"Don't Forget to Take the Cupcakes out of the Oven": Prospective Memory, Strategic Time-Monitoring, and Context

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CECI, STEPHEN J., and BRONFENBRENNER, URIE. *"Don't Forget to Take the Cupcakes out of the Oven": Prospective Memory, Strategic Time-Monitoring, and Context.* CHILD DEVELOPMENT, 1985, **56**, 152–164. Strategies employed by children in tasks requiring prospective memory (i.e., remembering to do something in the future) were investigated to illuminate the nature of the processes involved, and their developmental and contextual determinants. Efficient strategy use was expected to increase with age but to decrease in an unfamiliar setting or on a task associated with higher sex-role expectations. Children were instructed to perform future activities after waiting 30 min. Children's clock-checking during the waiting period was assessed in their own homes or a university psychophysics laboratory. As predicted, strategic time-monitoring occurred less frequently in the laboratory than in the home. The anticipated differences associated with higher sex-role expectations and age were most salient for older boys in the laboratory setting. The findings indicate that, when observed in a familiar setting, children can be shown to employ sophisticated cognitive strategies. Emphasis is placed on the scientific power of the laboratory as a contrasting context for illuminating developmental processes.

Until recently, researchers interested in memory have accorded attention almost exclusively to *retrospective memory*, that is, recalling information about the past. Neglected has been another function of memory important in daily life: remembering to attend to a future event, or *prospective memory* (Meacham & Leiman, 1982; Meacham & Singer, 1977).

Numerous instances of "everyday remembering" attest to the importance of prospective memory, for example, remembering to take vitamins, catch the morning bus, send a spouse an anniversary card, meet with a student, or turn off the bath water in 10 min to prevent a "flood." Yet, despite the ubiquitousness of the phenomenon in our daily lives, there have been few attempts by developmentalists to study strategies used to support prospective remembering, and their developmental and contextual determinants.

Investigations of prospective memory have, to date, focused mainly on one aspect: the use of external retrieval cues (Kreutzer, Leonard, & Flavell, 1975; Meacham & Colombo, 1980; Wellman, Ritter, & Flavell, 1975). For example, in their interview study, Kreutzer et al. (1975) asked children how they would go about remembering to bring their ice skates to school the following day. Children frequently reported that they would use an external retrieval cue to remind them, for example, placing the skates by the front door or pinning a note to their clothes.

In this study, we identify and investigate yet another strategy employed by children when called upon to perform a task at some future time. We call it *strategic time-monitoring* because its use is associated with less frequent clock-checking during a waiting period, thus releasing time for other activities. In addition to providing evidence for the use of this strategy, we examine its development as a function of the age and sex of the child, and investigate ecological factors that interact with these personal characteristics to influence efficient cognitive functioning.

Three distinct phases of strategic time-monitoring can be identified: (1) an early "calibration" phase wherein subjects engage in

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frequent clock-checking to "synchronize their psychological clocks" with the passage of real clock time, (2) an intermediate phase of reduced clock-checking while pursuing other activities, and (3) a "scalloping phase" wherein clock-checking sharply increases as the deadline approaches. Operationally, the use of the strategic time-monitoring strategy is manifested by a U-shaped distribution of such behavior over the course of the waiting period.

The recent work of Harris and Wilkins (1982), with adults, is consistent with the division of time-monitoring into the three phases just described. The U-shaped distribution of their subjects' clock-checks over time can be interpreted as an initial flurry of clock-checking activity in order to calibrate one's psychological clock, followed by a prolonged period of reduced clock-checking, and finally a relatively rapid burst of "last minute" clock-checks (i.e., a scalloping effect).

It remains to be demonstrated, however, that such a U-shaped distribution of clock-watching over time is indeed efficient, that it does decrease the total amount of monitoring behavior without reducing punctuality, thus releasing time for other activities. Hence,

Hypothesis 1:
In tasks requiring prospective memory, children who employ a pattern of strategic monitoring, manifested in a U-shaped distribution of clock-checking over time, will spend less total time in clock-watching but still be punctual.

As with all behavior, a child's use of strategic time-monitoring can be expected to vary as a function of the situation. In particular, we anticipated that children would be more likely to exhibit this more efficient pattern of behavior in the home than in the laboratory. This expectation was based on Bronfenbrenner's conclusion, drawn from a comparison of studies conducted in both settings (Bronfenbrenner, 1979), that the laboratory, as a typically strange and unfamiliar environment, tends to evoke higher levels of anxiety, especially in children, thereby leading to reduced efficiency in cognitive functioning. Our second hypothesis therefore reads as follows:

Hypothesis 2:
Resort to strategic time-monitoring, as manifested in a U-shaped distribution of clock-checking, will be more pronounced when tasks requiring prospective memory are presented in the familiar environment of the home as opposed to an unfamiliar laboratory setting.

Similar considerations gave rise to two corollary hypotheses. First, if children in the laboratory do not exhibit much strategic time-monitoring, what should be the pattern of their clock-checking during the waiting period? Greater anxiety tends to be accompanied by greater vigilance. Vigilance would be reflected in a constantly rising rate of clock-checking throughout the waiting period. We refer to this phenomenon as *anxious time-monitoring*. Accordingly:

Hypothesis 2a:
Anxious time-monitoring, as manifested by a constantly increasing pace of clock-checking during the waiting period, should be more pronounced in the laboratory setting than in the home.

Second, the combined effect of reduced efficiency and greater strain should result in higher overall levels of clock-checking. Hence,

Hypothesis 2b:
The total frequency of clock-checking should be greater in the laboratory than in the home.

The remaining three hypotheses focus more sharply on developmental issues relating to the age and sex of the child and the manner in which these personal characteristics interact both with the nature of the task and the setting in which it is performed.

Hypothesis 3:
Since the use of more advanced cognitive strategies is expected to increase with age, resort to strategic time-monitoring will be greater among older children, with a corresponding reduction of total time spent in clock-watching. By contrast, younger children will make less use of strategic monitoring, and spend more time in clock-watching, particularly in the unfamiliar laboratory setting.

What should be the effect of age on anxious time-monitoring? On the one hand, older children, being more mature, might be expected to feel less insecure, especially in an unfamiliar situation. On the other hand, being older, they may feel a greater responsibility to accomplish the assigned task. Because of these conflicting considerations, we could not make a specific a priori prediction on this score.

Because the processes of socialization encourage different expectations for boys than girls (Maccoby & Jacklin, 1974; Shepherd-Look, 1981), we anticipated that children's time-monitoring would vary systematically as a joint function of the sex of the child and the nature of the task. Our specific hypothesis was based on the following consideration. Tasks associated with higher expectations for a particular sex are likely to engender more anxiety than activities not regarded as sex-appropriate, with a corresponding reduction in efficiency. Our fourth hypothesis expresses this prediction in more specific form:

Hypothesis 4:
On a traditionally female sex-typed task, such as baking, girls will make less use of strategic time-monitoring. Instead, they will exhibit a more anxious pace of clockwatching than boys and spend more time in the process. Correspondingly, on a traditional male sex-typed task, such as charging a motorcycle battery, boys will exhibit the analogous pattern. Because of increasing sex-role expectations with age, these relationships should be more pronounced with older than with younger children.

Finally, on a more general plane, we assumed that the familiarity of the setting would affect not only the overall level of a particular pattern of clock-checking, but also the extent to which this pattern would be affected by other factors relating to characteristics of the child or the situation. To state our final hypothesis in more specific form:

Hypothesis 5:
The joint influence of age, sex, and nature of the task on patterns of time-monitoring will be greater in the laboratory setting than in the home.

Like Hypothesis 2, this prediction derives from Bronfenbrenner's (1979) comparative analysis of studies conducted in the laboratory versus naturalistic settings. One of the conclusions suggested in the review was that, in the less familiar setting of the laboratory, research findings were more likely to be influenced by external factors such as social class, age, and sex differences, or systematic variations in experimental procedure.

Method

Subjects.—Ninety-six children, 48 10-year-olds (mean age = 10.7 years, SD 9 months) and 48 14-year-olds (mean age = 14.6 years, SD 11 months) were recruited through their college-aged siblings and offered $5 either to bake cupcakes or to charge a motorcycle battery. Half of the children at each age were girls. Occupational information was available for 67 of the 96 children's parents. Based on the Hodge-Siegel-Rossi Occupational Prestige Equivalents (Davis, Smith, & Stephenson, 1980), there were no significant group differences in socioeconomic status as a function of age, sex, context, or task assignment, nor was there any among-group variation in the percentage of single-parent households or of homes where the mother was employed.

Procedure.—All children were tested individually. Those children asked to bake cupcakes were instructed to place them in the oven by a specified time and to remove them 30 min later (as per Jiffy Mix instructions). While waiting, the children were invited to make unlimited use of a Pac Man video machine, beginning 15 min prior to placing the cupcakes into the oven and continuing during the entire 30-min baking period. (The 15-min warm-up period was provided to familiarize children with the game.) At the start of the 30-min baking period, children's attention was directed to a wall clock, and they were instructed to remove the cupcakes 30 min from the time shown, for example, "It's now ——— o'clock. Be sure to let them bake exactly 30 min. So, you should remember to take them out of the oven at exactly ——— o'clock." (Conveniently, no children were wearing wristwatches on the day of their participation.)

The Pac Man game was always placed in an adjoining room sufficiently far from the oven to preclude the use of various external retrieval cues such as oven buzzers or the aroma of the maturing cupcakes. The game was bonded to a table top with suction cups. This was done so that the child's back would have to face the wall clock when playing Pac Man. Thus time-monitoring behaviors (turning in one's seat to check the wall clock) could easily be recorded by an unobtrusive observer who was in the room, pretending to be reading a book or magazine.

For children assigned to the motorcycle battery charging task, the same verbal instructions were employed as for the baking task, except that references to baking were replaced with references to battery charging. The children were instructed to remove the battery charger cables after the battery had been charged 30 min. They too were provided with the unlimited use of Pac Man beginning 15 min before the task began and continuing for the entire 30-min charging period.

There were two contexts for each task, with 24 children of each age and sex (six per cell) assigned at random to each setting. Half of the children did the baking or charging in their own homes, the other half in a psychophysics laboratory. In the home, Pac Man was set up in whichever room children normally played games, provided there was a clock on the wall and a table on which the game could be affixed. All of the children in both settings in fact did play Pac Man while waiting to remove either cupcakes or the battery-charging cable.

In the home, the children's older siblings, who were undergraduates trained by the experimenters, acted as unobtrusive observers during the waiting period. While pretending to be reading in another part of the room, they recorded each instance when their younger sibling turned away from the game in order to check the time. None of the observers was informed about the purpose and design of the experiment, or the reasons for recording clock-checking, until after the study had been completed. Pilot testing of the recording procedure indicated nearly perfect reliability among a group of five of the observers who subsequently participated in the experiment.

In the laboratory context, children were brought to a university psychophysics laboratory by their older brothers or sisters. The baking or battery-charging instructions were given by an unfamiliar age-mate of their older sibling, who was also trained to record the children's clock-watching while they played Pac Man in the laboratory. The child's older sibling was not present during the experiment in the laboratory. Thus, the two contexts differed both in the physical characteristics of the setting (home furnishings vs. psychophysics instrumentation) and in the familiarity of the persons present (older sibling vs. unfamiliar adult).

Debriefing.—Children were debriefed by their older siblings. They were informed that the primary purpose of the study had not been to bake cupcakes (or to recharge a battery) but to gain insight into how they kept track of time. It was explained that it was sometimes necessary for researchers to mislead subjects in order to gain knowledge, but that deception was never an ethically attractive way to deal with other people and was used with some reluctance by the researchers. The older siblings explained that there was no right or wrong way to monitor the passage of time. Children were encouraged to ask any questions they had concerning their participation. Finally, they were thanked for their participation and given the agreed-upon $5 stipend.

Results

Pilot studies and preliminary analyses.—As a precaution, we sought to determine whether there were any systematic age or sex differences in children's interest and/or proficiency in playing Pac Man, inasmuch as the presence of such differences could affect the capacity of the game to occupy boys' and girls' attention equally. At the outset of the study, children had been asked to indicate how frequently they played Pac Man (daily, biweekly, weekly, bimonthly, or less often) and how much they enjoyed it (*not at all* to *very much*). In addition, gains achieved between initial and final scores, as well as the number of games they played during the waiting period, were recorded as measures of children's concentration on the game. Each of these measures was entered in a multivariate linear regression as a predictor of clock-checking for each 5-min interval. In no instance did any of these variables account for significant variation in children's clock-checking. Somewhat surprisingly, girls expressed slightly more interest in Pac Man than boys and claimed to play it equally often.

For the baking task only, all of the older siblings happened to be females. Because of the possibility of confounding by sex of older sibling, another preliminary analysis was undertaken. Since, in the battery-charging task, half of the older siblings were males, the sex of the older sibling was used as a predictor of clock-checking frequency in a discriminate function. The resultant Wilks's lambdas indicated that, at least on this task, the sex of the older sibling was not associated with variation in the frequency of clock-checking by boys and girls.

Principal findings.—With the foregoing possibilities of confounding eliminated from serious consideration, we proceed to an examination of results bearing on the main hypotheses of the study. For this purpose, children's frequencies of clock-checking were analyzed by means of a five-way analysis-of-variance design (Age × Sex × Context × Task × Time Interval), with the first four factors being between-subjects dichotomies and the final factor being a repeated measure within subjects. In order to test for the hypothesized U-shaped distribution of clock-checking, six successive 5-min intervals were analyzed for both linear and quadratic components.[1] The method of orthogonal polynomials was em-

[1] All between-subject main effects and interaction effects were tested using 1 and 80 *df* and MSe = .69. All within-subject effects were tested using 5 and 400 *df* and MSe = .49. Linear and quadratic analyses employed 1 and 80 *df* and MSe's of 1.48 and 1.10, respectively. Neuman-Keuls tests were significant at $p < .01$ unless stated otherwise.

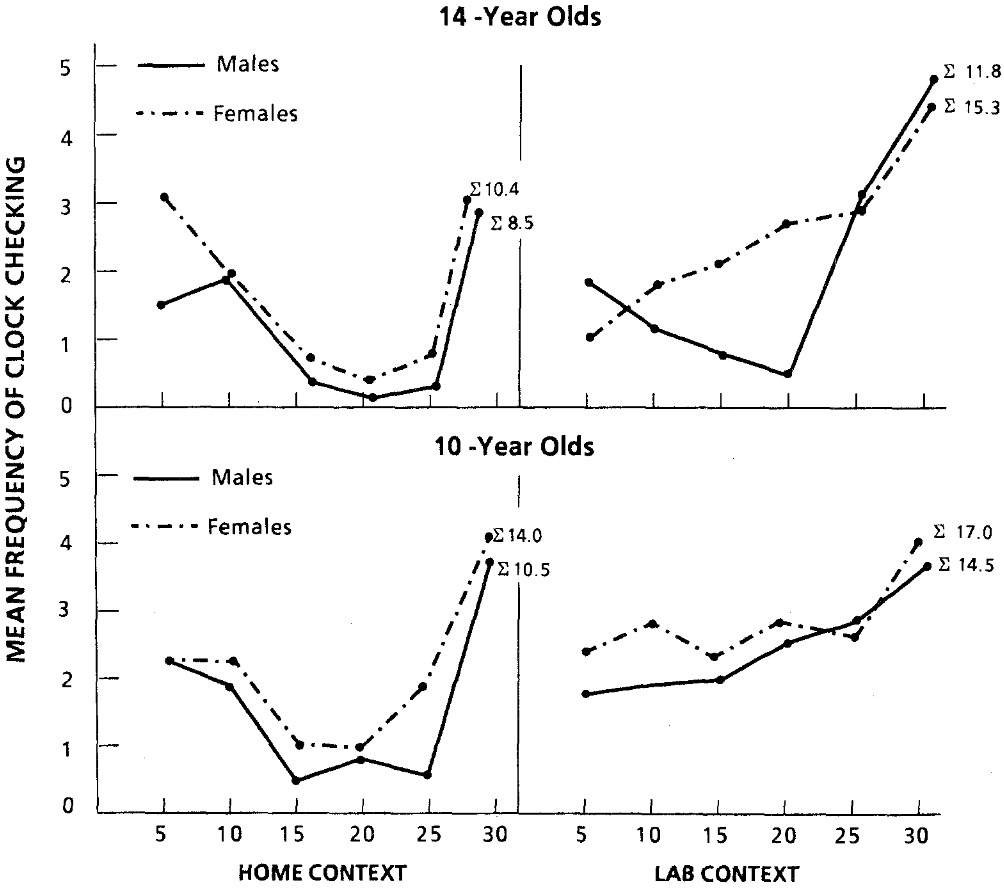

FIG. 1.—Children's clock-checking frequencies on the cupcake-baking task, late responders excluded (Σ = mean total number of clock-checks).

ployed for this purpose since it permits testing for the presence of a specifically parabolic function rather than a more general quadratic curve (Fisher, 1929; Winer, 1971). A test of goodness-of-fit revealed that the residuals from linear and quadratic regression were small and nonsignificant. (The linear and quadratic components together accounted for 91% of the within-subjects variation associated with the six 5-min time intervals.) Hence, these two regression components can be regarded as accurate summary measures of the distribution of clock-checking over time.

To turn to the findings themselves, Figures 1 and 2 depict the distribution of clock-checking during the waiting period for each of the 16 subgroups of subjects included in the experimental design. Data points along each graph show average frequencies of clock-checking for successive 5-min intervals, with the mean totals for the 30-min periods recorded at the right of each curve.

Hypothesis 1

The first hypothesis requires that strategic monitoring, as manifested by a U-shaped distribution of clock-checking, be associated with less total time looking at the clock. Evidence in support of this hypothesis is initially apparent from an inspection of Figures 1 and 2. Perhaps the most striking feature of the two figures is the contrast in the shapes of the curves appearing in the left and right halves of each diagram. With but one exception (to be discussed below), all of the parabolas appear at the left, whereas the curves at the right are generally linear. Hence, an approximate test of the first hypothesis can be made by comparing overall time-checking scores for each successive pair of setting contrasts. As indicated by the means cited in each panel, in every paired comparison, the total amount of clock-checking was greater in the laboratory setting than in the home. This pattern of consistent contrasts is reflected in a highly significant

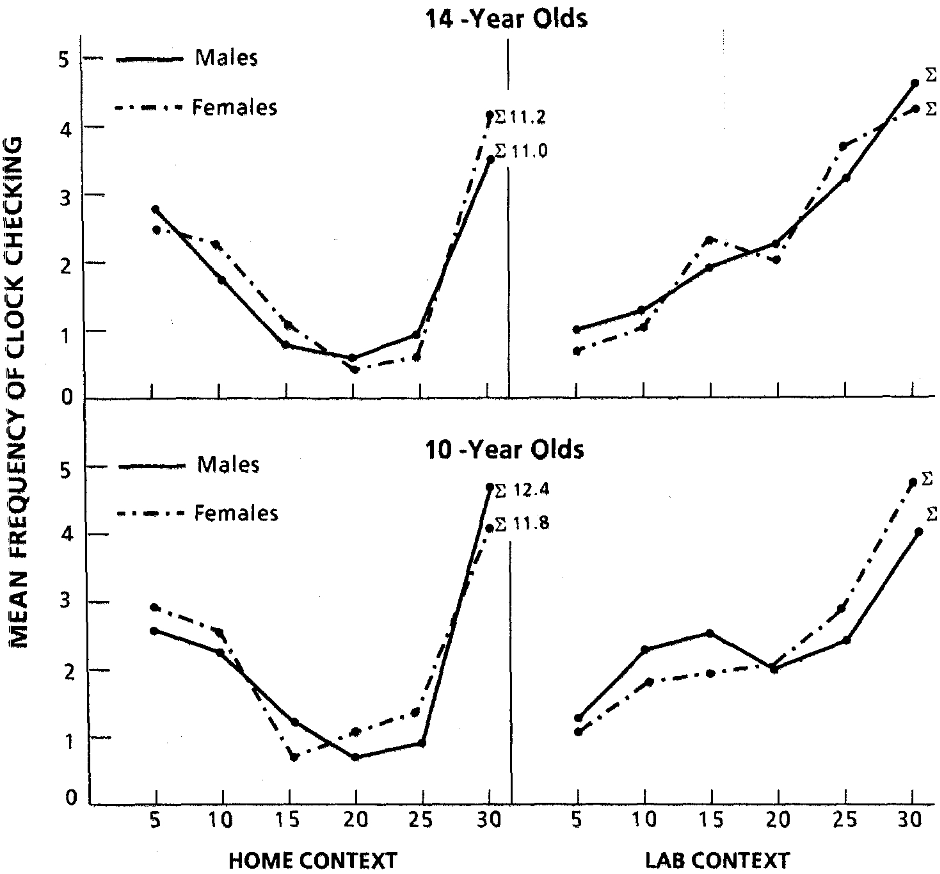

FIG. 2.—Children's clock-checking frequencies on the battery-charging task, late responders excluded (Σ = mean total number of clock-checks).

main effect for Context, $F = 59.8$, $p < .001$. In substantive terms, children observed in the home not only made greater use of strategic time monitoring, as indicated by the larger quadratic components, but they also spent less clock-watching time in the process.

A more precise measure and test of the first hypothesis is provided by examining this same relationship at the level of individual subjects, that is, calculating a correlation between the amount of time spent by each child in clock-checking, on the one hand, and, on the other, a measure of the extent to which the child resorted to strategic monitoring. Such a measure is obtainable by calculating, for each child, the quadratic regression coefficient for the distribution of his or her own clock-watching over the 30-min waiting period. The resulting correlation for the total sample was, as expected, rather high and negative in sign, $r = -.78$, $p < .01$.

It is instructive to calculate the analogous correlation between total time spent by each child in clock-checking and the degree of his or her anxious time-monitoring as measured by the corresponding linear regression coefficient. If our theoretical expectations are correct, the resulting correlation should again be substantial, but this time positive in sign. The obtained coefficient is in fact .67, indicating, not surprisingly (though not necessarily), that children who exhibited a pattern of anxious time-monitoring engaged in more clock-checking overall.

Taken together, these correlational results also constitute evidence of construct validation for our interpretation of the two principal patterns of clock-checking that have been distinguished: *strategic* and *anxious* time-monitoring.

Hypothesis 2

The consistently contrasting patterns in Figures 1 and 2 provide even stronger support for the second hypothesis and its two corollaries. Strategic monitoring was indeed more pronounced in the more familiar setting of the home, whereas anxious time-monitoring was more evident in the laboratory and resulted in more time spent in total clock-watching. This fact is confirmed statistically by highly significant interactions of Context both by linear, $F = 54.8$, $p < .001$, and by quadratic Time Intervals, $F = 30.7$, $p < .001$.

Hypothesis 3

With respect to the effects of Age, we find, as anticipated, that adolescents spent less time in clock-watching than did 10-year-olds. Their respective means for the half-hour waiting period were 11.2 and 14.1, $F = 24.2$, $p < .001$. On the average, older children also made more use of strategic time-monitoring, as revealed by a significant Age × Time quadratic, $F = 4.8$, $p < .05$. Further analysis of quadratic trends, however, revealed that the age difference was significant only in the laboratory setting, $F = 30.7$, $p < .001$. The same qualification applies to the influence of Age on anxious time-monitoring, but the effect is in the opposite direction. While using a more efficient strategy of clock-checking than younger children, adolescents of both sexes nevertheless showed a stronger tendency to increase their clock-checking over time. This finding is consistent with the interpretation that older children felt a greater pressure to perform the assigned task on time. Taken together, the contrasting signs of these interaction effects also demonstrate that the two strategies of time-monitoring are not simply opposite sides of the same coin, since they are not always correlated in the same direction.

Hypothesis 4

The effects of Age on both types of clock-watching were further qualified simultaneously by the Sex of the child and nature of the Task, $F = 5.8$, $p < .01$, for the Age × Sex × Context × Task quadratic trend. To summarize in substantive terms, older boys, again only within the laboratory setting, tended to be most efficient and least anxious when asked to bake cupcakes. The above finding clearly speaks to the fourth hypothesis of the study: the prediction that strategic monitoring will be reduced, and the frequency and pace of clock-checking increased, on a task associated with higher sex-role expectations for the group in question. There was only partial support, however, for the remainder of the hypothesis: the corresponding relationship for girls, while in the expected direction, was not statistically significant, that is, girls did not engage in reliably less clock-checking on the battery-charging task than their female peers on the baking task.

It was further anticipated that these sex-role effects would be more salient in older children than in younger children. The findings cited above are in accord with this expectation with respect to the distribution of clock-watching over time. Older boys, particularly in an unfamiliar laboratory setting, exhibited a more anxious and less efficient clock-checking strategy when requested to disconnect a battery charger (a male-typed task) than when asked to take cupcakes out of the oven (a female-typed task).

The results on the overall frequency of time-monitoring also provide corroboration for the fourth hypothesis. As specified in a significant Sex × Task interaction, $F = 24.2$, $p < .001$, boys looked at the clock more often in the battery-charging task, and girls in the baking task, particularly when the latter was conducted in the home. None of these relationships was qualified by the Age of the child, nor were there any significant main effects for Sex or Task.

Hypothesis 5

Finally, as the reader may have noted, a familiar refrain resounds throughout the last few paragraphs: the phrase "only in the laboratory." This recurrence reflects the fact that significant interaction effects were, almost without exception, limited to the laboratory setting. In accord with our final hypothesis, this finding supports the view that the laboratory, as an unfamiliar and thereby somewhat anxiety-arousing environment, is more likely to activate variation in research findings as a function of characteristics of both the person (e.g., age and sex) and the immediate situation (e.g., the nature of the task).

Taken as a whole, the results of this study indicate that, especially when observed in a familiar environment, children as young as 10 years of age can employ a fairly sophisticated cognitive strategy for monitoring the passage of time, one that substantially reduces the overall burden of clock-checking. The question may be raised, however, whether the reduction in amount of clock-checking is achieved at some sacrifice to punctuality. Specifically, did children in fact remember to take the cupcakes out of the oven before they were burned, or to disconnect the battery cable before the battery burned out? And if some children forgot, was the failure in prospective memory related to the strategy of clock-watching that they employed?

When prospective memory fails.—There were in fact 14 children who were more than

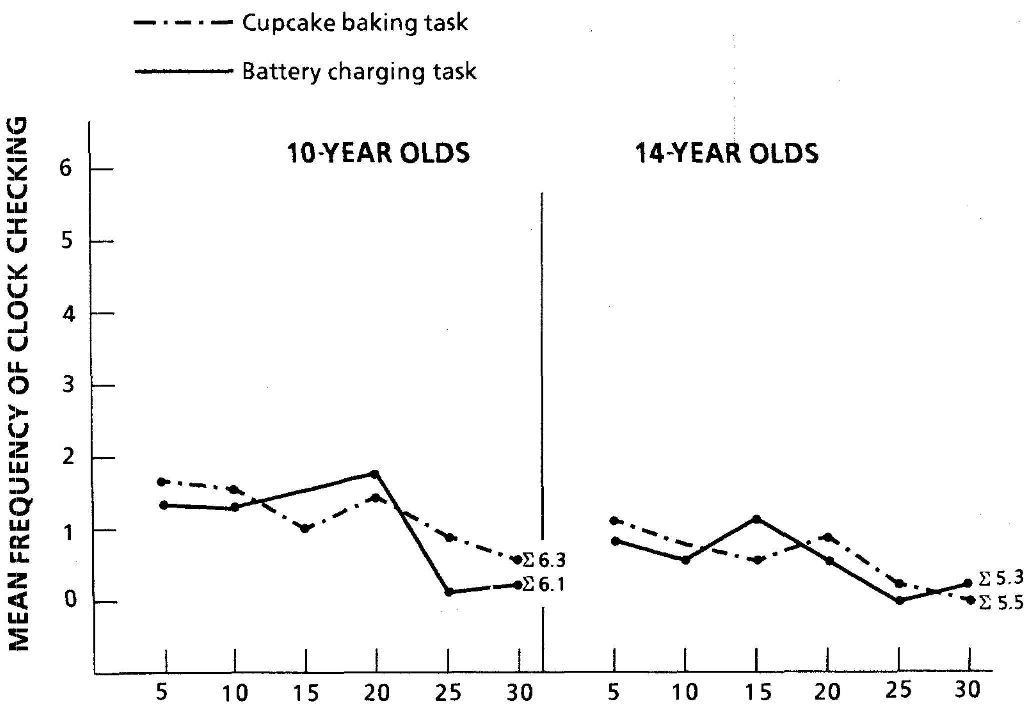

FIG. 3.—Clock-checking frequencies of "late responders" in the HOME context. No cases of late responding occurred in the LAB context (Σ = mean total number of clock-checks).

90 sec late in removing cupcakes from the oven or removing the battery-charger cable, and an additional seven who were between 60 and 90 sec late. Seven instances of late responding involved 10-year-olds on the baking task, six of whom were boys. All seven of these children had been assigned to the home context. Another eight instances of late responding involved 10-year-olds on the battery-charging task, five boys and three girls. All but one had been assigned to the home context. Six older children (all but one of whom were boys) responded late, three on the baking task and three on the charging task. All had been assigned to the home context. Thus, there was only a single instance of "forgetting to remember" in the laboratory context. And, overall, boys were more than three times as likely to forget as were girls (16 vs. 5).

Since nearly all of the forgetting occurred in the home and the home was also the context for most of the strategic time-monitoring, the question arises whether the latter type of behavior is indeed effective. Does it not occasionally result in failure to perform the task on time? To check on this possibility, we examined the pattern of clock-checking for the late responders as a group. As is apparent from Figure 3, these late arrivals did not engage in strategic monitoring. This observation is supported statistically by the high point biserial ($r = -.81$, $p < .01$) between the regression coefficients for the quadratic components and lateness versus "on time." This result confirms that, to a marked extent, those who responded late did not employ strategic time-monitoring. An analysis of individual late responders' patterns of clock-checking revealed that the magnitude of their quadratic coefficients did not exceed chance in a single instance (all p's $> .10$).

Moreover, an inspection of Figure 3 reveals that late responders approached the task differently from their "on-time" peers. First, as previously noted, they neither engaged in strategic monitoring, nor did they increase their clock-watching over time. Instead, to the extent that they showed any variation in rate, it was to decrease the frequency of checking as they approached the deadline. Even more striking is the low overall level of clock-checking that characterized this group, a total of less than six checks for the entire 30-min waiting period compared with 10–16 checks for the sample as a whole (see Figs. 1 and 2). Given this weak and waning pattern of response, it is not surprising that they forgot to perform the task on time.

The deviant behavior of the late responders also suggests a more general inference. A reduction in the overall level of clock-checking can apparently result from any of several processes. One of these is the use of a strategic pattern of monitoring; another may reflect a low level of effort accorded to the monitoring task. Moreover, these processes can lead to somewhat different consequences. On the one hand, the fact that none of the late responders had used a calibration strategy suggests that such a strategy insures against missing the deadline while at the same time reducing the total time expended in monitoring. On the other hand, reducing clock-watching for other reasons can result in "forgetting to remember." For example, an analysis of the relationship between late responding and the absolute frequency of clock-checking revealed that the children who checked the clock least often were the latest in removing cupcakes or battery cables, $Q = .81$, $p < .01$, by Yule's Coefficient of Association. This result replicates a similar finding in an earlier study by Harris and Wilkins (1982).

The foregoing analyses of data from late responders permit an extension of our earlier generalization. Strategic monitoring not only reduces the overall burden of clock-watching, but also accomplishes this economy without risk to the effective functioning of prospective memory; one does not "forget to remember."

Discussion

The principal conclusions of this experiment are most appropriately presented in the context of the specific hypotheses of the study. Thus we believe our findings clearly demonstrate that children as young as 10 years of age are able to employ fairly sophisticated cognitive strategies in support of prospective memory. Whether they in fact do so, however, depends in significant degree on the context in which prospective memory is activated. Our findings show equally clearly that children are far more likely to use a complex, time-conserving strategy in the familiar environment of the home than in the unfamiliar setting of a psychophysics laboratory. By contrast, the latter milieu evokes a pattern of response involving an escalating pace of clock-checking suggestive both of greater caution and greater anxiety. There is no evidence, however, that either of these strategies is more effective than the other in terms of achieving the ultimate goal of remembering to carry out a specified task at some future time. Those children who failed to make the deadline employed neither of the above patterns of clock-checking but rather telegraphed their failure by reducing the frequency with which they were verifying the passage of time.

There are indications, however, that the two effective strategies have rather different trade-offs. Moreover, these are trade-offs that children 10 years of age can already recognize and act upon. Thus it would appear that what we have called anxious time-monitoring insures against missing the deadline but does so at the sacrifice of intervening time that could be employed for other purposes. Strategic time-monitoring, by contrast, offers an intervening period for other activities, but possibly at some risk of failing to perform the required task on time. Our findings suggest that children perceive the request to carry out a future task as a less demanding, and perhaps less important, responsibility when the task is to be performed in the presumably more relaxed atmosphere of the home than in the less familiar and possibly more prestigious environment of the laboratory. Correspondingly, children in the latter setting, even though already capable of using a less time-consuming strategy, take precautions to insure that they will not fail to live up to expectations. It is a nice instance of Freud's principle of "anxiety in the service of the ego."

The interpretation of our results as a function of increased tension evoked by the strange and unfamiliar setting of a psychophysics laboratory requires further comment. Although not without some theoretical and empirical basis, this explanation is nevertheless an inference not grounded in any data from the experiment itself. In order to provide such direct data, we carried out an additional subexperiment making possible a further and more critical test of our a priori explanation.

A test case: A halfway house between laboratory and home.—For this purpose, an additional group of 24 children were asked to perform the cupcake-baking task in a standard kitchen located in a former residential apartment of a home economics building. While waiting, children played Pac Man in an adjacent living room. In all other respects the procedure was identical with that followed in the laboratory setting. Thus we were now introducing a third context that, in terms of familiarity, was intended to be intermediate between the other two: at one extreme, one's own kitchen; then an ordinary kitchen in an unfamiliar but compatible environment (i.e., the home economics building); and, at the other extreme, the psychophysics laboratory.

The results for this intermediate context are quite straightforward, and readily summarized as follows. For the younger children, the pattern of findings in the home economics kitchen was practically indistinguishable from that for the laboratory. Thus there was little evidence of strategic monitoring, the pace of clock-checking increased with time, and the overall frequency was only slightly lower than that for the laboratory (14.5 and 15.7, respectively). It was substantially and significantly higher, however, than the corresponding figure for the home (12.3). In sharp contrast, the results for the 14-year-olds in the home economics kitchen were scarcely distinguishable from those for the home; both of these groups showed high levels of strategic monitoring, and correspondingly low frequencies of overall clock-watching (10.2 for the home economics setting and 9.5 for the home setting vs. 13.5 for the laboratory).

The foregoing findings are consistent with a hypothesis of an increase in strategic monitoring and a decrease in the frequency and pace of clock-checking as a joint function of the age of the child and the familiarity of the setting. For a 10-year-old, an unfamiliar kitchen in a home economics building at a university is no less strange than a psychophysics laboratory and has similar effects on reducing the efficiency of cognitive strategies that support remembering. But for an adolescent, an ordinary kitchen in one location is no less familiar than in another, whether the place is a home or a university building, with the result that cognitive strategies remain efficient and unaffected.

The results of the "kitchen-on-campus" experiment also shed some light on which aspects of context evoke differences and similarities in patterns of time-monitoring. Following the usual practice in a laboratory experiment, we employed as observers in that setting research assistants who were unknown to the subjects of the study. A similar procedure was followed in the "kitchen-on-campus" experiment. Hence any differences in styles of clock-checking in these two contexts cannot be attributed to the presence of a familiar versus unfamiliar observer. Accordingly, the more anxious and less efficient pattern of time-monitoring exhibited by older children in the laboratory setting must have been induced by some features peculiar to that environment that also had special significance for youngsters of high school age. Such features might include, for example, the profusion of elaborate technical equipment or, at a more abstract level, the prestigeful and perhaps mystifying aura of science.

With respect to younger children, however, the influence of interpersonal relationships cannot be ruled out since the contrast in their pattern of monitoring in home versus out-of-home environments was confounded by the presence of an older sibling in the home setting. Hence, for this age group, the possible effect of a family member's presence on the cognitive strategies employed by the child remains an issue for future research.

The laboratory and ecological validity.— It is clear that, had our experiment been conducted only in the laboratory, we would have reached rather different conclusions. In particular, we would have underestimated many children's ability to employ a fairly sophisticated cognitive strategy in order to "remember not to forget." Recall that in the laboratory setting there was little evidence for strategic monitoring. Instead, children exhibited what we now recognize as comparatively high levels of clock-watching. Moreover, with the exception of older boys in the baking task, the frequency of clock-watching increased steadily during the course of the half-hour waiting period.

Over a decade ago, developmentalists voiced concern as to whether principles developed from laboratory experiments would generalize to "everyday settings" (Brown, Bransford, Ferrara, & Campione, 1983; Stevenson, 1970; White, 1970). While these arguments were not based on empirical comparisons, others have recently reported substantial differences in the effects of what is ostensibly the same behavior observed in the lab and nonlab settings (Acredolo, 1979; Bickman & Henchley, 1972; Cole, Hood, & McDermott, 1982; DeLoache, 1980; Graves & Glick, 1978; Luria, 1982; Strayer, 1980). In perhaps the seminal investigation of the lack of correspondence between laboratory and naturalistic measures of remembering, Istomina (1975) showed that children recalled approximately twice as many items from a word list when it was presented as a shopping list as opposed to a laboratory study of memory. This and other demonstrations of the noncorrespondence between naturalistic memory and laboratory remembering (e.g., Cole et al., 1982) have prompted some researchers to condemn laboratory settings, and even the analytical apparatus that experimentalists bring to the task of gathering new knowledge (e.g., Cole et al., 1982; Gergen, 1978).

In our view, the results of the present study are more properly construed not as a criticism of laboratory procedures per se, but rather as a demonstration of the limitations involved in relying exclusively on a laboratory context for clues to children's competencies on everyday tasks. Our findings point to the as yet unexploited power of the experimental laboratory as an ecological contrast that helps to highlight the distinctive features of other settings as contexts of development (Bronfenbrenner, 1977, 1979), including the development of cognitive strategies.

"Calibrating one's psychological clock": Fact or fiction?—It is possible to argue that the high levels of early clock-checking did not reflect children's use of the calibration strategy. After all, the deployment of the calibration strategy was only an inference. We shall contend, however, that the type of time-monitoring characteristic of high levels of early clock-checking must have been qualitatively different from the type of time-monitoring employed by children who engaged in low levels of early clock-checking. In short, more than the numbers of clock-checks were different between these groups. Otherwise, how could children with high levels of early clock-checking have been able to reduce their subsequent checking well below the levels exhibited by those with low levels of early clock-checking? It seems that the most parsimonious explanation for this turnabout in clock-checking behavior is to consider that those children who began with high levels of clock-checking were comparing the passage of real time with their subjective judgments of the length of time that had gone by; that is, they were calibrating their psychological clocks. It would appear that acquired confidence in one's estimation of time, derived through an early comparison process, was what permitted children with high levels of early clock-checking to reduce such behavior substantially during what they estimated to be the intervening period of waiting.

Caveat lector.—Three shortcomings of the study need to be acknowledged. First, the present design did not permit an assessment of which aspects of the various contexts were implicated in the observed results. Further work is required to determine the importance of factors such as familiar furnishings, the presence or absence of older siblings, a "scientific" atmosphere, or some combination of these or other features in producing the observed effects. Second, one may legitimately wonder how specific the observed findings were to: (*a*) the use of a 30-min waiting period, (*b*) the particular tasks, (*c*) the instructions provided, and (*d*) the use of Pac Man as the intervening task. Third, some might claim that what we are calling time-monitoring is not a memory function but rather a process of attention-directing. We agree that time-monitoring *is* a form of attention-directing, but contend that this process is integrally involved in prospective remembering. Thus, we have referred to it as "a cognitive strategy that supports prospective memory," much like other support processes (e.g., rehearsal, metamnemonic awareness, knowledge-based strategies, etc.). That the tasks we employed entailed prospective memory can hardly be disputed; 21 out of the 96 children who participated in these tasks in fact forgot to fulfill the assigned responsibility.

Conclusion

The present findings would appear at first glance to run counter to the view that complex forms of memory monitoring are undeveloped in young children (see Flavell & Wellman, 1977). In this study, children as young as 10 exhibited a reasonably well-developed type of monitoring during the waiting period. Of course there is no way to be certain of our inference about what the children were doing during the waiting period, short of rerunning the experiment using clocks programmed to run faster or slower than normal—which is being done presently. Attempts through postexperimental interviews to elicit information about children's awareness of using calibration proved uninformative. To the extent that children employed a calibration strategy, they appeared to do so spontaneously, without effort or awareness, for they were unable to confirm its use during interviews. Recently, research has begun to reveal many forms of processing that are undertaken by children without awareness or effort (see Ceci, 1983, 1984, for reviews). Ceci and Howe (1982) have provided a framework and some empirical support for the position that some forms of monitoring occur ". . . without intention, and neither the process of directing the attention, or the resultant product of this attention, ever became conscious. . . . We have seen that parts of the cognitive system appear to be outside the control of the thermostat (metamemory)" (p. 162). Thus, the present findings raise the interesting specter of a fairly complex strategy being automatically deployed. If confirmed, this would help explain why young children appear to be adept at its use, as automatic processing has been shown to be age-invariant, provided that a minimal level of experience has occurred (Ceci, 1983).

In conclusion, we suggest that this series of experiments has some broader implications for research on development-in-context. First, the developmental significance of strategies employed to support retrospective memory is highlighted by the results of administering the present experiment in a nonconventional kitchen in a university building. For 10-year-olds, the kitchen may as well have been a university laboratory; for adolescents, it may as well have been their own kitchen at home. For younger children, one room at a university was as strange as another; for the adolescents, a kitchen was a kitchen regardless of where it was located, and it connoted none of the special challenge and concern experienced by young high school students exposed to the world of sophisticated science.

Even the latter, however, can lose its stirring power if the task to be performed seems unimportant. In the laboratory setting, adolescent boys steadily escalated their clock-checking lest they fail to disconnect the motorcycle battery charger on time. But when the task to be performed was remembering to remove cupcakes from the oven, there was little speedup during the waiting period; instead, the 14-year-old boys, after spending the first few minutes calibrating their psychological clocks, relaxed into a pace of less frequent monitoring until a few minutes before the expected deadline, when they again began to check the clock more often. No such temporary respite was shown by adolescent girls. For them, apparently, remembering to take cupcakes from the oven was no less challenging in a scientific setting than was disconnecting a battery charger.

None of the subtle yet psychologically significant differences in responding would have been observed, however, had the experiment been carried out solely in the home. Earlier we commented that the conclusions drawn from the study would have been different had it been conducted only in the laboratory; clearly the converse of this statement is equally true. This reciprocal relationship testifies to the scientific importance and power of the laboratory as a contrasting context for illuminating developmental processes and outcomes. Such a view of the laboratory's potential is hardly new. In a recent paper, Markova (1982) calls attention to George Herbert Mead's (1934) strong stand on this same point: ". . . it was Mead who vehemently defended the laboratory against those who claimed that all psychological phenomena should be explored and could be understood only in terms of individual experience. Arguing against phenomenologists and positivists at the same time, he claimed that it was wrong to overemphasize the artificiality of the experimental apparatus and technique of the psychological laboratory (Mead, 1938, p. 35). They are a necessary part of a psychological investigation because they enforce a specific and exact kind of human conduct which otherwise would not be available for investigation" (Markova, 1982, p. 197).

The repetition in the laboratory of experiments or observations conducted in a naturalistic setting like the home, or vice versa, offers rich and as yet unexploited possibilities for revealing the remarkable capabilities of children, from the earliest ages onward, to respond to their environments in ways that are cognitively complex and discriminately adaptive both to the opportunities and the risks that these environments present for the child's development.

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