Adult Age Differences in the Effects of Environmental Context on Memory Performance

Julie L. Earles
Furman University
Greenville, South Carolina, USA

Anderson D. Smith
Georgia Institute of Technology
Atlanta, Georgia, USA

Denise C. Park
University of Georgia
Athens, Georgia, USA

In two experiments, we examined the hypotheses that the memory performance of older adults is more dependent than that of younger adults on environmental context, and that the integration of to-be-remembered items with contextual cues benefits older more than younger adults. When younger and older adults were shown simple line drawings that were not explicitly associated with the external environment, there was no effect on recall of a change in environmental context for either age group. However, when subjects heard sentences that connected the simple drawings with environmental cues, an environmental context effect was observed. Both age groups recalled more in the same than in a different environment, and the magnitude of the facilitation effect of the familiar context was equal for younger and older adults. However, the integration of the to-be-remembered items with the context facilitated recall regardless of the context present at retrieval, and this effect was larger for younger adults, suggesting that the younger adults were better able to use the provided integrations than were the older adults.

It has often been suggested that older adults may not encode contextual information as effectively as younger adults, and that this difference in

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Address correspondence to Julie Earles, Department of Psychology, Furman University, Greenville, SC 29613. E-mail: earles_julie/furman@furman.edu.

contextual encoding may contribute to the often observed age differences in memory performance (e.g., Craik & Jennings, 1992). Research findings, however, suggest that older adults do use context effectively, and in many cases do so as well as younger adults (e.g., Park et al., 1990). Most of this research, however, has involved contextual cues that were part of the memory task itself (i.e., intratask context), such as the cues in cued recall or the stimuli in paired-associate learning. With stimulus-bound context (e.g., spatial or color information), on the other hand, large age differences are consistently found in the ability to remember contextual information (e.g., Smith & Park, 1990). Context is a complex construct (Davies & Thomson, 1988), and the nature of the contextual information may be a determinant of age differences in the use of context. One potentially important type of context that has not been studied with older adults is extratask environmental context (i.e., the physical environment in which encoding or remembering tasks occur). While some researchers have found environmental context effects with young adults (e.g., Smith, 1979), other investigators, again using younger adults, have failed to find effects at all (e.g., Fernandez & Glenberg, 1985).

There are several reasons to believe, however, that environmental context may actually be more important for the memory performance of older than of younger adults. First, as suggested by Hasher and Zacks (1988), older adults may pay more attention to contextual information not directly related to the task at hand. Younger adults may not attend to extraneous environmental cues as much as older adults. Thus the older adults may benefit more from reinstatement of the learning environment during retrieval. Second, older adults may be more dependent than younger adults on environmental support, as suggested by Craik and Jennings (1992), and thus need to have the same environment at retrieval as at learning. Finally, results show that older adults actually receive more benefit than younger adults from cues that are perceptually related to the to-be-remembered items, most likely due to the limited working memory requirements to use such cues (Park et al., 1990). Because environmental cues are more likely to be perceptually related to the memory-task items than are more typical verbal cues, older adults may find environmental cues to be especially useful.

It is interesting to note that even though environmental context seems to be an important part of our everyday attempts to remember episodic memories (e.g., "Where was I when I last saw my keys?" or "That poster reminds me of the time we . . ."), there is a lack of studies in the literature that have systematically examined the effects of environmental context on item recall in different adult age groups. Although no studies of environmental context have involved age comparisons, as mentioned earlier, studies have been conducted using only younger adults, with

conflicting results. Several researchers (e.g., Eich, 1985; Godden & Baddeley, 1975; Smith, 1979) have found recall performance in the same learning context to be better than when recall occurs in a different context. Other researchers (e.g., Fernandez & Glenberg, 1985; Saufley et al., 1986), however, have found no evidence for environmental context-dependent recall in younger adults.

The task performed during encoding seems to influence whether or not environmental context effects are found in younger adult subjects. In the studies that found no environmental context effects on recall, subjects often performed elaboration tasks with the words (e.g., Fernandez & Glenberg, 1985). Elaboration may turn the subjects' attention away from potentially relevant environmental cues.

Although age differences in environmental, or extratask, context have not yet been closely examined, age differences in the use of other types of context have been extensively studied. Age differences have been found in memory for stimulus-bound contextual information (i.e., the qualities of the to-be-remembered item itself). For example, older adults do not remember the color of items (Park & Puglisi, 1985) or the source of information (McIntyre & Craik, 1987) as well as do younger adults. If older adults do not remember as much contextual information, they will most likely be less able to use it to facilitate recall.

The use of contextual information by older adults has primarily been examined using intratask context (i.e., contextual information that is part of the learning task, such as the cue that is presented along with each to-be-remembered item in paired-associate learning). There are no age differences in encoding specificity using intratask context. Older adults find a match between cues present at encoding and at retrieval as facilitative as younger adults (Park et al., 1987; Park et al., 1984; Puglisi et al., 1988). If older adults do not remember as much contextual information, a reinstatement of contextual information during retrieval may not benefit performance.

In addition to type of context, another factor that seems important in determining whether or not there are age differences in the use of contextual information may be the degree of association between the item to be remembered and the cue. The more closely the item and the context are associated at encoding, the larger the facilitative effects of the presence of the same contextual cues at retrieval. Craik and Jennings (1992) suggest this is especially true for older adults. If the target and cue are unrelated, self-initiated processing, requiring working memory resources, would be necessary to relate the cue and target together. Like Craik and Jennings, Park et al. (1990) also propose that a primary determinant of how well older adults use context to facilitate memory is the degree that the items to be remembered are integrated, or linked, with the contextual

cues. The "integration" hypothesis predicts that the memory performance of older adults is facilitated more than the performance of younger adults when the items to be remembered are well integrated with contextual cues. Older adults should benefit more from already existing relationships between target and cue because older adults have reduced working memory capacity, and working memory is required to engage in self-initiated processing. Age differences are expected to increase as there is less external support and more need for self-initiated processing. Park et al. (1990) found that when contextual cue and target pictures were related to each other, and thus the task involved low self-initiated processing requirements, the integration facilitated the cued recall performance of older adults more than it did the performance of younger adults.

In the present research, two experiments were conducted to examine age differences in the use of environmental context, varying the degree of integration between the environment and targets. The first experiment, conducted with both older and younger adults, established baseline effects by using the classical procedure for studying environmental context effects. The environmental context present at learning was either the same or different at retrieval. In the second experiment, conditions for obtaining environmental context effects were optimized by providing associations between the environmental cues and the to-be-remembered items. Older adults were expected to benefit more than younger adults from the provision of integration.

EXPERIMENT 1

Method

Participants

Forty-eight undergraduates (M age = 20.2, SD = 1.5) who received extra credit in a psychology course, and 48 community-dwelling older adults (M age = 68.8, SD = 4.1) who were paid \$10 participated in this experiment. There were 21 females in the older group and 20 in the younger group. The older adults had significantly more years of education (M = 15.2, SD = 2.4) than did the younger adults (M = 13.5, SD = 1.2), $F(1, 94) = 18.68$, $p < .05$, and also scored significantly higher on the 40-item Shipley vocabulary test (M = 33.7, SD = 5.8) than did the younger adults (M = 30.0, SD = 3.4), $F(1, 94) = 14.89$, $p < .05$. Health was rated on a scale of 1 (*poor*) to 4 (*excellent*). While the older adults had slightly lower health ratings (M = 3.3, SD = .8) than did the younger adults (M = 3.6, SD = .5), F (1,94) = 4.62, $p < .05$, both groups rated their health between *good* and *excellent*.

Materials

The stimulus items were 50 simple line-drawing pictures of easily identified everyday objects presented by slides on a screen in the front of the room. Two different rooms were used for the environmental contexts. Room A was a small, empty room (9′ × 12′) on the second floor of a classroom building. It had one window, was uncarpeted, and contained a slide projector and screen, and two chairs. Room B was a student office (10′ × 13′) on the first floor of the same building. It was a carpeted room without windows. There were three bookshelves filled with books, six small tables, three chairs, a microwave oven, kitchen utensils, games, and many other items. A subject waiting room was located on the first floor of the same building.

Design

There were 12 younger and 12 older subjects in each of four conditions. Half of the subjects were presented with the target pictures in Room A, and half were presented with the pictures in Room B. From each of the groups, half of the subjects then attempted to recall the pictures in the same room as learning, and half attempted to recall the pictures in a different room.

Procedure

Subjects were tested individually in a 30-min session. They were taken to either Room A or Room B where they were shown the series of 50 pictures from slides at a rate of 5 seconds each. The room was not darkened, so subjects could see their surroundings as well as the slides. Subjects were told to name each picture that they saw and were also told that they would later be asked to recall as many of the pictures as they could. Strand (1970) found that the disruption caused by changing rooms can have detrimental effects on memory, so to ensure that all subjects were disrupted between learning and test, all subjects were taken to the waiting room for 5 minutes. During this time they began to fill out a questionnaire and to take the Shipley vocabulary test (Shipley, 1940). At the end of 5 minutes, the subjects were taken back either to the same room where they had seen the pictures or to the different room. They were then given 5 minutes to list as many of the picture names as they could. They then completed the vocabulary test and demographics questionnaire that they had started during the distractor period.

Results

The number of picture names correctly recalled by each subject was computed by matching the name given by the subject to each picture as

it was presented with the responses given during the free recall period. A 2 (Age: young, old) × 2 (Contextual Condition: same, different) analysis of variance (ANOVA) was conducted. The younger adults recalled significantly more picture names than did the older adults, F (1,92) = 22.26, $p < .001$. The main effect of contextual condition, however, was not significant, F (1,92) < 1. There was also no significant Age × Contextual Condition interaction, F(1,92) < 1. Younger adults in the same context condition recalled a mean of 22.79 (SD = 3.74) items, and those in the different context condition recalled a mean of 22.71 (SD = 3.64) items. The older adults in the same context condition recalled an average of 18.08 (SD = 4.96) items, and those in the different context recalled an average of 18.70 (SD = 5.51) items.

Discussion

The results of Experiment 1 suggest that, although the younger adults recalled more in all conditions, neither age group was benefited by the physical reinstatement of the environmental context. In other words, there were no environmental context effects in either the younger or the older group. The present result is inconsistent with the findings of Smith (1979) and Godden and Baddeley (1975), but consistent with the findings of Fernandez and Glenberg (1985) and Saufley et al. (1986), who also found no environmental context effects on recall. The age difference in memory performance found in Experiment 1, therefore, could not be explained by suggesting differential dependence on the reinstatement of environmental context at retrieval.

Experiment 2 was conducted to optimize conditions for producing environmental context effects and to examine the effects of contextual integration on age differences in memory performance. Using only younger adults, Eich (1985) demonstrated increased environmental context effects when the environmental cues and the to-be-remembered information were integrated. Because of the apparent importance of integration effects in different age groups, a technique similar to Eich's was used in Experiment 2 to manipulate the integration of learned material with the environmental context.

Under some conditions, therefore, the environmental context present during a learning situation may become associated or integrated with the learned information. It was predicted that when the items to be remembered become integrated with the environmental context, then memory would be facilitated. If the integration of environmental context works in a similar fashion to the intratask context that is presented with each item to be remembered (e.g., Park et al., 1990), then the older adults should

be more facilitated than the younger adults by the integration of items with contextual cues.

Unlike the Eich (1985) study, integrations in the present study were provided for the subjects, rather than generated by them. Craik and Jennings (1992) have suggested that older adults have greater problems with "self-initiated" processing, and Smith, Park, and Earles (1990) have found that older adults find it more difficult than do younger adults to produce integrations. The provision of integrations should decrease the need for self-initiated processing and make environmental cues easier to use.

EXPERIMENT 2

Method

Participants

Sixty-four undergraduates (M age = 20.66, SD = 1.64) who received extra credit in a psychology course and 64 community-dwelling older adults (M age = 69.23, SD = 4.18) who were paid $10 participated in Experiment 2. There were 25 females in the younger group and 24 in the older group. As in Experiment 1, the older adults had significantly more years of education (M = 15.3, SD = 2.9) than did the younger adults (M = 14.4, SD = 1.4), $F(1, 126) = 4.63$, $p < .05$, and also scored higher on the Shipley vocabulary test (M = 34.9, SD = 3.1) than did the younger adults (M = 31.0, SD = 2.9), $F(1, 126) = 54.98$, $p < .05$. All subjects rated their health on a scale of 1 (*poor*) to 4 (*excellent*). The younger adults had significantly higher health ratings (M = 3.6, SD = .52) than did the older adults (M = 3.2, SD = .70), $F(1, 126) = 18.68$, $p < .05$, but the mean of both groups was above *good*. Visual acuity was also tested, and all participants had 20/40 corrected vision or better.

Materials

Two experimental rooms were used. Room A (14′ × 17′) was located on the third floor of an office building and was arranged to look like an office. Room B (15′ × 18′) was on the second floor of the same building and was arranged to resemble a lounge. Care was taken to ensure that the rooms were configured differently and contained different items. There were approximately 40 items in each room, not including furnishings. A subject waiting room was located on the third floor of the same building.

Fifty simple line drawings with above 95% naming agreement, as normed by Snodgrass and Vanderwart (1980), were used as the target

items. There were two sets of 25 pictures, and each set had two orders (Order 1 and Order 2). One of the pictures in each set was used for demonstration purposes during the instructions. One set of pictures was used in Room A, and the other set was used in Room B. Each picture was mounted on a separate 4 × 6 index card and put together, in the presentation order, in a booklet held together with a metal ring.

Design

There were 32 younger and 32 older adults in each of the two integration status conditions (i.e., an integrated condition in which each target was linked to an environmental cue, and an isolated condition in which each target was not integrated with the environment). Within each of these conditions, 16 younger and 16 older adults were presented with the pictures in Room A, and 16 younger and 16 older adults were presented with the pictures in Room B. Half the subjects in each room saw sentence Order 1, and half saw sentence Order 2. At testing, half the subjects within each group were taken back to the room where they originally saw the pictures, and half were taken to the different room from learning.

Procedure

Each subject was tested individually in one 35-min session. In the integrated condition, subjects flipped through 25 picture cards one at a time, with the first picture serving as practice. The participants saw each picture for 15 seconds. As each picture was presented (a signal indicated that the subject should turn to the next picture), a sentence was read to the subject. The sentences were presented via a Sony microcassette recorder, and the reading voice was that of an adult male. The sentences related each target picture to an item located in the physical environment of the room. For example, "The key fit the lock on the file cabinet." Subjects rated how well they thought each sentence integrated the items on a scale from 1 to 7. There were many more items in the room than those used as contextual cues. To be more certain that the subjects attended to the environmental cues, they were told that locating the objects in the room would be helpful in their sentence ratings. Subjects were observed during the task, and all subjects did look up during the presentation of each sentence.

After all 24 pictures were presented, the subjects were taken to the waiting room where they were given a Snellen vision test and began to fill out a demographics form and the Shipley vocabulary test for 5 minutes. Half the subjects within each group were then taken back to the room where they originally saw the series of pictures, and half were taken to the other room. They were then given 5 minutes to recall the names of the pictures. Subjects were then given 5 minutes to recall the items

Table 1. Mean number of pictures recalled as a function of age, contextual condition, and integration status (experiment 2)

Age	Context	Integrated	Isolated
Young	Same	20.6 (2.4)	11.3 (3.8)
	Different	16.3 (3.1)	11.0 (1.9)
Old	Same	14.8 (3.7)	9.0 (2.6)
	Different	11.2 (3.7)	9.6 (2.8)

Note. Standard deviations are in parentheses.

that had been paired with the pictures in the sentences (i.e., the context items that the sentences related to the picture targets). After testing, subjects in the different context condition were given 5 minutes to list anything they could remember about the room where they first saw the pictures. All subjects then completed the vocabulary test and the information form begun earlier.

The second condition, the isolated condition, was the same as the integrated condition except that while each picture was presented, a sentence was presented that contained the name of the picture and the name of an item not present in the room, such as, "The key fit the lock on the car." The subjects were told that they were to rate how well each sentence integrated or related each picture with an object. The recall task was the same as in the integrated condition except that during the second 5-min period the subjects attempted to recall the objects in the sentences rather than in the room.

Results

A one-way ANOVA revealed no significant difference between the number of pictures recalled in Room A and Room B, or with either picture Order 1 or Order 2, $F < 1$, so the data were collapsed across these variables. A 2 × 2 × 2 ANOVA was conducted with Age Group (young vs. old), Contextual Condition (same vs. different context at recall), and Integration Status (integrated vs. isolated sentences) as the independent variables and the number of picture names recalled as the dependent variable. The means and standard deviations are presented in Table 1.

All three main effects were significant. The younger adults recalled significantly more items than did the older adults, $F(1, 120) = 44.90$, $p < .05$; subjects recalled more in the same rather than in a different context, $F(1, 120) = 12.11$, $p < .05$; and subjects recalled more items in the integrated than in the isolated condition, $F(1, 120) = 101.90$, $p <$

.05. All of these main effects, however, were qualified by significant interactions.

There was no significant three-way interaction, $F(1, 120) < 1$. There was also no significant Age Group × Contextual Condition interaction, $F(1, 120) < 1$. However, there was a significant Contextual Condition × Integration Status interaction, $F(1, 120) = 14.19$, $p < .05$. In the integrated condition, the participants recalled significantly more pictures in the same context ($M = 17.69$, $SD = 4.26$) than they recalled in the different context from the one in which learning took place ($M = 13.75$, $SD = 4.22$), $F(1, 62) = 13.80$, $p < .01$. In the isolated condition, there was no significant difference between the number of picture names recalled in the same context and the different context, $F(1, 62) < 1$. It is important to note that even when subjects attempted to recall the pictures in a different context from learning, those in the integrated condition recalled more than those in the isolated condition, $F(1, 62) = 15.74$, $p < .01$.

There was also a significant Age Group × Integration Status interaction, $F(1, 120) = 10.94$, $p < .05$. The younger adults recalled significantly more target pictures than the older adults in the isolated condition, $F(1, 62) = 6.78$, $p = .01$. In the integrated condition, the younger adults also recalled more than the older adults, $F(1, 62) = 32.96$, $p < .01$, but the age difference was much larger than in the isolated condition. The younger adults, therefore, benefited more than the older adults from the integration of the targets with the environmental cues.

The Contextual Condition × Integrated Status and the Age × Integration Status interactions were not likely to be due to a difference in sentence quality or memorability. In a separate study, 16 younger adult subjects were presented with 24 integrated sentences and 24 isolated sentences in two randomized groups of 24 sentences. After the presentation of each sentence group, they were given 4 minutes to recall as many of the nouns as possible. An analysis of variance revealed no significant difference between the number of nouns recalled from the integrated sentences ($M = 10.19$, $SD = 2.83$) and the number of nouns recalled from the isolated sentences ($M = 10.56$, $SD = 3.61$), $F(1, 15) < 1$.

Because subjects may have had difficulty distinguishing between targets and cues during retrieval, an analysis of intrusions (i.e., items generated that were not targets) was conducted. There were no significant interactions and no significant main effects of context or integration status, $p > .05$. The older adults made significantly more intrusions ($M = .78$) than did the younger adults ($M = .22$), $F(1, 120) = 12.94$, $p < .01$, but the actual number of intrusions was very small.

If older adults did not benefit from contextual information as much as did younger adults, it might be because they were less able to remember

the contextual cues. The younger adults recalled significantly more contextual cues than did the older adults, $F(1, 120) = 18.65, p < .05$. There were no significant interactions with age, $p > .05$, but there was a significant Contextual Condition × Integration Status interaction, $F(1, 120) = 36.06, p < .05$. In the integrated condition, subjects recalled significantly more contextual cues in the same context ($M = 19.47$, $SD = 3.50$) versus in the different context ($M = 13.06$, $SD = 4.48$), $F(1, 62) = 40.64, p < .01$. In the isolated condition, however, there was no significant difference between the same context condition ($M = 6.19$, $SD = 3.70$) and the different context condition ($M = 7.13$, $SD = 3.04$), $F(1, 62) = 1.23, p > .05$. Subjects in the integrated, same context condition were in the room with the contextual cues when they recalled them. In other words, for these subjects, the memory task for contextual cues was more like recognition than recall. It is important to note that, as with the recall of pictures, when tested in a different context from learning, those subjects in the integrated condition recalled significantly more contextual cues than did those in the isolated condition, $F(1, 62) = 38.54, p < .01$.

An analysis of memory for items located in the learning room was conducted for subjects in the different context condition. Those subjects with the integrated sentences recalled an average of 15.69 items, and those with the isolated sentences recalled an average of 6.00 items. The number of room items recalled with the integrated sentences includes those items that were recalled as contextual cues, so comparison of the two groups is difficult to interpret. In the integrated condition, the room items were part of the learning task. It is important to note that in the isolated condition subjects remembered very little about the room in which learning took place.

GENERAL DISCUSSION

In Experiment 2, effects of environmental context were found as expected when the targets were directly associated with cues in the environment, but were not found when there was no integration between targets and the environment. The isolated condition of Experiment 2 replicated the findings of Experiment 1 in that no effects of changes in environmental context were found for either age group when environmental information was in an extratask context that was incidental to the memory task. Though subjects in the isolated condition of Experiment 2 performed a task with the pictures and were shown fewer pictures than those subjects in Experiment 1, memory performance was almost identical. The younger subjects in both Experiment 1 and the isolated condition of Experiment 2 recalled approximately 46% of the pictures. The

older subjects in Experiment 1 recalled approximately 37%, and those in Experiment 2 recalled approximately 39% of the pictures.

There are several possible reasons for the lack of environmental context effects when there is no integration between target and context. In the isolated condition in Experiment 2, the subjects may have formed alternative cues due to the elaboration task (i.e., rating the sentences). These alternative cues may have made the environmental cues less useful for recall. The most likely explanation, however, seems to be that in both Experiment 1 and the isolated condition of Experiment 2, the subjects did not attend to environmental information and thus could not use it to facilitate performance. In fact, subjects in the isolated condition in Experiment 2 were unable to recall much at all about the learning environment.

In Experiment 2, when subjects were provided with sentences that related the target pictures with cues in the environment, a change in context disrupted memory for the pictures. This is consistent with the findings of Eich (1985). However, contrary to expectation, when an environmental context effect was found, there were no age differences in the nature of this environmental context effect. In other words, in the integration condition of Experiment 2, both age groups were equally facilitated by retrieving the pictures in the same room in which learning occurred. It was hypothesized that the older adults would be facilitated more than the younger adults by reinstatement of the environmental context. However, in the present study subjects had to realize that the cues would be useful and then had to locate the cues in order to use them. If older adults had more difficulty than younger adults integrating the targets with environmental cues, then these cues may have been less useful during recall.

Consistent with the integration hypothesis of Park et al. (1990), both younger and older adults recalled more when the target pictures were integrated with environmental cues than when the target pictures were integrated with cues not present in the environment. However, the age difference in the integrated condition was larger than the age difference in the isolated condition because the younger adults were facilitated more by the integration condition than were the older adults. This was an unexpected finding and stands in contrast with the previous finding using intratask context in which an increase in integration facilitated older adults more than it did younger adults (Park et al., 1990). The type of context and the amount and type of integration seem to mediate the relationship between integration and age differences in memory for pictures.

In the Park et al. (1990) study, pairs of pictures were shown that were physically interacting, semantically related, or not related, and the older adults were facilitated more by an increase in integration between the two

pictures than were the younger adults. Unlike the present study, however, the contextual cues in the Park et al. study were either semantically related or perceptually interacting with the targets, whereas in the present study, the targets were associated with the cues through the use of verbal sentences. Park et al. found no additional facilitation of providing verbal sentences explaining the relationship between target and context. Another potentially important difference between the two studies was that in the Park et al. study, each target item was presented with a single contextual cue, whereas in the present study, each target was matched with a contextual cue, but all of the cues were present at all times. Older adults may have had more difficulty locating the cues and associating the target with the cue using the sentence provided. In the Park et al. study, the items were interacting in the picture, so the participant did not have to create an image. In the current study, older adults may have been less able to create an interactive image between the picture and the contextual cue.

In the isolated condition of Experiment 2, there was no integration between the targets and the environment, but each target was linked with a verbal cue in a sentence. The results suggest that the provision of physical, visual cues in addition to verbal cues is more beneficial to younger than to older adults, though the memory performance of older adults did improve when physical cues were given.

The present research represents a first step in adding environmental context into the conceptual framework of age-related context effects on memory. The results are consistent with the Park et al. (1990) finding of memory facilitation with increased integration. The results of the current study suggest that the memory performance of older adults may not benefit as much as that of younger adults from integration of to-be-remembered items and environmental cues. However, both younger and older adults were equally facilitated by the reinstatement at retrieval of the learning environment. This suggests that both age groups can use environmental cues to facilitate memory performance, but only in cases where subjects are forced to use environmental cues.

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