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The role of stimulus familiarity in context-dependent recognition

PAMELA DALTON
New York University, New York, New York

Investigations of context-dependent recognition, a phenomenon in which recognition is better for items studied and tested with the same rather than different context, have shown serious inconsistencies. A simple organization of (1) contextual cues, distinguishing between local context (specific cues) and global context (general cues), and (2) stimulus familiarity, distinguishing between novel and familiar stimuli, reduces much of this variability. In two experiments, changes in both local context (descriptive label) and global context (environment) were manipulated in order to examine their effects on recognition memory for faces that differed in familiarity. Changes in local context impaired recognition of both unfamiliar and familiar faces; changes in environmental context impaired recognition only of unfamiliar faces. These results are consistent with the many failures to find impaired recognition of verbal stimuli under changed environmental contexts, and they suggest that stimulus familiarity is a critical parameter modulating environmental context effects.

A central question guiding a significant amount of memory research in the last 20 years can be stated quite simply: What is the effect of context on memory? To be sure, attempts to find evidence of context specificity on learning and memory have yielded numerous demonstrations in many domains: state-dependent learning effects (see Eich, 1980), environmental context effects on animals (see Spear, 1978 for review) and on humans (see, e.g., Godden & Baddeley, 1975; Smith, Glenberg, & Bjork, 1978), effects of mood states (Bower, 1981; Bower, Monteiro, & Gilligan, 1978; Eich & Metcalfe, 1989; Weingartner, Miller, & Murphy, 1977), and effects of semantic context (Tulving, 1972; Tulving & Thomson, 1973). In reports of context specificity, it is claimed that reinstatement of the original learning context—be it an environmental cue, a drug state, or a word associate—results in optimal performance of the learned response or material. However, although context effects have often been found, there have also been many failures to do so. And although context effects have often been regarded as a unitary phenomenon at a theoretical level, no such uniformity of effects has been true at the empirical level. In the present paper, I offer a new perspective on what determines the effect of context on memory and describe an approach to context effects that yields a simple organization of much of their variability.

Issues in Context Research

One problem in context investigations is confusion over what elements of a situation constitute a "context." Although the term *context* can signify any element of the situation other than the focal or to-be-remembered item, it has been frequently invoked without any distinction's being made among the several types of context. Moreover, the various contexts, such as words, descriptive labels, colored backgrounds, drug states, and rooms, have differed, sometimes dramatically, in their effects on memory.

Glenberg (1979) distinguishes between specific cues and general cues as different component levels of context; in the present article, I employ a similar distinction between context categories: *local context* comprises elements, such as semantic context, which are encoded uniquely to one or a few stimulus items; *global context* comprises elements such as drug state or environment, which are associated with many stimulus items. With this distinction, it becomes apparent that local context effects, such as that of semantic word context, have consistently been found (see, e.g., Tulving & Thomson, 1973),[1] whereas effects of global context, particularly on recognition memory, have been unaccountably difficult to demonstrate in the laboratory (see, e.g., Fernandez & Glenberg, 1985; Smith, 1988; but see Cann & Ross, 1989; Malpass & Devine, 1981; Smith, 1985, 1986).

The concept of local context has been illustrated well by Tulving and Thomson (1973), who found effects of semantic context on word recognition. Their subjects learned paired associates that consisted of target words

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and accompanying context words. At test, the target word was presented for recognition in one of two conditions: either with the original context word or with a new word that had not been seen at study. Because each context word was presented and encoded with only one target word at study, this manipulation fits the definition of local or specific context. In the experiments to be described here, local context consisted primarily of descriptive verbal labels paired with no more than two stimulus items.

In contrast with local context, global context is a more general encoding component. This term refers to cues, like the physical environment or a drug or mood state, that persist relatively unchanged throughout the study or test experience. In the present research, the effect of one type of global cue—environmental context—was considered, that of the rooms in which the subjects studied and were tested.

Theoretical Use of Context

Despite the absence of consistent empirical confirmation of the role of context, many modern memory theorists (e.g., Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1981; Tulving & Thomson, 1973) have often placed great explanatory emphasis on it. This is a concern inasmuch as most have implicated context effects as central to theories of memory without specifying the type of context to which they refer. In particular, since most theoretical uses of context implicate what according to the present definition sounds like *global* context, the inconsistency of these effects cannot be ignored.

Two recent chapters on environmental context and human memory (Bjork & Richardson-Klavehn, 1989; Smith, 1988) have provided a comprehensive review of the dissociation of environmental context specificity on recall and recognition. They also review a number of hypotheses that have been proposed to explain the unreliability of global context effects on recognition (see, e.g., Baddeley & Woodhead, 1982; Eich, 1980; Smith, 1988). These proposals fall into several general classes, which range from explanations that concern the type of contextual processing (see, e.g., Godden & Baddeley, 1980), to the strength of the context manipulation (see, e.g., Fernandez & Glenberg, 1985), to the nature of the available context cues (see, e.g., Smith, 1988). What all of these proposals have in common, however, is their emphasis on how the effectiveness or processing of the context determines the level of contextual control. One parameter has been virtually ignored in investigations and accounts of context in human cognition: the prior history of the stimulus.

For several decades, researchers have attempted to demonstrate effects of environmental contextual change on the recognition of words or verbal materials and, when unsuccessful, have primarily directed their efforts toward modifying the context manipulations. This article presents evidence that changing both local *and* environmental context can have detrimental effects on recognition when attention is turned to properties of the stimulus rather than of the context.

Role of Stimulus Familiarity

Several observations support the hypothesis that stimulus parameters may influence the degree of context dependency. One anecdotal observation seems to have clear implications for the laboratory investigations: many people report that failure of recognition memory when the context is changed occurs less frequently for persons or items that are familiar or well learned. Of course, the laboratory paradigm of recognition memory is not exactly comparable to the usual task of recognition in the real world: the experimental task requires that subjects attend to every stimulus face presented and render a recognition decision—a goal that is certainly not always present in real-world situations. Therefore, real-world failures may in fact still occur more frequently than in the laboratory, due to differences among the situational goals, attentional demands, and expectancy effects (see, e.g., Hastie, Park, & Weber, 1984; Wyer & Srull, 1986).

Empirical support for the notion that stimulus familiarity plays a role takes several forms. Davies and Milne (1982) showed subjects pictures of both novel and celebrity faces while varying background, pose, and expression. They found reduced recognition performance for novel, but not celebrity, faces as a function of all three changes. Unfortunately, they used a small number of faces and the performance for the familiar faces was at ceiling, causing some interpretive problems with their data. Yet the demonstration of differential local context effects for familiar as opposed to novel faces was encouraging. It seemed plausible that modulation by the environmental context might differ for novel and familiar stimuli as well.

The important role of stimulus familiarity is also supported by results in the domain of animal learning, where context effects on recognition-like tasks have traditionally been more reliable. Recognizing the importance of the relation between stimulus and context, Lubow, Rifkin, and Alek (1976) showed that exposing a stimulus prior to presenting it in a novel environmental context (i.e., making it familiar) enhanced perceptual learning, in comparison with the simple presentation of a novel stimulus in the learning context.

There are other salient reasons why a stimulus attribute like familiarity might be a parameter of contextual modulation. Whether contextual attributes such as temporal or spatial information are present or absent constitutes one of the critical distinctions that Tulving (1972) makes between episodic and semantic memory systems. According to Tulving, multiple presentations of an item allow that item to be abstracted from its context. As the item representation becomes progressively more semantic in nature, its reliance on specific contextual attributes for recognition is diminished. The representation can be considered in a state of "decontextualization," whereby it can be activated and the corresponding item can be recognized without the reinstatement of cues present at encoding.[2]

This emphasis on the nature of the relationship between stimulus familiarity and context suggests why changes in environmental context do not reliably affect word recognition (but see Smith, 1985, 1986). Words used in recognition memory studies are, necessarily, familiar items; they have been learned outside the laboratory, and, prior to the study, they thus have a preexisting mental representation or "code." When the words are encountered once again in the study phase, code activation can provide the basis for a later recognition judgment. Simple activation of the code at study is not likely to induce the encoding of whatever environmental cues are present in the experimental setting.

In contrast, the robust effects of semantic context on word recognition seem to indicate that local context has a large effect on familiar stimuli, such as words. In these cases, however, the local context often determines, or at least influences, the meaning of the stimulus (e.g., the "jam" in *strawberry jam* as opposed to the "jam" in *traffic jam;* Light & Carter-Sobell, 1970). Thus, although the word code is already present, the processing of the associated semantic context may create an integrated "episode" of context and stimulus representation. The result of such an association is that stimulus recognition relies on reinstatement of the semantic context.

Thus, on the basis of the available evidence, there is reason to predict that (1) changes in semantic or local context will impair recognition for both familiar and unfamiliar items, but (2) changes in global or environmental context will affect recognition for unfamiliar or novel items only.

Face Recognition and Context

If stimulus familiarity produces decontextualization of the global context, the use of words as stimuli is an unfortunate choice in environmental context manipulations used to test recognition. As Davies and Milne's (1982) study suggests, a more promising class of stimuli consists of unfamiliar faces (see also Beales & Parkin, 1984; Memon & Bruce, 1985; Thomson, Robertson, & Vogt, 1982; Watkins, Ho, & Tulving, 1976; Winograd & Rivers-Bulkeley, 1977). In a number of studies of face recognition, changes in local contexts such as semantic labels, face associates, or background cues have resulted in decreased recognition accuracy. In addition, in several demonstrations, changes in global context have resulted in decreased recognition for unfamiliar faces (see, e.g., Cann & Ross, 1989; Gage & Safer, 1985; Malpass & Devine, 1981).

Face recognition may rely on context reinstatement more than word recognition does because of the importance of stimulus novelty. With verbal stimuli, the identification of a letter string as a word requires experience with that particular letter string; hence it can hardly be considered a novel stimulus. Faces, however, possess the unique property that at the time of the experiment, they can be completely novel to the subject yet can be readily and easily identified and processed as faces. Given the consistency of local context effects on faces, coupled with demonstrations of global context effects on unfamiliar faces, faces seem highly promising as a test medium for examining the effects of context on recognition memory.

The present study represents an attempt to demonstrate that local and global context effects on face recognition are determined by the subject's prior experience with the stimulus. Results from pilot studies showed that descriptive occupational labels formed an effective local context for faces, whereas changes in the experimental setting between study and test proved to be an effective global context. Thus, in Experiment 1, the familiarity hypothesis was tested in an attempt to demonstrate local and environmental context-dependent recognition for both novel and familiar faces. Experiment 2 was an attempt to replicate the findings of Experiment 1, but without the possible interpretive problem of ceiling effects on recognition for familiar faces.

Overview of the General Design

In the following experiments, two types of context were assessed for their ability to modulate recognition: (1) local context, in the form of a descriptive label specific to a small number of stimuli, and (2) global context, in the form of the physical environment in which the faces were encoded and tested. This combination of local and global context manipulations has not been employed in most previous research (but see Smith et al., 1987). Another important feature of these experiments is that *all* context manipulations were made within subjects. Other studies of context manipulations have been done with between-group designs. The need for a within-subjects design with respect to global context manipulations is evident when one considers the potential for significant criterion changes for study items tested in different environmental conditions. A within-subjects design avoids this problem in the global context manipulation. Because the test in each room mixes faces that have originally been studied in that room as well as faces that have originally been studied in the other room, a subject should set a single response criterion for all faces that are tested in the same room (which may vary between each label condition, of course). In the present experiments, every subject studied and was tested with all local context manipulations in both global context conditions. Therefore, each subject served as his/her own control in each condition.

EXPERIMENT 1

The purpose of Experiment 1 was to discover whether the effects of context on face recognition differ from its effects on word recognition by testing the familiarity hypothesis described earlier. The familiarity hypothesis asserts that the subject's prior experience with the stimulus is an important parameter of context modulation. Novelty has been a potentially important characteristic of the stimulus faces in most of the earlier research that has yielded context effects on recognition (e.g., Baddeley & Woodhead, 1982). For the subjects in those studies, the faces were unfamiliar at the time of study and encoding. If stimulus familiarization diminishes a subject's dependence on accompanying contextual information, preexposure to stimuli may produce a codified representation of the stimulus that allows recognition in the absence of contextual reinstatement. This finding would be consistent with the findings of minimal or no global context effects on word recognition.

Davies and Milne (1982) had, in fact, used familiar faces as stimuli and found no effect of context changes on recognition for familiar faces. Unfortunately, these faces were known to the subjects from personal experience and had not, within the context of the study, ever been novel faces. One advantage of experimentally familiarizing the subjects with novel faces rather than using well-known or celebrity faces is that for different subjects, any given face can be novel or familiar; thus, one can control for distinctiveness or memorability of certain faces. Also, an experimental frequency manipulation allows a controlled amount of familiarization. If global context encoding and specificity is a function of stimulus familiarity, the familiar faces should be less dependent on the reinstatement of the environmental context than the novel ones. Familiar items, like words, typically do show effects of local (semantic) context, however. Hence, familiarization may not modulate their reliance on local context reinstatement.

Method

Subjects. Twenty-eight students at Rutgers University served as subjects. Eleven partially fulfilled an introductory psychology course requirement by doing so; the remainder were students enrolled in an experimental psychology course. They were run in groups of 2-6.

Materials. Seventy-two female portraits were selected from a previous university yearbook. All faces were head-and-shoulder photographs with full face poses. None wore glasses, and any jewelry or hair ornaments present were removed by computer retouching. The black and white photographs were video digitized and stored as image files. With a graphics software program, the images were displayed against a neutral background, with an occupational label below each face. Forty-eight occupations were generated and used as descriptive labels. The resulting images were then photographed directly from the computer monitor, using a Dunn Instruments camera system. All stimulus faces were reproduced as 35-mm slides and were presented for study/test with a Kodak autofocus slide projector with an automatic advance. The resolution and quality of the stimulus slides were extremely good.

Design. The experiment was structured as a within-subjects design, in which the variables were level of familiarity (novel or familiar), type of environmental context (old or new room), and type of local context (old or new label). Figure 1 presents the design.

The subjects studied two sets of 24 faces, one in each room. Each face was presented with an occupational label. Twenty-four different labels were used at study, so that two study faces appeared with each label. One set of faces was studied in Environmental Context A, and the other was studied in Environmental Context B. The order of this assignment was counterbalanced across subjects.

There were 72 faces in the recognition test: the 48 studied faces plus 24 distractors. The subjects were given two recognition tests: one in each room context. The test in each room was composed of faces in the following six conditions:

Old global-old local: Six faces that had been studied in that room and were tested with their original local context.

Old global-new local: Six faces that were studied in that room (old room) but with a new (i.e., unstudied) local context.

New global-old local: Six faces that were studied in the alternate room, but now tested with a local context that was "old" with respect to the test room (i.e., it had been studied with another face in that room).

New global-new local: Six faces that were studied in the alternate room, now tested with an unstudied local context.

New face-old local: Six "new" distractor faces, tested with a local context that was "old" with respect to the test room.

New face-new local: Six "new" distractor faces, tested with an unstudied local context.

Thus, the test in each room consisted of elements (faces and labels) that had been studied in that room, elements (faces) that had been studied in the alternate room, and elements (faces and labels) that had not been studied. The new local context was chosen from the occupational labels not used in the study phase.

For the familiarity manipulation, the 72 test faces were divided into two groups. Half the subjects saw one set as the familiarization set; half saw the alternate set. As shown in Figure 1, the result was that for all subjects, half the faces in each test condition had been familiarized prior to the study and test.

All the faces were photographed multiply with different labels, so that the assignment of faces and local context could be balanced across all conditions. The faces themselves were rotated through the old-new conditions.

Environmental contexts. The two study/test environments differed on visual and olfactory dimensions. Both environments were on the same floor in the psychology lab building, but Room A was a small windowless cubicle, 8×10 ft, with only a table, chairs, and the slide projector. Room B was a large room, 28×54 ft, used both for laboratory work and storage—hence it was cluttered with much old equipment and machinery, as well as tables and desks. Additionally, a female experimenter administered the study and test in one room, while a male experimenter administered the study and test in the second room. The assignment of faces to rooms was balanced across the two environmental contexts, as was the assignment of the experimenter. Prior to each study/test session, the rooms were scented either with a fruit and floral spray or with a cinnamon oil. Olfactory cues were paired with the rooms, to enhance the global context differences as well as to include cues that could be processed while visual attention was directed to the focal stimuli. In addition, there is limited evidence that odor serves as an effective global context for pictorial stimuli; the presence of the same odor at study and test has been shown to facilitate the recognition of faces (Cann & Ross, 1989). Odors were also counterbalanced across rooms following a 24-h delay.

Familiarization. Approximately 1 week before the scheduled study and test, subjects were brought into the laboratory for a familiarization session. They were taken to a neutral context—a room that would not be used for either study or test—for this phase. They were familiarized by seeing 36 of the to-be-tested faces in a continuous recognition test. The slides they viewed were half of the test faces presented without any accompanying contextual information. The subjects were instructed to judge how familiar the faces were by rating them on a 3-point scale (1 = *very familiar*, 3 = *not familiar*). The subjects were familiarized with the faces by showing each face once in each of four blocks. The order of faces within each block was randomized. The subjects had 5 sec to view each face and make their ratings. They were then reminded of the study appointment and dismissed.

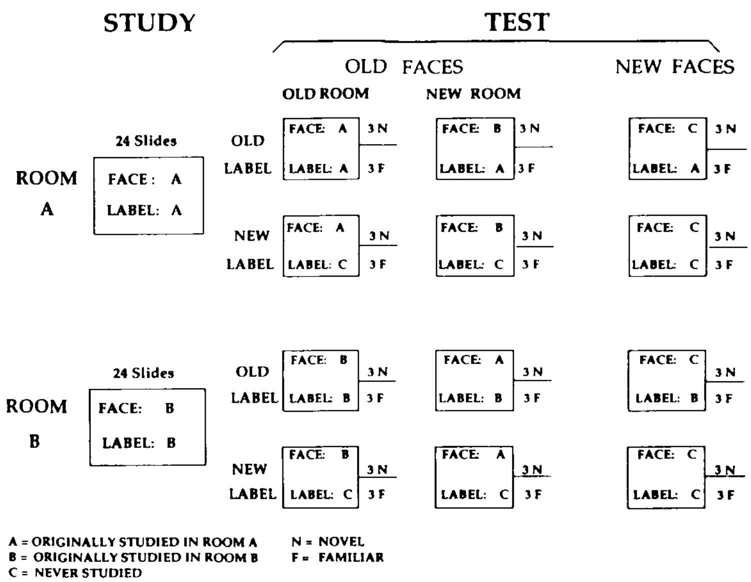

Figure 1. Design of Experiments 1 and 2, in which changes in local context (label) and global context (study and test room) were manipulated in order to study their effects on recognition of familiar and unfamiliar faces. Each subject participated in all of the study and test conditions illustrated.

Study. Five to 7 days later, the subjects returned for the study and test session. They were informed that they would be participating in a study in which they would view female faces and rate them on various dimensions. They were told they would perform this rating task in each of two rooms. They were not told to expect a memory test.

The subjects were brought into either Room A or Room B. They were told that the female faces would be presented with an occupational label, and they were instructed to judge how well the person seemed to "match" the occupation. Ratings were made on an 8-point Likert scale (1 = *poor match*, 8 = *good match*). The study faces were each displayed for 5 sec, during which the subjects made their ratings. After the study in one room, the subjects were immediately taken to the other room for the second study phase. Following the study phase, the subjects were given a 10-min retention interval in a third, neutral room.

Test. The subjects were taken back to the first room for the recognition test. They were told that they would see another series of face slides and were to indicate whether they recognized the face as having been one of the faces that they had rated earlier in that session. They were instructed that they were only to respond "yes" to faces that had been presented that day; faces seen in any other session should be responded to with a "yes" only if they had also been rated that day. The subjects were to indicate they had rated the face before by circling "yes" or "no" on the answer sheet. They were also instructed to indicate their confidence by circling a number from 1 to 3 (1 = *not sure*, 3 = *very sure*). Before the test, the subjects were told that the label accompanying the faces might be changed from the original presentation; although they were told that reading the labels would be helpful, they were instructed to make their recognition decision on the basis of the face alone. All test faces were shown for a duration of 10 sec. After completing one test, the subjects were taken to the second room for the remaining test. Following the second test, they were debriefed and dismissed.

Results and Discussion

Hit rates were calculated for studied faces on which the subjects were tested in each of the four local and global context conditions (old global-old local, old global-new local, new global-old local, and new global-new local). Since distractor faces were "new" with respect to *either* global context, the same false alarm rate was used to evaluate the responses made in old and new global context conditions. Altogether, then, there were only four false alarm rates. Hit rates, false alarm rates and d' values were calculated separately for novel and familiar faces, on the basis of six scores in each condition. The values shown in the tables are the averages of these individual scores. Because there were no differences between the tests in each room, the data were collapsed across this variable.

Whether context effects occur primarily on discrimination or also on response bias is still under debate. It has recently been argued that for pictures, words, and faces, context change often has effects on response bias that are equal to or greater than effects on discrimination (Feenan & Snodgrass, 1990). To measure discrimination, d' values were calculated and analyzed.

In the present studies, because faces from each global context condition were tested in each environmental context, the subjects necessarily fixed their criterion placement within a given room. Hence, the effects of global context cannot be due to response bias. Because a criterion measure was meaningless for evaluating the effects of global context, it was not used to evaluate criterion changes as a function of local context, either. However, there is reason to believe that both the familiarity and the local context change manipulations can produce criterion changes. Because the same pool of items was used for "new" faces in all four conditions, a change in false alarm rates can suggest an effect on criterion. Thus, the false alarm rates were analyzed to roughly evaluate criterion changes as a function of familiarization as well as local context change.

Recognition confidence judgments were collected in both experiments. Because analysis of the confidence judgments showed the same pattern as that seen with the accuracy measures, they are not reported. All reported analyses were performed on the d' values and false alarm rates. Because the effects of context change were only expected to lower recognition, the alpha level for all tests of significance on the d' values was set at .05, one-tailed.

The data analysis examined two issues: the specific effects of context change and the overall effects of familiarization. To analyze the effects of global and local context change, three sets of planned comparisons were conducted on the d' values. These provided a precise characterization of the change of environmental context and label context on recognition performance. The first comparisons were made to determine the effect of changing the label on novel and familiar faces that were tested in the old study room. The next comparisons were made to determine the effect of changing the label on novel and familiar faces that were tested in a new (nonstudy) room. The final comparisons were made to determine the effect of changing the environmental context on novel and familiar faces. These final comparisons, however, were only made for faces that were tested with completely new (unstudied) labels (old global-new local vs. new global-new local). This seemed advisable because the relationship between "old" label and face differed, depending on the room (study or nonstudy) in which the test took place.[3] Therefore, the most compelling evidence of an effect of environmental context change came from this comparison.

Effect of label change on novel and familiar faces tested in the study room (old global-old local vs. old global-new local). The first and fourth rows of Table 1 present the data for novel and familiar faces with which the subjects were tested in the study room and that either retained the label from study to test or had the label changed. Recognition for novel faces was significantly impaired when the label was changed from study to test [$t(27) = 2.13$, $MS_e = .196$]. Recognition for familiar faces was also adversely affected by a label change from study to test [$t(27) = 3.20$, $MS_e = .275$]. Thus, recognition performance shows a clear disruption when the local context is changed in this condition. These comparisons, however, cannot determine whether the recognition decrement is due to the presence of a new context or to the disruption of the configural cue by removal of the old context. Those alternatives can be distinguished by comparing the effects of retaining the label with the effects of changing the label for faces tested in the nonstudy room.

Table 1
Recognition Performance for Old and New Upright Faces in Experiment 1, as a Function of Local (Label) and Global (Room) Context Change

Context	Novel		Familiar	
	p (old)	d'	p (old)	d'
With Old Labels				
Old global-old local	.75	1.13	.89	1.12
New global-old local	.59	.79	.86	1.00
New face-old local	.31		.55	
With New Labels				
Old global-new local	.62	.87	.93	.67
New global-new local	.42	.41	.92	.60
New face-new local	.26		.71	

Effect of label change on novel and familiar faces tested in the nonstudy room (new global-old local vs. new global-new local). The second and fifth rows of Table 1 present the data for novel and familiar faces that had the label changed from study to test but with which the subjects were tested in the new (nonstudy) room. To determine whether a change of label impaired recognition for these novel or familiar faces, planned comparisons were made on d' values between faces tested with old labels and faces tested with new labels. Recognition performance for novel faces was significantly impaired when the label was changed to a new one [$t(27) = 2.34$, $MS_e = .366$]. Familiar faces were also adversely affected [$t(27) = 2.37$, $MS_e = .400$].

It is important to emphasize why the significant decrement seen in these comparisons provides the most unequivocal measure of the effects of local context change. Because none of the occupational labels were shown in both rooms, that meant that faces with old labels tested in the alternate (nonstudy) room were tested with a label that had been studied in that room, but not with that particular face. That is, the labels were "old" by virtue of having been studied in the first phase, but they were originally studied with a different face. By contrast, in the condition in which old faces were tested with old labels in the original study room (old global-old local), the faces were actually paired at test with their original study label. Consequently, the faces tested with a label change in the alternate room provide the clearest evidence that recognition is significantly impaired by the presence of a new label alone, not simply because a face-label configuration has been disrupted. The significant difference between old and new label conditions in the new room is not due to the loss of configural information, because it was never present in this test condition.

Effect of room change on novel and familiar faces tested with new labels (old global-new local vs. new global-new local). Of critical interest was whether the historically elusive effects of environmental context would be seen on recognition performance for novel and/or familiar faces. To evaluate the effect of environmental context change, planned comparisons were carried out for novel and familiar faces tested in the old (study) and the new (nonstudy) rooms. These comparisons were only made for faces tested with new labels (old room/new label vs. new room/new label), because these provide the strongest measure of an environmental context change alone. That is, as noted with respect to local context, old faces tested with an old label in the study room potentially included a configural element not present for old faces tested with an old label in a new room. However, if responses to faces tested with new labels differ, it can only be as a function of a change in the global context.

The relevant means for these conditions are presented in the fourth and fifth rows of Table 1. The d' values differed significantly for novel faces with new labels that were tested in the alternate (nonstudy) room [$t(27) = 3.87$, $MS_e = .202$]. For novel faces, recognition performance was better when the faces were tested in the old (study) room than when they were tested in the new room ($d' = .87$ vs. .41). The d' values did not differ significantly for familiar faces tested in different rooms, however ($t < 1$, $d' = .67$ vs. .60). A dissociation between global context effects on familiar and novel faces was found; unlike novel faces, familiar faces tested in the alternate room did not show a recognition decrement.

Effects of familiarization. While one immediately obvious effect of stimulus familiarization was to increase both the hit and the false alarm rates, overall discrimination was roughly the same for novel and familiar faces ($d' = .80$ vs. .85). To examine the effects on criterion, the false alarm rates were entered into a two-way analysis of variance. There was a highly significant main effect of familiarization [$F(1,27) = 33.02$, $MS_e = .078$]. This suggests that the change in responding as a function of familiarity is perhaps more of a change in response bias than in sensitivity (FA = .32 vs. .62). There was no significant effect of changing the label on false alarms, but there was a significant interaction [$F(1, 27) = 11.87$, $MS_e = .018$]. Changing the label decreased the false alarm rates for novel faces (.31 vs. .26) but increased the false alarm rates for familiar faces (.55 vs. .71). This finding will be addressed following presentation of data from Experiment 2.

Summary

Experiment 1 provided evidence of impairment of recognition of both novel and familiarized faces when local context (occupational label) was changed from study to test. However, when the environmental context was changed from study to test, there was an effect of the room context change only on the novel faces.

One factor to be considered in interpreting the lack of global contextual mediation for familiar faces is the possibility of a ceiling effect on recognition. Hit rates for familiar faces were quite high across all conditions of context manipulations. It should be noted that despite this recognition ceiling, an effect of local context was found. However, the effect of local context change on d' was more a result of changing false alarm rates between old and new labels, not lowered hit rates. To determine whether ceiling recognition rates were obscuring any effect of environmental context change on familiar faces, hit rates needed to be lowered. Experiment 2 was designed to address this issue through presentation of inverted test faces, thus rendering the stimuli more difficult to recognize.

EXPERIMENT 2

In Experiment 1, hit rates for familiarized faces were so high that, potentially, effects of changing the global context on these faces might have been masked. One method for disrupting face recognition and degrading accuracy is to present the faces in an inverted orientation. A number of studies have shown recognition of faces and other expertly processed stimuli to be subject to serious disruption by inversion (Diamond & Carey, 1986; Valentine & Bruce, 1986; Yin, 1969). Apparently, and unsurprisingly, memory for a stimulus such as a face, which is usually processed in an upright orientation, suffers great impairment when the stimulus is inverted. It was hoped that studying an upright face that was inverted at test would allow encoding of the local and global context but diminish overall recognition. Reducing hit rates for recognition of familiar faces to an intermediate level should make it possible to detect effects of changing the environmental context on familiar faces, if such effects are present.

Method

Subjects. Forty-one students at Rutgers University participated in this experiment to fulfill an introductory psychology course requirement. As in Experiment 1, they were run in groups of 2-6 students.

Procedure. The procedure was similar to that in Experiment 1, with the following modifications: familiarization and study slides were presented in an upright orientation as before, but all test slides were presented in an inverted orientation for recognition judgments. Since occupational labels were also inverted, they were read aloud at study and test by the experimenter to both ensure and facilitate their processing.

Results and Discussion

The data were analyzed as in Experiment 1. The principal results are summarized in Table 2. As had been hoped, the inversion manipulation reduced overall recognition accuracy and eliminated any suggestion of a ceiling effect.

As before, a set of planned comparisons was conducted on three critical contrasts. These comparisons were to de-

Table 2
Recognition Performance for Old and New Inverted Faces in Experiment 2, as a Function of Local (Label) and Global (Room) Context Change

Context	Novel		Familiar	
	p (old)	d'	p (old)	d'
With Old Labels				
Old global-old local	.76	1.04	.86	.63
New global-old local	.59	.55	.85	.60
New face-old local	.37		.63	
With New Label				
Old global-new local	.62	.49	.85	.47
New global-new local	.55	.29	.82	.39
New face-new local	.43		.69	

termine the effect of (1) changing the label on novel and familiar faces tested in the old study room, (2) changing the label on novel and familiar faces tested in a new (nonstudy) room, and (3) changing the environmental context for novel and familiar faces tested with new labels.

Effect of label change on novel and familiar inverted faces tested in the study room (old global–old local vs. old global–new local). The first and fourth rows of Table 2 present the data for novel and familiar inverted faces that were tested in the study room and had either the same or a different label at study and test. Recognition for novel inverted faces was significantly impaired when the label was changed from study to test [$t(40) = 3.00$, $MS_e = .681$]. Recognition for familiar faces was also affected by a label change from study to test, although only marginally so [$t(40) = 1.44$, $MS_e = .248$, $p < .07$]. Thus, recognition performance shows a clear disruption when the local context is changed for novel inverted faces and a marginally significant disruption when the local context is changed for familiar inverted faces. As in the evaluation of the outcome of Experiment 1, these comparisons cannot determine whether the recognition decrement is due to the presence of a new context or to the disruption of a configuration by removal of the old context. Those alternatives can be more clearly distinguished by the next planned comparisons of effects of label change for novel and for familiar faces tested in the nonstudy room.

Effect of label change on novel and familiar inverted faces tested in the nonstudy room (new global–old local vs. new global–new local). The second and fifth rows of Table 2 present the data for novel and familiar faces that had the label changed from study to test but with which the subjects were tested in the new (nonstudy) room. To determine whether a change of label impaired recognition for these faces, planned comparisons on d' values were made between faces tested with old labels and faces tested with new labels. Recognition performance for novel faces was significantly impaired when the label was changed to a new nonstudied one [$t(40) = 1.79$, $MS_e = .429$]. Familiar faces were again adversely affected, although the difference just failed to reach significance [$t(40) = 1.52$, $MS_e = .396$, $p < .068$]. As in the same comparison in Experiment 1, these faces provide clear evidence that recognition is significantly impaired by the presence of a new label alone, not simply because a face–label configuration has been disrupted.

Effect of room change on novel and familiar faces tested with new labels (old global–new local vs. new global–new local). Determining whether environmental context effects were evident on novel and familiar inverted faces was again of major interest. To evaluate the effect of environmental context change, planned comparisons were carried out for both novel and familiar faces tested in the old (study) and the new (nonstudy) room. Again, comparisons were made only for faces tested with new labels, because these comparisons provide the strongest measure of an environmental context change. As noted before, old faces tested with an old label in the study room potentially included a configural element not present for old faces tested with an old label in a new room. If responses to faces tested with new labels differed, it was only as a function of change in the global context.

The means for the relevant conditions are presented in the fourth and fifth rows of Table 2. Recognition for novel faces with new labels was affected when they were tested in the new room [$t(40) = 1.93$, $MS_e = .217$]. Most importantly, the dissociation of global context effects on novel and familiar faces found in Experiment 1 was replicated with inverted faces. For novel inverted faces, recognition performance was superior when the faces were tested in the original study room rather than when they were tested in the new (nonstudy) room ($d' = .49$ vs. $.29$). There was no evidence of a difference between d' values for familiar inverted faces tested in the old and new rooms ($t < 1$). Unlike the decrement shown for novel faces, there was no corresponding recognition decrement for familiar faces when they were tested in the alternate room ($d' = .47$ vs. $.39$).

Effects of familiarization. Hit rates for familiarized faces averaged 20% higher than those for novel faces across all conditions. However, the difference between recognition performance for novel as opposed to familiar faces was attributable to changes in the false alarm rates as well as the hit rates. To examine the effects on criterion, the false alarm rates were analyzed separately. Although overall discrimination for novel and familiar faces did not differ reliably, a two-way analysis of variance conducted on the false alarm rates showed a highly significant effect of familiarization [.42 vs. .63; $F(1,40) = 47.21$, $MS_e = .043$]. There was also a significant effect of label change on false alarm rates [$F(1,41) = 6.49$, $MS_e = .021$], but no interaction. In this study, changing the label increased the false alarm rates for both novel and familiar faces (.37 vs. .43 and .63 vs. .69, respectively). Both this increase and the interaction seen in Experiment 1, where false alarms increased for novel faces as a function of new context, are somewhat unexpected. One common assumption about the effects of an old context is that it biases the subject to judge the accompanying stimulus as old. Here, the pattern of data is partially inconsistent with this assumption. As noted earlier, however, changes in false alarm rates are only suggestive of criterion changes. Determining the precise role of a new context on criterion was beyond the scope of the present design. These data raise interesting questions, however, that future research can address.

Summary

In conclusion, the inversion manipulation was successful in lowering recognition performance for the familiarized faces. After elimination of a possible ceiling effect, however, changing the local context was still effective in impairing recognition performance for both novel and familiar faces. Yet, replicating Experiment 1, the environmental context change produced much more disruption of recognition for novel as opposed to familiar inverted faces.

GENERAL DISCUSSION

The finding that emerges consistently from these studies is that there are effects of context, both local and environmental, on recognition memory for faces. Of greater importance, however, is the identification of a significant determinant of environmental context dependency, as shown by the differential effects of context in both studies. Results from these experiments indicate that the prior history of the stimulus—namely, the degree of familiarity—is a critical parameter in modulating the effect of environmental context and should be included in any theoretical account of contextual association and control.

Implications for Context Effects on Word Recognition

The fact that local context affects both novel and familiar faces, whereas global environmental context more strongly affects novel faces meshes well with the findings in the literature on context in word recognition. The effects of local or specific context have been amply demonstrated in word recognition studies involving changes of semantic context (e.g., Light & Carter-Sobell, 1970; Tulving & Thomson, 1973), where the trace or code is semantically altered by means of the contextual word cue with which it is paired; recognition judgments suffer if the semantic cue is changed from study to test. It appears less likely that the incidental features of the environment force a reencoding of the stimulus that results in a new or modified trace containing these contextual attributes. Indeed, effects of environmental context on stimuli such as words have been elusive. The present studies suggest that local context that is intentionally processed with the stimulus can influence or even determine the encoding and retrieval of both novel and familiar stimuli. Words, which are assumed to be familiar or "codified" representations, show this effect, and in the present studies, so do both novel and familiar faces.

The finding that environmental context change affected only novel faces suggests that a global context may only strongly affect recognition when encoded with a stimulus that is being processed for the first time. In that case, the initial episodic representation may include all features of the context—as most memory theories that invoke a contextual mechanism suggest. The strength and duration of this context dependency appears fragile, however. In these studies, merely four presentations of the stimulus in a neutral context prior to the study and test exposure effectively decontextualized the stimulus and neutralized any effects of changing the global context. Most words used in recognition memory experiments have a prior history of extraexperimental exposure that exceeds this threshold. Thus, it is perhaps not surprising that environmental context effects on words have been weak.

That codification is the relevant aspect of familiarization remains to be investigated, however. In comparing words and pseudowords for repetition and frequency effects, Salasoo, Shiffrin, and Feustel (1985) have argued that pseudowords show effects of "codification" by six presentations. The codification threshold for unfamiliar faces remains to be determined.

Such an interpretation says that a stimulus that has not yet been codified is more likely to show environmental context effects. This mechanism would presumably apply to other uncodified stimuli, such as nonsense syllables and even pseudowords. Although no direct testing of this assumption has taken place, support for this idea is found in an unpublished study reported by Smith (1988), who found evidence of environmental context dependency only for consonant-vowel-consonant combinations (CVCs) that were low in meaningfulness. If one assumes that meaningless CVCs are less word-like than CVCs that are high in meaning, it follows that their codification threshold might be higher. While they are uncodified, they would presumably be susceptible to incorporation of the current context.

Reconciliation With Proposals About the Role of Context

Numerous attempts have been made to organize and explain the variability of context effects on recognition memory. A brief examination of several of the major proposals and consideration of the present results follows.

The integration hypothesis. In a classic study, Godden and Baddeley (1975) had divers learn word lists either on land or underwater, and observed significant decrements in recall performance for divers tested in the different rather than the same context. In a later study done with exactly the same context manipulation, recognition performance was unaffected (Godden & Baddeley, 1980). To account for this dissociation between memory measures, Baddeley and his colleagues (Baddeley & Woodhead, 1982; Godden & Baddeley, 1980) have proposed that recognition, unlike recall, is not contextually dependent unless context and stimulus are interactively encoded or integrated at study. Baddeley and Woodhead's (1982) integration hypothesis would account for the local context dependency observed in these studies, because, according to their criterion, the labels were deeply and interactively processed with the faces. This would result in the context-dependent recognition found for novel and familiar faces in both experiments. However, the integration hypothesis would not predict the environmental context-dependent recognition found for novel faces in these studies. At no time were subjects instructed to interactively process the global context with the stimuli. The contextual encoding of the environmental features that took place did so in the absence of demands for intentional interactive processing. Thus, type of processing appears not to be a necessary parameter of environmental context dependency.

The outshining hypothesis. Alternatively, Smith (1988) has proposed the "outshining hypothesis" to account for the effects of context on recognition. This account of contextual processing emphasizes the nature of the available retrieval cues. That is, when a good copy cue of the stimulus exists, as it does in recognition tasks, then environmental cues (which are inherently weak) are irrelevant to retrieval. According to this reasoning, elements that are integrated with the target or are deeply processed are superior cues.

To apply the "outshining hypothesis" to the present data requires the assumption that familiar faces are processed differently from novel faces in a way that produces superior copy cues. That is, at the time of face-label rating, subjects may recognize and differentially process the familiar faces. While it is somewhat unlikely that familiar faces are processed more deeply than novel faces, it is possible that a familiar face has a more integrated copy cue that would outshine the environmental context cues. Some evidence against this explanation can be found in a study by Beales and Parkin (1984), in which context-dependent recognition was demonstrated for faces that had received either deep or shallow processing.

The experimental context hypothesis. Fernandez and Glenberg (1985) made one of the more rigorous and systematic attempts to demonstrate context effects on memory. After failing to find context-dependent recognition or recall in over 300 subjects, they proposed that laboratory context manipulations are inherently ineffective because, from the subject's perspective, all environmental context changes occur within the broader "experimental context." This overriding experimental context diminishes the salience of any environmental manipulations between study and test. Fernandez and Glenberg's intriguing proposal has received some empirical support from a study in which a radical context change was employed, with subjects' recognition memory being tested over the telephone when they were at home (Canas & Nelson, 1986). Another investigation done with a similar paradigm, however, failed to yield any effect on recognition (Wippich, Mecklenbrauker, & Hoffmann, 1985). In the present studies, however, Fernandez and Glenberg's hypothesis of contextual processing does not account for the findings of environmental context-dependent recognition on the novel faces. While the environmental contexts employed in the present set of studies may certainly have differed in individual features from the ones that they used, it is doubtful that any differences between these manipulations and theirs underlie the disparate findings. Both of the present contexts resided wholly within the greater context of the experiment, a distinction that, they propose, undermines contextual specificity. More to the point, the "experimental context hypothesis" cannot account for the differential effects of familiarity demonstrated in these studies.

The familiarity hypothesis. It is not to be suggested that the aforementioned hypotheses should be summarily disregarded. Although incomplete, with respect to accounting for the present findings, each one incorporates likely parameters of contextual effects. As described by the "experimental context hypothesis," the magnitude of the global contextual change, particularly with manipulations of drug or emotional states, may well mediate the degree of the context effect. Similarly, by the logic of the "integration hypothesis," the degree to which a stimulus is intentionally encoded with contextual attributes may interact with the stimulus familiarity and determine the amount of contextual specificity. Future research can address the differential ability to produce this interactive encoding, which is potentially a function of the "belongingness" of stimulus and context.

In terms of the present studies, however, the "outshining hypothesis" comes closest to identifying the variables deemed relevant here. One of its implications is that the use of contextual cues in recognition is most likely a second-order process. That is, the subject may look to the context for information only if the focal element is not activated strongly enough to exceed the threshold of recognition. It follows, then, that if the copy cue provides adequate activation, the context will be disregarded. The outcome of the present studies is compatible with this. What determines the subject's reliance on context is not simply the presence or absence of good copy cues, however, but the nature of the representation to be matched with the copy cue. And it is here that one must consider the importance of stimulus familiarity.

The explanation arising from the present studies makes the stimulus parameter of familiarity a critical determinant of contextual modulation. When a stimulus is initially encoded in a particular environmental context, the trace or code retains those contextual attributes for a period of time or number of presentations. In this phase, recognition of the stimulus appears contextually bound. A stimulus that has been exposed in more than one context so that its codified representation may be activated without the presence of specific contextual attributes is considered to be decontextualized. In this state, context other than local or semantic context (which, when interactively processed, influences the encoding and retrieval of even familiar stimuli) will not affect recognition. It follows, then, that other forms of global context, such as mood states or pharmacological states, could be expected to show differential modulation for novel and familiar "decontextualized" stimuli.

An alternate explanation for the environmental decontextualization, which the present studies cannot distinguish, concerns the effect of stimulus presentation in varied contexts. It has been shown that when learning takes place in varied contexts rather than a single, consistent context, the negative effects of changing environmental context are diminished (Smith, 1985, 1986; Smith et al., 1978; Smith & Rothkopf, 1984; Tiberghien, 1986). Since the familiarized faces were originally presented in a room other than the study and test room, they had the additional feature of having been exposed in varied contexts. Novel faces were only exposed within the same context during learning, and they showed environmental context-dependent recognition effects. In addition, the local context (labels) were only studied in a single context, and they too showed context-dependent recognition ef-

Table 3
Context Effects on Novel Faces: Discrimination Index (d') for Novel Faces in Experiment 1 (Upright) and Experiment 2 (Inverted), as a Function of Changes in Local Context (Old vs. New Label) and Global Context (Old vs. New Room)

	Label	
Room	Old	New
	Experiment 1	
Old	1.13	.87
New	.78	.41
	Experiment 2	
Old	1.04	.49
New	.55	.29

fects in both experiments for all types of faces. Thus, it may be the case that stimulus encoding in varied contexts is responsible for the decontextualization effects seen here. Although the present studies cannot determine whether decontextualization occurs solely as a function of familiarity or also as a function of learning in varied contexts, future research can directly test this distinction.

The Effects of Context Change on Novel Faces

Having established a differential pattern of context modulation for novel as opposed to familiar faces, I next turn to more closely examine the pattern of context effects for the novel stimuli. Table 3 presents the d' values for *novel* faces in Experiments 1 and 2, tested in all context conditions. The most notable feature of the table is that greater changes in the contextual elements from the original study condition are associated with greater recognition impairment. The best discrimination performance is for faces presented as they were at study (reinstating room and label). In Experiment 1, recognition performance decreases in the following order of conditions: faces tested in the old room, but with new local context; faces tested in the new room with switched "old" local context; and finally, faces tested in the new room and with a new label. Each additional change of contextual elements brings a corresponding decrease in recognition performance. In Experiment 2, the pattern is almost identical, except that novel faces tested in the new room with switched "old" local context are equally well recognized as faces tested in the old room with new local context.

This pattern of recognition decrement even holds true with respect to comparing faces that are tested in the alternate room with "switched" labels versus "new" labels. It might well be considered that "switched" context would function as a new context for the face with which it is paired. The summary in Table 3 shows otherwise. Evidently, a local context that is familiar, although newly paired with the target, confers some recognition advantage over a local context that is entirely "new." These results are consistent with global theories of recognition such as SAM (Gillund & Shiffrin, 1984).

CONCLUSION

In summary, the present experiments show clear evidence of context modulation of recognition memory for faces. In particular, they provide evidence of environmental context effects that are robust when the stimulus is novel, but that disappear as it becomes familiarized. The importance of this finding can be viewed in several ways. First, this dissociation suggests an explanation for the inability of earlier research to find effects of environmental context-dependent recognition for words, which are highly familiar stimuli. With the inclusion of this parameter, extensions of environmental context dependency to the verbal stimulus domain (e.g., using nonwords or pseudowords) may be more successful. In addition, evidence that novel and familiar faces are differently mediated by the context may provide an important window on the process of familiarization and the development of representational codes. Studying contextual phenomena as a means of investigating the development and modification of the stimulus representation as it acquires familiarity seems warranted. Finally, at the theoretical level, additional evidence concerning the empirical effects of context need to be incorporated. If memory theorists continue to invoke context as an explanatory mechanism for such phenomena as forgetting or recognition failure, the parameters of the context phenomenon itself should be well specified and understood.

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NOTES

1. Underwood and Humphreys (1979) have argued that the magnitude of local context effects are roughly equivalent whether the accompanying context is semantically associated or unrelated to the target word.

2. It is not suggested that the stimuli in this study necessarily have developed semantic representations, as in Tulving's distinction. His position is that episodic representations rely to different degrees on contextual attributes and that this differential reliance may be a consequence of familiarization.

3. Because none of the occupational labels were shown in both rooms, faces with old labels tested in the new (nonstudy) room were actually tested with a label that had been studied in that room, but not with that particular face. That is, the labels were "old" in the sense of having been studied in the first phase, but they were originally studied with a different face.

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