An episodic-memory trace of an event consists of information about both the focal elements and setting of an event (Tulving, 1983). The setting is the psychological background or environment in which the event takes place. The relations or associations between the focal elements and the setting are integral to the episodic memory. As long as the trace is episodic in nature, the setting is always one of the defining features of an event (Tulving, 1983), and it can also provide a source of retrieval cues for the focal elements. Thus, in order to understand the episodic memory entirely, one should deal with both the focal elements and the setting of the episode, and the associations between them. The setting is usually referred to as context. In the present paper, the setting will be referred to as “episodic context”.

The episodic context contains multiple elements, such as the time of day and the place of the event, the person(s) with whom the subject spent the duration of the event, and any other situational information. Thus, for the manipulations of the episodic context in the present experiments, the author varied three contextual elements: the rooms in which subjects studied items and received a test; the experimenter who instructed subjects; and interpolated tasks which characterize the situation of the experimental session. This compound manipulation of the context was designed to vary the psychological as well as the physical context. Fernandez and Glenberg (1985) have pointed out that the critical feature of the events occurred within an experimental context would not change with a change of room even if changing the room was to produce a massive change in physical environment. Thus, the present experiments were designed to manipulate psychological environments within an experimental context. More specifically, the manipulation for same-context (SC) condition was designed to imply to subjects that the test session was the same kind of experiment as that at study, whereas that for different-context (DC) condition was designed to imply the different one.

The author and his colleague have referred to the context, defined by the same manipulations used in the present experiments, as “environmental context” (e.g., Isarida, 1991, 1992; Isarida & Morii, 1986), because the defined context represents the psychological environment of the event. The defined context, however, and the environmental context that the majority of researchers used are not the same, because there are some differences between the environmental context and the episodic context. In the present paper, therefore, the author will use the term “episodic context” instead of “environmental context”. We must not give one name to two different concepts to avoid confusion in communication. The term “environmental context” used by the majority of investigators has been restricted to the physical aspects of the environment in which subjects encoded and retrieved to-be-remembered (TBR) materials (e.g., Smith, 1979, 1988), whereas the term “episodic context” contains much more elements than the physical environments. Indeed, an episodic context includes a mental representation of a physical environment, an environmental context, and even if the environmental context may be the greater part of the episodic context, the two contexts should not be the same. Further, the environmental context, especially in laboratory experiments, exists incidentally with the focal elements (e.g., Bjork & Richardson-Klavehn, 1989; Fernandez & Glenberg, 1985), whereas the episodic context works interactively with the focal elements. Tulving (1983) stated that the setting of an episode, the episodic context, works interactively with the perception and the encoding of the focal elements.

Several researchers have stated that internal rather than external features of the environment would directly produce context-dependent memory. Eich (1995) demonstrated that internal states such as mood mediate the environmental context-dependent memory. Furthermore, Smith (1995) states the mental context hypothesis that “many incidental events (components of the mental context) are represented in memory in association with the focal experimental stimuli. Included in the mental context are not only representations of mood and ambient environments but the participant’s mental set, physiological events, active memories, and other incidental factors. (Smith, 1995, p. 309)” The notion of the episodic context is similar to these claims, especially to the notion of the mental context, because the episodic context does not include only the internal states such as mood. There are, however, some differences between the mental context and the episodic context. The mental context consists of a variety of incidental elements, whereas the episodic context works, as described above, interactively with the focal elements. Additionally, Smith has manipulated no more than the physical features of the environment (e.g., Smith, 1979, 1988), whereas the
author and his colleague have manipulated more than the merely physical ones (e.g., Isarida, 1991, 1992; Isarida & Morii, 1986).

The purpose of the present paper is to clarify how the episodic context determines the production of the study-time effect, one of the most basic phenomena in episodic memory. An increase in time for studying TBR items has been explained to result in an increase in trace strength of individual items (e.g., Atkinson & Shiffrin, 1968; Craik & Lockhart, 1972) and in associative strength among items (e.g., Tulving, 1962). These explanations are restricted to the effects on focal elements, which contain TBR items and interitem associations among items. If the episodic traces consist of both focal elements and episodic context, processing for studying should strengthen the association between the focal elements and the episodic context. If this is the case, the study-time effect should be determined by a reinstatement of the episodic context at study. When study context is reinstated, one can use the episodic context as retrieval cues for the focal elements, and therefore, the associative strength between the focal elements and the episodic context should be reflected in the probabilities of retrieving items. On the other hand, when study context is not reinstated, the associative strength would not be reflected. Consequently, the production of the study-time effect may depend on the reinstatement of the episodic context at study.

Recently, certain episodic context-dependent phenomena have been reported (Isarida, 1992; Isarida & Morii, 1986). Isarida & Morii (1986) reported that the spacing effect of repetitions, ranging from a few to tens of seconds, was determined by the reinstatement of the episodic context. The spacing effect appeared when the study context was reinstated at a 24-hour delayed free-recall test, whereas the effect was eliminated when the context was not reinstated. Furthermore, the magnitude of the spacing effect was correlated with the number of elements used for reinstating the context. Isarida (1992) reported that the effect of the number of rehearsals on free recall depended on the reinstatement of the episodic context. The context was manipulated the same way as in the present experiments. The number of rehearsals had a much larger effect when study context was reinstated at test than when the context was not reinstated.

There are still few findings, however, to support the episodic context-dependent phenomena (Isarida, 1992; Isarida & Morii, 1986). Moreover, these few findings were obtained under relatively ambiguous conditions, in which subjects were able to engage in interitem relational processings. Interitem relational processings produce associations between a set of items and semantic or local context (e.g., Glenberg, 1979; Light & Carter-Sobell, 1970) and associations among a set of items. These associations can provide stronger cues for retrieval than the episodic context (e.g., Glenberg, 1979; Smith, 1988). These interitem relational cues are less overloaded (Watkins & Watkins, 1975) than the episodic context, because they are associated with the fewer items than the episodic context. Further, the semantic or local contexts are processed more interactively with the items than the episodic context (e.g., Baddeley, 1982). Thus, these interitem relational cues may outshine the episodic context; or at least they affect the episodic context-dependent retrieval processes.

Therefore, one must control interitem relational cues in studying episodic context-dependent phenomena. Hence, in Experiments 1 and 2, any interitem relational processings were suppressed. In order to suppress the interitem relational processings, calculation tasks were imposed before and after studying each TBR item. Further, in Experiment 3 and 4, interitem relational processings and episodic context were independently controlled.

Experiment 1

Method

Design. A 4 x 3 mixed factorial design was employed. The first factor, manipulated within subjects, was study time per item: 3, 6, 9, and 12 seconds. The second factor, manipulated between subjects, was test condition: same context (SC), different context (DC), and immediate recall (IR). SC subjects received a free recall test in the same episodic context as that at study, whereas DC subjects received it in a different context from that at study. In both SC and DC conditions a 24-hour retention interval was imposed in order to prevent subjects from mentally reinstating the study context, because a retention interval of several hours would make it impossible for subjects to reinstate the original context mentally (e.g., Bjork & Richardson-Klavehn, 1989; Smith, 1988). Although both SC and DC conditions needed two experimental sessions across two days with subjects leaving the laboratory, most studies concerning the effects of the amount of processing on free recall (cf., Nelson, 1977) needed only one session without leaving the laboratory. Thus, IR condition was induced as the control condition in order to compare the present experiment with the referent experiments. In IR condition, a free recall test was started immediately after the list presentation so that both
study and test sessions were completed within one experimental session without subjects leaving the laboratory. In summary, episodic contexts were varied between SC and DC conditions, and retention intervals were varied between IR and SC conditions.

**Episodic context** A combination of three contextual elements (room, experimenter, and situation) was systematically varied. DC subjects were required to attend at a different day and place from that at study. Additionally, the experimenter who instructed subjects was different from that at study. On the other hand, SC subjects attended the test session at the same place as that at study, and received instructions from the same experimenter as that at study. Further, before testing, subjects completed the same calculation task as that imposed before and after studying items. To make the fair comparison between SC and DC, the test session in SC condition was conducted at a different day from that at study.

For the room element, the width, interiors, and smells of the room were manipulated. Thus, two rooms (Room A and B) were used. Room A was 375 cm in width x 570 cm in depth x 230 cm in height. A large bookshelf covered one wall, three large cabinets stood along another wall, and in a third wall was a large window through which subjects could see outside. Room B was 175 cm in width x 150 cm in depth x 230 cm in height, with two beige walls and two light blue partitioning curtains. In Room B, an aromatic of lime was sprinkled. When each room was used at study, a computer system (NEC PC-9800 system) was set for presenting both TBR items and interpolated calculation tasks. Room A and B were at the same floor of the same building. In IR and SC conditions, half the subjects were run in Room A for both study and test, and the others were run in Room B. On the other hand, in DC condition half the subjects studied in Room A and were tested in Room B, and the others studied in Room B and received the test in Room A.

For the experimenter element, either a male teacher who lectured in a course on General Psychology that the subjects attended (experimenter A) or a female undergraduate who was not acquainted with the subjects (experimenter B) served as experimenter. One half of both IR and DC subjects were instructed by experimenter A and the others were instructed by experimenter B for both study and test. On the other hand, a half of the DC subjects were instructed by experimenter A for studying and by experimenter B for testing, and the others were instructed by experimenter B for studying and by experimenter A for testing.

For the situational element, an interpolated task was used. Before and after studying each item, the subjects engaged in a 20-second calculation task so that the subjects' episode would not consist of "studied words only" but "studied words together with calculation tasks". Additionally, both IR and SC subjects received the same calculation task as that before and after studying before testing, whereas DC subjects received no task before testing. For the calculation task, subjects received two-term addition problems one by one on a CRT-display connected to the computer system, and then they were required to press the numeric key corresponding to the first digit of the sum as fast and correctly as they could. A tone "peep" was fed back to each correct response, and a buzzer was fed back to each incorrect response. Each response started to present the next problem, whether it was correct or not.

**Subjects.** The subjects were 97 undergraduates of Shizuoka University, Shizuoka, Japan, and were naive about any kinds of psychological experiment. They received extra points toward a liberal arts Psychology course credit for their participation. They were randomly assigned to one of the three subject groups. Seven of the subjects were replaced from the analysis of the results, because six of them verbally reported that they made some interitem relational processing and one of them reported that she anticipated the testing at the second session. Consequently, each condition consisted of 30 subjects.

**Materials.** A TBR list consisted of 16 unrelated Japanese three-kana-letter nouns whose familiarity values were from 4.00 through 4.99 (Koyanagi, Ishikawa, Okubo, & Ishii, 1960).

**Procedure.** All the subjects were individually run. IR subjects participated in one 20-minute session, whereas both SC and DC subjects participated in two 20-minute sessions separated by a 24-hour retention interval. The procedure of the first session was identical for all the subjects, except for the room and the experimenter. The subject came and knocked on the door of the teacher's room. Then experimenter A or B took the subject to either Room A or B. Sitting on a chair in the room, the subject was instructed about the procedure of the experiment by the experimenter.

Following the instruction, the subject received a list of 16 TBR items one by one on the CRT-display. The subject was required to study only each currently presented item without making any interitem associations. The presentation time for each item was randomly selected from the four rates of presentation (3, 6, 9, and 12 seconds/item) with
restrictions as follows: (a) each of the four rates appeared four times, and (b) no more than two successive items were presented at the same rate. The presentation order of the items was also randomized over the subjects. The presentation order of the items was randomized across the subjects. Every item presentation was preceded and followed by a 20-second calculation task so that every item would be studied discretely from each other. The subject engaged in the task 17 times. At the end of the last calculation task, if triple question marks (???) were presented, then the subject had to receive a recall test, and if an end mark (END) was presented, then the first-day session was finished without testing. Subjects also received the following dummy instructions: "The purpose of the present experiment is to investigate cognitive relationships between arithmetic skills and mnemonic skills. More specifically, the experiment is designed to measure the changes in task performance with an increasing number of items. The subject must calculate as fast and correctly as possible. The subject also must study as many of the words as possible." The instructions were designed to keep the subject's mind from the following day's test, so that she or he would not rehearse the items during the retention interval, as well as to construct the subject's episode as "studied words together with calculation tasks" instead of "studied words only". IR subjects received the question marks so that they received a free recall test. Both SC and DC subjects received the end mark so that the first session was finished without testing.

Twenty-four hours after the first session, both SC and DC subjects returned to the teacher's room. Then SC subjects were taken to the same room by the same experimenter, whereas DC subjects were taken to the other room by the other experimenter. Then SC subjects received a recall test after completion of the same task as that at study, whereas DC subjects received the test without any calculation task.

After the recall test, an introspective report was recorded. If the subject reported that she or he anticipated the test and/or that she or he engaged in any interitem relational processing, then she or he was replaced from the analysis of the results. At the end of the experimental session, subjects were informed about the true purposes of the experiment.

Results

Table 1 shows the proportions of items recalled as a function of study time and the test conditions. The study time seems to yield no systematic changes of the proportions in Table 1. A 4 x 3 (study time x test condition) analysis of variance (ANOVA) using mean numbers of items recalled as dependent measure was computed. There were neither the main effect of study time \( F(3, 261) = 1.62, \text{MSE} = 0.52 \) nor the interaction \( F < 1 \). One-way ANOVAs within the test conditions showed no effects of the study time \( \text{IR: } F(3, 87) = 1.34; \text{SC and DC: } F < 1 \). Only the main effect of the test conditions \( F(2, 87) = 24.58, \text{MSE} = 0.91, p < .001 \) was significant. Newman-Keuls pairwise comparisons (critical difference = 0.25, \( \alpha = .05 \)) showed that the differences both between IR and SC and between SC and DC were significant.

Discussion

Neither IR, SC, nor DC condition yielded significant study time effect on recall, although a significant effect of the episodic context on recall was found. No effects of study time in both IR and SC conditions are inconsistent with the various previous experiments (e.g., Nelson, 1977). More essentially, the relation between the study time effect and the episodic context is not clarified by the results.

The lack of the study time effect would be caused by the failure to inhibit the processing to the other than currently presented item. Most subjects carried out extra processing of the previously presented items along with the currently presented item. The extra processing equates the actual study times of items whose nominal study times were different among each other. Manipulating the factor of study time within subjects required subjects to study items with equivalent familiarity values for the different length of time. Moreover, 12 sec was too long to study a single item. Thus, during the presentation of a 12-sec item, subjects may have processed the previously presented items with shorter-presentation time such as 3 sec along with the current item in order to compensate for the shortness of the study time. In addition, the arithmetic task may be too easy to prevent subjects from additional processing. Interitem association should also bring out the extra processing. The familiarity of TBR items may be so meaningful as to associate together.

Experiment 2
In Experiment 2, several modifications of procedure and materials were implemented in order to inhibit the associative processing at input. First, the factor of study time was manipulated between subjects. Second, the 12-second condition of the study time was eliminated. Third, the subsidiary task was made more difficult by using three-term additions than two-term additions. Finally, the familiarity values of TBR items were made lower by ranging from 3.00 through 3.99 than by ranging from 4.00 through 4.99.

Method

Design. A 3 x 3 factorial design was employed. All the factors were manipulated between subjects. The first factor was study time per item: 3, 6, and 9 seconds. The second factor was test condition: same context (SC), different context (DC), and immediate recall (IR). The other design was identical to that used in Experiment 1.

Episodic context. For the calculation task, the subject received a matrix of randomly selected numbers on a 364 mm x 258 mm paper, and then she or he was required to write the sum of three successive numbers under the three numbers from left to right for 20 seconds. The other manipulations of context were identical to that used in Experiment 1.

Subjects. The subjects were 223 undergraduates enrolled in a liberal arts Psychology course at Shizuoka University, Shizuoka, Japan. They received extra course credit for their participation. They were randomly assigned to one of the three groups. Seven of the subjects were replaced from the analysis of the results, because four of them verbally reported that they made some interitem relational processing and three of them reported that they anticipated the testing at the second session. Consequently, each condition consisted of 24 subjects. The other features of the subjects were identical to those in Experiment 1.

Materials. A TBR list consisted of 16 unrelated Japanese three-kana-letter nouns whose familiarity values were from 3.00 through 3.99 (Koyanagi, Ishikawa, Okubo, & Ishii, 1960).

Procedure. All the subjects were individually run. IR subjects participated in one 20-minute session, whereas both SC and DC subjects participated in two 20-minute sessions separated by a 24-hour retention interval. The procedure of the first session was identical for all the subjects, except for the room and the experimenter. They were required to study only each currently presented item without making any interitem associations. Each item presentation was preceded and followed by a 20-second calculation task. The subject engaged in the task 13 times. The other procedure was identical to that used in Experiment 1.

Results

Table 2 shows the proportions of items recalled as a function of study time and the test conditions. The results indicate that the proportions in both IR and SC conditions increase with the study time, but there are no changes in DC condition. A 3 x 3 (study time x test condition) analysis of variance (ANOVA) using mean numbers of items recalled as dependent measure was computed. The main effects of the test conditions \[F(2,207) = 168.02, MSe = 1.22, p < .001\] and of the study times \[F(2,207) = 37.21, MSe = 1.22, p < .001\] were significant, and the interaction was also significant \[F(4,207) = 8.49, MSe = 1.22, p < .001\]. Each test condition was subanalized, because the interaction was significant. The study-time effect was significant in both IR condition \[F(2,207) = 34.84, MSe = 1.22, p < .001\] and SC condition \[F(2,207) = 18.72, MSe = 1.22, p < .001\], but no effect in DC condition \[F < 1\].

Discussion

The results of Experiment 2 indicate that the production of the study-time effect depends on the reinstatement of the episodic context at study. That is, the study-time effect appeared when the study context was reinstated (SC condition), whereas the effect was eliminated when the study context was not reinstated (DC condition). In the present SC condition, item information and context were available as retrieval cues, whereas in the present DC condition, only item information was available. Therefore, the processes that use contextual cues may have produced the study-time effect in SC condition.

On the contrary, the retention interval did not determine the production of the study-time effect but the total amount of items recalled; the effect was neither eliminated nor appreciably reduced with a 24-hour retention interval, although the total amount of items recalled was reduced with the retention interval. The results of the effects of retention interval are consistent with previous results (Isarida, 1992).
The present episodic context-dependent study-time effect indicates that the recall probabilities of TBR items are a function of associative strength to an episodic context. Subjects study items not in a cognitive vacuum but within a context surrounding the episode. Thus, studying items can induce an association between items and an episodic context. Furthermore, the association between an episodic context and items cannot be variable, because an episodic context does not change throughout the experimental session. The strength of the association between an episodic context and items, therefore, rather than the variability of the item-context associations would produce the study-time effect. Consequently, the associative strength of the items and an episodic context may increase with an increase in the amount of processing at study, such as the number of rehearsals, number of repetitions, and the study time.

The present results also indicate that the effects of the amount of processing, including the study time and the number of rehearsals, were eliminated when study context was not reinstated, whereas the previous results (Isarida, 1992) showed that a small but significant effect was preserved. The differences may have been produced by the differences in retrieval cues available at test. The available cues were (1) interitem relational cues and an episodic context in Isarida's (1992) SC condition, (2) interitem relational cues in Isarida's (1992) DC condition, (3) an episodic context in the present SC condition, and (4) no other than item information in the present DC condition, respectively. As a result, the effect was eliminated only in the present DC condition, whereas positive effects were preserved in the other conditions. These findings may imply that the association between the items and an episodic context as well as interitem relational processes can influence the production of the study-time effect.

Experiment 3 (Experiment 1 in TIC98)

Experiment 2 and the previous results (Isarida, 1992) demonstrated that both the episodic context and interitem relational processes determine the production of the study-time effect. The purpose of Experiment 3 is to make clear the roles of both the episodic context and interitem relational processes, and their interactions in producing the study-time effect. Thus, the roles of the episodic context and interitem relational processes were experimentally separated. More specifically, subjects were required to encode separate groups of items which were relationally processed together in memory. Then, it was examined how the episodic contextual cues and interitem relational cues enhanced the retrieval of the groups and individual items.

Method

Design. A 2 x 2 factorial design was employed. All the factors were manipulated between subjects. The first factor was processing time for each set of items: 10 and 30 seconds. The second factor was test condition: SC and DC. IR condition was omitted, because IR condition was not necessary to test the context effect.

Episodic context. The manipulation of context was identical to that used in Experiment 1 and 2.

Subjects. The subjects were 120 undergraduates of Shizuoka University, Shizuoka, Japan. They received extra points toward a liberal arts Psychology course credit for their participation. They were randomly assigned to one of the 2 x 2 between-subject conditions. Consequently, each condition consisted of 30 subjects.

Materials. A list consisted of 16 unrelated Japanese two-kanji-letter words whose familiarity values were from 3.00 through 3.99 (Ogawa & Inamura, 1974).

Procedure. All the subjects were individually run in two 20-minute sessions separated by a 24-hour retention interval. The procedure of the first session was identical for all the subjects, except for the room and the experimenter. The to-be-processed list was composed of four blocks of four items. Each block of items was visually presented in a 2 x 2 matrix on the CRT-display. Subjects were required to generate a sentence by using the currently presented items in mind in 10 or 30 seconds, and then to report the sentence orally in 10 seconds. A buzzer was presented as a start signal for the oral report of the sentence. During the oral report, no items were presented. Before and after each presentation of the block of items, a 30-second interpolated task was imposed. The task was the same as that used in Experiment 2. The other procedure was identical to that used in SC and DC conditions of Experiment 1 and 2.

Results

The results in Experiment 3 were summarized in Table 3.

Total. The first row of Table 3 shows the proportions of total items recalled as a function of study time and
context conditions.

The results indicate that SC subjects reveal greater study-time effect on total recall than DC subjects. At the same time, DC subjects still showed small but positive study-time effect. A 2 x 2 (study time x context) ANOVA using mean numbers of total items recalled as dependent measure was computed. The main effects of study time $[F(1, 116) = 47.69, \text{MSE} = 5.17, p < .001]$ and of contexts $[F(1, 116) = 26.41, \text{MSE} = 5.17, p < .001]$ were significant. The interaction was nearly significant $[F(1, 116) = 3.71, \text{MSE} = 5.17, .05 < p < .10]$. Subanalysis showed that the study-time effect was significant in both SC $[F(1, 116) = 39.01, \text{MSE} = 5.17, p < .001]$ and DC conditions $[F(1, 116) = 12.39, \text{MSE} = 5.17, p < .001]$, and that the context effect was also significant in both 10-sec $[F(1, 116) = 5.15, \text{MSE} = 5.17, p < .05]$ and 30-sec condition $[F(1, 116) = 24.96, \text{MSE} = 5.17, p < .001]$.

**Block.** The second row of Table 3 shows the proportions of blocks recalled (Block) as a function of study time and context conditions. The measure Block refers to that the number of blocks in which recalled items were presented at study. The study-time effect is shown in SC but not in DC. A 2 x 2 (study time x context) ANOVA using Block as dependent measure was computed. The main effect of study time $[F(1, 116) = 4.37, \text{MSE} = 6.17, p < .05]$ and of contexts $[F(1, 116) = 21.62, \text{MSE} = 6.17, p < .001]$ were significant. Although the interaction was not statistically significant, the F value was not negligible $[F(1, 116) = 2.64, \text{MSE} = 6.17]$. Subanalysis showed that the study-time effect was significant in SC $[F(1, 116) = 6.91, \text{MSE} = 6.17, p < .01]$ but not in DC $[F < 1]$, and that the context effect was significant in both 10-sec $[F(1, 116) = 4.56, \text{MSE} = 6.17, p < .05]$ and 30-sec condition $[F(1, 116) = 19.72, \text{MSE} = 6.17, p < .001]$.

**Within.** The third row of Table 3 shows the proportions of items within blocks recalled (Within) as a function of study time and context conditions. The measure Within refers to that the number of items recalled within the recalled blocks, and it is given by Total divided by Block.

The study-time effect is shown in both SC and DC, whereas the context effect is not shown in both SC and DC. A 2 x 2 (study time x context) ANOVA using Within as dependent measure was computed. The main effect of study time was significant $[F(1, 116) = 27.81, \text{MSE} = 6.36, p < .001]$, but neither the effect of contexts $[F < 1]$ nor the interaction $[F < 1]$ was statistically significant.

**LR.** The forth row of Table 3 shows LR scores as a function of study time and context conditions. The measure LR is the proportion of clustering by blocks. It is given by $R$ divided by Total; $R$ is the number of times two items from the same block appear together in the recall protocol. All the LR scores were significantly higher than the chance level (SC-10 sec: $t(29) = 6.59, \text{MSE} = .054, p < .001$; SC-30 sec: $t(29) = 13.31, \text{MSE} = .040, p < .001$; DC-10 sec: $t(29) = 6.19, \text{MSE} = .059, p < .001$; DC-30 sec: $t(29) = 9.21, \text{MSE} = .053, p < .001]$. A 2 x 2 (study time x context) ANOVA using LR as dependent measure was computed. The main effect of study time was significant $[F(1, 116) = 13.21, \text{MSE} = 5.17, p < .001]$, but neither the effect of contexts $[F < 1]$ nor the interaction $[F < 1]$ was statistically significant.

**Discussion**

In Experiment 3, the episodic context-dependent study-time effect appeared on total recall; the study-time effect was greater when study context was reinstated (SC) than when not reinstated (DC). Further, total recall was divided into two components, which have different properties from each other. Block, one of the components, showed complete dependence on the episodic context in producing the study-time effect; study-time effect appeared when study context was reinstated, whereas it was eliminated when the context was not reinstated. On the contrary, Within, another component, showed independence of the episodic context; it increased as a function of only study time whether study context was reinstated or not. Additionally, LR scores showed identical pattern of results to that of Within.

Some measures of the results in Experiment 3 replicated the previous findings. The results of the measure Total replicated Isarida’s (1992) findings; SC subjects showed the greater rehearsal effect (Isarida, 1992) or study-time effect (Experiment 3) than DC subjects did, and DC subjects showed a small but positive effect. Moreover, the results of the measure Block replicated those of Experiment 2; a positive study-time effect appeared in SC condition, but no effects in DC condition. These replications prove the reliabilities of the episodic context-dependent study-time effects.

**Experiment 4 (Experiment 2 in TIC98)**

The purpose of Experiment 4 is to replicate the findings of Experiment 3 with some modifications of procedure.
That is, an intentional learning task was used instead of the incidental one used in Experiment 3, and hence, a 10-sec. period for reporting sentences was eliminated.

Method

Design. A 2 × 2 factorial design was employed. All the factors were manipulated between subjects. The first factor was processing time for each set of items: 10 and 30 seconds. The second factor was test condition: SC and DC.

Episodic context. The manipulation of context was identical to that used in Experiment 1, 2, and 3.

Subjects. The subjects were 80 undergraduates of Shizuoka University, Shizuoka, Japan. They received extra points toward a liberal arts Psychology course credit for their participation. They were randomly assigned to one of the 2 × 2 between-subject conditions. Each condition consisted of 20 subjects.

Materials. The list was identical to that used in Experiment 3.

Procedure. All the subjects were individually run in two 20-minute sessions separated by a 24-hour retention interval. The procedure of the first session was identical for all the subjects, except for the room and the experimenter. The to-be-remembered list was composed of four blocks of four items. Each block of items was visually presented in a 2 × 2 matrix on the CRT-display. Presentation time per block of items was 10 or 30 sec. Subjects were required to study the currently presented items. Before and after each presentation of the block of the items, a 30-sec interpolated task was imposed. The task was the same as that used in Experiment 2. The other procedure was identical to that used in SC and DC conditions of Experiment 1, 2, and 3.

Results and Discussion

The results in Experiment 4 are summarized in Table 4. The results in Experiment 4 were almost identical to those in Experiment 3.

Total. The first row of Table 4 shows Total as a function of study time and context conditions. The results indicate that SC subjects reveal greater study-time effect on total recall than DC subjects. At the same time, DC subjects still showed small but positive study-time effect.

A 2 × 2 (study time × context) ANOVA was computed using mean numbers of total items recalled as dependent measure. The main effect of study time [F(1, 76) = 23.55, MSE = 4.01, p < .001] and of contexts [F(1, 76) = 22.48, MSE = 4.01, p < .001] were significant. The interaction was not significant [F(1, 76) = 2.61, MSE = 4.01]. Subanalysis showed that the study-time effect was significant in both SC [F(1, 76) = 20.93, MSE = 4.01, p < .001] and DC conditions [F(1, 76) = 5.23, MSE = 4.01, p < .05], and that the context effect was also significant in both 10-sec [F(1, 76) = 4.87, MSE = 4.01, p < .05] and 30-sec condition [F(1, 76) = 20.22, MSE = 4.01, p < .001].

Block. The second row of Table 4 shows Block as a function of study time and context conditions. The study-time effect is shown in SC but not in DC. A 2 × 2 (study time × context) ANOVA using Block as dependent measure was computed. The main effect of study time [F(1, 76) = 5.66, MSE = .637, p < .05] and of contexts [F(1, 76) = 24.01, MSE = .637, p < .001] were significant. The interaction was not significant [F < 1]. Subanalysis showed that the study-time effect was significant in SC [F(1, 76) = 5.64, MSE = .637, p < .05] but not in DC [F < 1], and that the context effect was significant in both 10-sec [F(1, 76) = 7.68, MSE = .637, p < .01] and 30-sec condition [F(1, 76) = 17.29, MSE = .637, p < .001].

Within. The third row of Table 4 shows Within as a function of study time and context conditions. The study-time effect is shown in both SC and DC, whereas the context effect is not shown in both SC and DC. A 2 × 2 (study time × context) ANOVA using Within as dependent measure was computed. The main effect of study time was significant [F(1, 76) = 16.02, MSE = .468, p < .001], but neither the effect of contexts [F < 1] nor the interaction [F < 1] was statistically significant.

LR. The forth row of Table 3 shows LR scores as a function of study time and context conditions. All the LR scores were significantly higher than the chance level [SC-10 sec: t(19) = 5.39, MSE = .047, p < .001; SC-30 sec: t(19) = 7.33, MSE = .059, p < .001; DC-10 sec: t(19) = 5.93, MSE = .045, p < .001; DC-30 sec: t(19) = 10.78, MSE = .039, p < .001]. A 2 × 2 (study time × context) ANOVA using LR as dependent measure was computed. The main effect of study time was significant [F(1, 76) = 11.11, MSE = .047, p < .001], but neither the effect of contexts [F < 1] nor the interaction [F < 1] was statistically significant.
The results in Experiment succeeded in replicating the total findings of Experiment 3 with some modifications of procedure. These results demonstrate the reliability of the episodic context-dependent phenomena.

General Discussion

Episodic context-dependent memory

Patterns of the phenomena. The present experiments have found three patterns of the context-dependent effect of study-time as follows. The first pattern is the perfect dependence of the study-time effect on the reinstatement of the episodic context at study. That is, the recall probability in the SC condition increases as a function of the study time, whereas that in the DC condition does not. This pattern was found in Experiment 2, and was replicated in the measure Block of both Experiment 3 and 4. The second pattern is that of partial dependence. The magnitude of the study-time effect was greater in the SC condition than that in the DC condition, but both the effects were significant. This pattern was found in the total recall of Experiment 3, and was replicated in that of Experiment 4. Additionally, Isarida (1992) reported the context-dependent effect of the rehearsal-number, which showed the same pattern as the second one. The third pattern is independence of the reinstatement of the episodic context. There were no differences between the SC and DC conditions, both of which showed identical study-time effects from each other. This pattern was found in both the measures Within and LR of Experiment 3, and was replicated in those of Experiment 4.

Pattern 1 should occur when discrete TBR units are directly cued by the reinstated episodic context. In Experiment 2, encoded TBR items were constrained to be discrete from each other by imposing a calculation task before and after studying each item, and hence, the function of any other cues than episodic context cue, such as interitem relational cues, were suppressed. In Experiments 3 and 4, several blocks of items were encoded discretely from each other by imposing a calculation task before and after each block. As a result, the recall of the blocks depended on the reinstated context. At the same time, neither the recall of the items within the blocks nor the clustering by the blocks depended on it, indicating that the retrieval of items within the blocks needed no help from the episodic context. Thus, Pattern 3 reflects the independent processes of the episodic context, such as retrieving items within the contexts that were cued by the episodic context. Pattern 2 may be a composite of Patterns 1 and 2. If no suppression of interitem relational processing is induced, the recall will partly depend on the episodic context, just as the total recall in Experiments 3 and 4, and the recall in Isarida (1992).

Retrieval processes. In the course of retrieving an episodic trace, subjects may use the hierarchical retrieval processes as follows. The results in Experiments 3 and 4 suggest that episodic context cues the blocks of items, and the blocks cue individual items within the blocks. More generally, the process whereby a more general context cues less general one, surrounded by the more general one, is recursively replicated until the target information is accessed. Similar recursive retrieval processes were reported by a research into everyday memory, which used protocol analysis of recalling the names of subjects’ classmates (Williams & Hollan, 1981).

Study time may strengthen the organization among the whole processes concerning the encoding and retrieval of the episodic trace. That is, the associative strength between the more general context and the less general one may increase as a function of the study time. The present results indicate that studying individual items strengthen the associations between the blocks and the episodic context. That is, the recall probability of the blocks increased as a function of study time when the study episodic context was reinstated, but it did not when the context was not reinstated. Study time may also strengthen the associations between the blocks and the items within the blocks. Probability of recalling items within the blocks also increased as a function of study time. Further, this increase was independent of the reinstatement of the episodic context. Episodic context may not directly cue individual items within the blocks, or if so, the effect of the episodic-context cue will be markedly restricted because of the cue-overload principle (Watkins & Watkins, 1975).

Most memory researchers might have, at least implicitly, proposed that the trace strength and the memory phenomena are universal (e.g., Atkinson & Shiffrin, 1968; Craik & Lockhart, 1972; Tulving, 1962). Thus, their findings were generalized over the context surrounding the episode. This might be overgeneralization, however, because they have proved their theories or explanations of memory only within an episodic context. That is, most experiments were completed within an experimental session without subjects leaving the laboratory; or even if subjects had to leave the
laboratory during a long retention interval, the test was conducted in the same context as that at study. The present findings imply that episodic-memory traces and episodic-memory phenomena usually depend on an episodic context, and further, are sometimes limited within the context. As long as the memory trace and the memory phenomena are episodic in nature, we must investigate it outside as well as within an episodic context.

**The reliability of episodic context-dependent memory**

All the present four experiments found clear context-dependent memory. Especially, Experiment 1 was not able to detect the study-time effect but did find context-dependent memory. A number of experiments, however, have failed to find the environmental context-dependent memory (e.g., Bjork & Richardson-Klavehn, 1989; Fernandez & Glenberg, 1985). What causes the differences between the present experiments and those that failed to find the context-dependent memory?

Theoretically, the episodic context is one of the fundamental elements of the episodic trace. Thus, episodic context will determine episodic memory, if the manipulation of the episodic context is successfully conducted. All the episodic traces, more or less, depend on the changes in episodic context. On the other hand, only the traces markedly associated with a place can depend on the environmental context. A place is one of the important elements of the setting of the episodic trace, but it is not everything in episodic context. The place element often has much weight in the setting of an episodic trace (e.g., Godden & Baddeley, 1975), but is sometimes not so important. Episodic memory does not always depend on the place.

Has the episodic context been manipulated reliably and validly here? What were the differences between the manipulation of the episodic context and that of the environmental context? What elements of the manipulation of the episodic context were effective in detecting the context-dependent memory?

**Compound manipulation.** In the present experiments, a combination of three contextual elements was systematically varied in order to manipulate psychological context within an experimental context. This manipulation was designed to influence the subject’s interpretation of the kind of experimental session. The author and his colleague have obtained such results that support the validity of the present manipulation (Isarida & Isarida, 1998). That is, they used the same contextual manipulations as those in the present experiments, and succeeded in finding the context-dependent memory. At the same time, they gave each subject a questionnaire on her/his psychological environment after a free recall test. As a result, when they entered the laboratory, 14 of the 18 SC subjects expected that the experimental session about to start was the same kind of experiment as that at study. On the other hand, 14 of the 18 DC subjects expected that the session would be different from that at study.

**Experimenter.** The manipulation of experimenter was designed to vary more than the physical environment, such as interpersonal impression or social power. In the present experiments, each of two people served as the experimenter. The two did not only have different physical appearances but also different social influence with the subjects. That is, Experimenter A was acquainted with all of the subjects. He lectured in a course the subjects attended regularly once a week. He was much senior to the subjects in age and above them in social standing. Age and social standing are extremely influential in human relationships in Japan. On the contrary, Experimenter B was not acquainted with any subjects. Experimenter B had more in common with the subject in terms of physical and psychological attributes.

Bjork and Richardson-Klavehn (1989) failed to find the context-dependent memory in spite of adding the experimenter-factor to the contextual manipulations, just as the present experiments. The experimenters they used had markedly different physical features from each other; one was a caucasian male and the other was an Asian-Indian female. Bjork and Richardson-Klavehn (1989) treated the experimenter, however, as no more than a further physical factor; their experimenters were only a part of the physical environment.

**Calculation task.** The present experiments added a calculation task to the manipulation of the episodic context. The calculation task was one of the main elements of the episode of the experimental session at study, although the manipulation of environmental context does not usually include a calculation task. The calculation task can produce context-dependent memory. For instance, Falkenberg (1972) reported context-dependent memory induced by calculation tasks in the Brown-Peterson paradigm. Isarida and his colleague reported the effect of the task in relation to other factors of the context (Isarida, 1988; Isarida & Morii, 1986). Isarida and Morii (1986) reported that contextual cues consisting place, experimenter, and task cues produced a greater spacing effect in 24-hour delayed free recall than that consisting of place and experimenter. Further, Isarida (1988) found that adding the task cue to DC condition
produced no advantages over DC condition without the task. These results suggest that the compounded Gestalt of the contextual elements produce the episodic context. Thus, the more elements that compose the context, the greater the effect is, and further, it is hard for isolated elements to produce the context-dependent memory.

Other factors concerning the context-dependent memory. The present experiments used a rather small number of TBR items, such as 12 to 16, whereas the majority of previous research has used more than several tens of items. The small number of items would contribute to avoid the cue-overload (Watkins & Watkins, 1975), although the small number was actually designed to avoid the floor effect in a long-delayed test.

All of the present subjects were naïve about any kinds of psychological experiment. The present experiments were the first any of them had attended. For such naïve subjects, the episodic memory of attending a psychological experiment would not be decontextualized (Smith, 1988). The more the subjects experience the experiments, the greater the memory of individual experiments would be decontextualized. Much experienced subjects may focus their memory on TBR items, and then they may cut off any information other than the items, such as the place, the experimenter, and any other situational information. Consequently, under the laboratory conditions, the naïve subjects may reveal the episodic context-dependent memory more likely than experienced ones.

REFERENCES

Table 1
Proportions of items recalled as a function of study time and test conditions.

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<td>DC</td>
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<td>(.177)</td>
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<td></td>
<td>.308</td>
<td>(.211)</td>
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<td>(.239)</td>
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<td></td>
<td>.267</td>
<td>(.193)</td>
<td>.267</td>
<td>(.155)</td>
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( ): standard deviation between subjects

Table 2
Proportions of items recalled as a function of study time and test conditions.

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<td></td>
<td>.250</td>
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( ): standard deviation between subjects

Table 3
Proportions of total items recalled (Total), of blocks recalled (Block), and of items within blocks recalled (Within), and LR scores (LR) as a function of processing time and context conditions.

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<th>DC</th>
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<td>Block</td>
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<tr>
<td>Within</td>
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<tr>
<td>LR</td>
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<td>(.231)</td>
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</table>

( ): standard deviation between subjects

Table 4
Proportions of total items recalled (Total), of blocks recalled (Block), and of items within blocks recalled (Within), and LR scores (LR) as a function of study time and context conditions.

<table>
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<th>Context</th>
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<th>DC</th>
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</tr>
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<td>Block</td>
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<td>LR</td>
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( ): standard deviation between subjects