Feedback was given if subjects responded incorrectly.

After the property verification test, subjects performed a property listing task, in which they saw, on a page of a booklet, the learning scene that was not shown in the property verification test and the name of a target concept, and they wrote down the properties of the concept. Subjects performed this procedure for all four concepts, presented in a random order.

Subjects. Subjects were 12 University of Chicago undergraduates, who were native speakers of American English. They were paid to participate in the experiment.

Results and Discussion

Property Verification Test. Only correct reaction times on the true trials were included in the analysis. Reaction times longer than 5 seconds (0% of the data) were excluded. On average, subjects responded to properties learned and tested in the same situations at the speed of 1120 msec, which was 177 msec faster than those tested in different situations (average reaction time 1297 msec, $F(1,11)=5.93$, $p<.05$). The result supports the Situation-Dependent Hypothesis. Subjects also made fewer errors in the same situations (error rate 4.17%) than in the different situations (error rate 6.94%), which indicates that the differences of response latencies between the two situations did not result from a trade-off between speed and accuracy.

Property Listing Test. The average positions of the listed properties in the two situations were calculated. Each listed property's absolute position was marked from 0 to 5, with 0 being the first property listed, and 5 the sixth property listed. A property's relative position was then calculated by dividing its absolute position by the total number of properties listed for the concept minus one. Therefore, a property's relative position being 0 means that it was listed first, 1 means that it was listed last, and 0.5 means that it was in the middle of the list. As predicted by the Situation-Dependent Hypothesis, subjects listed the properties learned in the test situations (average relative position 0.38) significantly earlier than those learned in the other situations (average relative position 0.61), $F(1,11) = 20.75$, $p <.001$). The position data again support the conclusion that people associate a concept's properties with the situations in which they learn the properties, such that they retrieve those properties more quickly when primed with the learning situations.

Experiment 2

Experiment 2 examines how situations become associated with concepts. The results of Experiment 1 suggest that appropriate situations facilitate the retrieval of certain aspects of a concept, but it is not clear how situations become associated with the concept to facilitate retrieval. Situation priming can result from simple cooccurrence relations between situations and properties, or it can result from more meaningful conceptual relations. Two factors may determine such relations: The first is whether the property is predictable from the situation or not. The second is whether the property manifests itself through interacting with the situation, or merely through cooccurring with the situation. Experiment 2 manipulated these two factors, related/neutral and interactive/cooccurring, in a two by two between-subject design.

Based on prior knowledge about a situation, people might expect certain properties to occur in it. For example, *swims* and *scaly* are common properties of underwater animals. Therefore, before actually learning any properties in the learning phase, subjects might expect an underwater animal to be able to swim and to have scales in a scene of the Pacific Ocean. In contrast, a property could be neutral to a situation in the sense that people do not necessarily expect the property to occur in the situation. For example, *swims* and *scaly* are not common properties for jungle animals. To learn that a jungle animal swims, subjects have to rely completely on the information presented in the learning phase. Experiment 1 employed only the latter type of properties. Experiment 2 manipulated both types of situation-property relations. Subjects in the related group learned novel concepts with properties predictable from situations, whereas subjects in the neutral group learned properties unpredictable from situations. If meaningful and conceptual relations are necessary for a situation to influence concept processing, then subjects in the related group should exhibit a stronger situation effect than those in the neutral group. If, on the contrary, simple cooccurrence between a situation and a property is enough to produce a situation effect, subjects in both groups should show the same size of situation effect.

Orthogonal to the related/neutral factor, whether a property interacts with a situation or not could also influence how they associate with each other. A situation may become associated with a concept in the following two ways: One possible mechanism is that a situation cooccurs with a concept's property so many times that when given the situation, subjects can mechanically respond with the property. Such a frequently cooccurring situation might not bear any meaningful relations with a concept, but still facilitate the retrieval of its relevant properties. Alternatively, it could be that a property has to interact in a meaningful way with a situation in order for the situation to prime it. A situation might bias people's attention to certain aspects of a concept, such that a property manifests itself only through interacting with the environment. For example, to associate an underwater animal with *blind*, subjects might imagine a diver swimming around the animal, and shining her spot light on the animal, and not seeing it respond. After repeated presentation of such a scenario, subjects come to associate the *underwater* situation with the property *blind*. Subjects in Experiment 1 received associated properties and situations in an interactive way, because, in the learning phase, they received sentences instructing them how to imagine the properties manifesting themselves in the situations. Experiment 2 examined both interactive and cooccurring associations by manipulating the existence of the sentences.

If a property has to bear a meaningful relation with a situation in order for the situation to prime processing, then the sentences would be crucial, especially when subjects do not expect the property to occur in the situation. Therefore, the situation effect should be stronger in the neutral-interactive condition than in the neutral-cooccurring condition. On the contrary, if simple cooccurrence between a property and a situation is sufficient to produce the situation effect, then it should not matter whether there is a sentence in the learning phase or not.

Method

Subjects and Design. Sixty-four University of Chicago undergraduates were recruited as subjects, all of them being native speakers of American English, and being paid to participate in the experiment. They were randomly assigned to one of the following four groups: related-interactive, related-cooccurring, neutral-interactive, and neutral-cooccurring. For each subject, half of the properties were learned and tested in the same situation, while the other half were tested in a different situation.

Materials. Four novel concepts and eight situations were created. The structure of the stimuli was the same as in Experiment 1, except that two types of materials, related and neutral, were created (see Table 2 for examples of the materials). The properties and situations for the two types of materials were same, but the situations were matched with the properties in different ways. In the related version, the properties were very likely to occur in the matched situations (e.g., underwater-swims, jungle-poisonous). A separate group of 16 subjects ranked how likely the properties were to occur in those situations, and the average rank for the related situations was 2.45 on a 1 to 10 ranking scale. When rearranging the same set of situations and properties in a different way, the properties were ranked as less likely to occur in the matched situations (e.g., jungle-swims, underwater-poisonous). The average rank for neutral situations was 6.3. As in Experiment 1, each property in the related-interactive and neutral-interactive versions was accompanied by a sentence instructing subjects how to image the property in the situation. In contrast, properties in the related-cooccurring and neutral-cooccurring conditions were not accompanied by any sentences.

Procedure. The procedure of Experiment 2 was similar to that in Experiment 1, except that in the learning phase of the two interactive conditions, the sentences were presented 5 seconds; while for the two cooccurring conditions, the properties simply remained on the screen for 5 seconds. In addition, the presentation time for the name of the concept in the test phase was shortened from 1 second to 0.5 second, and no fixation point was presented in this experiment.

Results and Discussion

Property Verification Test. Reaction times longer than 5 seconds were excluded from the analysis (0.72 % of the data). Figure 1 depicts subjects' mean reaction times to verify true properties in the same and different situations in the four conditions. Subjects in the neutral-interactive condition verified properties tested in the same situation 194 msec faster than those in a different situation (planned comparison $F(1,60)=6.74$, $p<.05$), replicating the pattern in Experiment 1. Subjects in the neutral-cooccurring condition, on the contrary, made no such distinction (planned comparison $F(1,60)=0.60$, n.s.), suggesting that the sentences instructing subjects to imagine the property in

Table 2. Examples of materials in Experiment 2.

Related Condition			Neutral Condition		
Concept	Situation	Property	Concept	Situation	Property
zod (an animal)	underwater	swims slimy scaly	zod (an animal)	rain forest floor	swims slimy scaly
	zoo	apathetic agitated nervous		formal garden	apathetic agitated nervous
foush (a plant)	rain forest floor	lush exotic poisonous	foush (a plant)	desert	lush exotic poisonous
	formal garden	fragrant ornamental perennial		zoo	fragrant ornamental perennial

the situation are crucial to producing the situation effect. Simple cooccurrence between a property name and a situation was not sufficient for the situation to facilitate processing.

Such a difference between interactive and cooccurring conditions, however, was not found in the two related conditions. For both the related-interactive and related-cooccurring conditions, subjects verified properties tested in the same situation faster than those in a different situation. The difference between same and different situations was 238 msec for the related-interactive condition (planned comparison $F(1,60)=10.24$, $p<.01$), and 193 msec for the related-cooccurring condition (planned comparison $F(1,60)=6.70$, $p<.05$), indicating that subjects in the latter condition were able to elaborate relations between situations and properties so that situations affected conceptual processing, even though they were not given the sentences. In other words, based on their pre-existing knowledge about environments, subjects expected to see certain properties in a situation, and thus overcame the lack of the interactive sentences.

As in Experiment 1, subjects in all the four groups made fewer errors in the same situations (average error rate 4.69%) than in the different situations (average error rate 11.33%). This again indicates that the priming effects did not result from a trade-off between speed and accuracy.

Property Listing Test. As illustrated in Figure 2, subjects in all the four groups listed properties learned in the same situation earlier than those learned in the other situation. On average, properties learned in the same situation were listed at the relative position 0.37, and those learned in a different situation were listed at the position 0.60, which was significantly later ($F(1,59) = 67.96$, $p<.0001$). In other words, a situation effect was found in both the property verification test (a recognition task) and the property listing test (a recall task) for the related-interactive, related-cooccurring, and neutral-interactive conditions, suggesting again that meaningful relations between a property and a situation is crucial for the situation to prime conceptual processing of the property. The neutral-cooccurring condition, on the contrary, showed a situation effect only in the property listing test (a recall task), but not in the property verification test (a recognition task). The lack of situation effect in a recognition task is a typical finding in research about environmental context effect on episodic memory (e.g., Godden & Baddeley, 1980; Baddeley, 1982; Smith, Glenberg, & Bjork, 1978), suggesting that subjects in the neutral-cooccurring group did not process the materials conceptually, but rather, they simply remembered the contingency between a scene and a property, without elaborating a meaningful relation between the two.

Conclusion

Experiment 1 demonstrates that subjects verify properties learned and tested in the same situations reliably more quickly than those tested in different situations. In the property listing task, subjects overwhelmingly listed the properties learned in the primed situations earlier than those in the unprimed situations. The results in both tasks support the Situation-Dependent Hypothesis. People not only process a concept but also the situation in which the concept occurs, associating different properties of a concept with different situations.

The results of Experiment 2 suggest that in order for situations to affect conceptual processing, it is crucial that

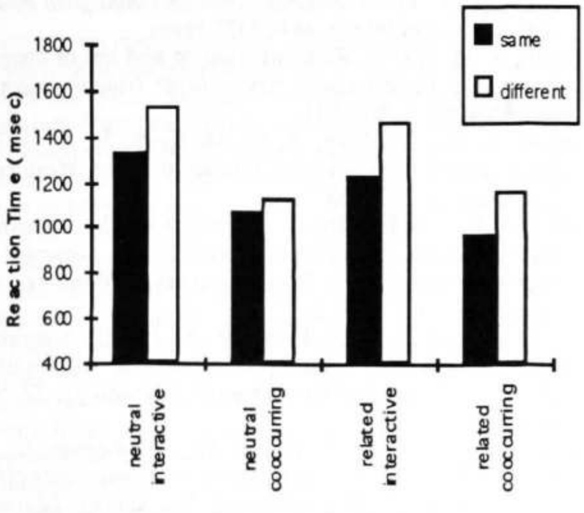

Figure 1. Subjects' mean reaction times to verify properties in the same and different situations as a function of related/neutral and interactive/cooccurring conditions, and whether the property is learned in the same or different situation.

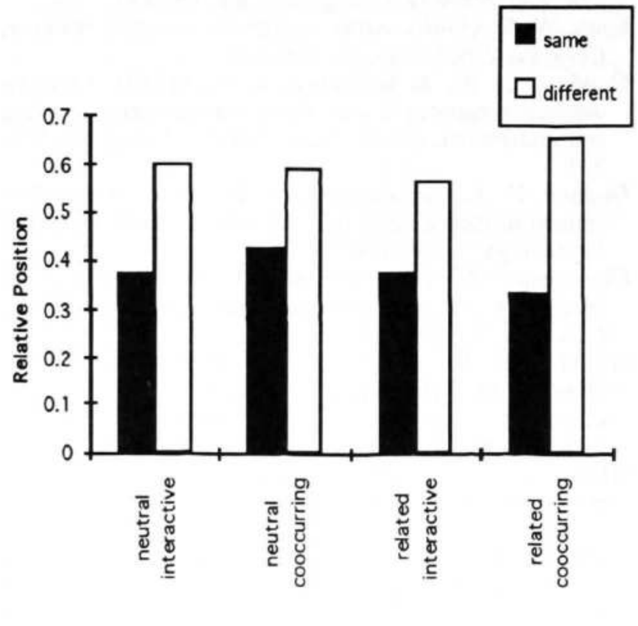

Figure 2. The relative position of properties listed in the property listing task as a function of neutral/related situation and interactive/cooccurring conditions in Experiment 2.

the properties of a concept interact meaningfully with the situations. Subjects could elaborate these relations by reading sentences that specify how a property occurs in a situation, or by using their pre-existing knowledge about the situation. If a property merely occurs contingently with a situation, without any conceptual relation between the two, as in the neutral-cooccurring condition, the situation does not affect how subjects verify properties, but rather, affects only the recall of the properties, as has been frequently found in research on environmental context effects.

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