PROSPECTIVE AND RETROSPECTIVE DURATION JUDGMENT: THE ROLE OF INFORMATION PROCESSING AND MEMORY

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ABSTRACT. Research comparing prospective and retrospective duration-judgment paradigms has produced diverse findings and conclusions. Two experiments reported here reveal that information-processing tasks influence duration judgment differently in the two paradigms. Experiment 1 shows that performing a more difficult task shortens prospective judgments but does not influence retrospective judgments. Experiment 2 shows that performing different kinds, rather than a single kind, of processing during a duration lengthens retrospective judgments but does not influence prospective judgments. Memory for nontemporal (stimulus) information processed during a time period cannot account for either prospective or retrospective duration judgment, because the pattern of effects and interactions is different. This finding rejects memory-storage models of duration judgment. Interactions of task and paradigm support a contextual-change model, which says that different kinds of contextual information subserve prospective and retrospective duration judgments.

1. Introduction

In his classic review, James (1890) discussed differences between the experience of a time period in passing and the memory of one in retrospect. He said that a duration seems longer in passing whenever "we grow attentive to the passage of time itself" (p. 626), whereas whether a duration seems relatively long in retrospect depends on "the multitudinousness of the memories which the time affords" (p. 624). Thus, James emphasized the importance of attentional processes in the experience of duration in passing and the importance of memory processes in the experience of duration in retrospect. Researchers investigate these claims by varying the temporal paradigm to which subjects are exposed: A prospective paradigm is used to study duration in passing, or experienced duration; whereas a retrospective paradigm is used to study duration in retrospect, or remembered duration (Block, 1979). The temporal paradigm presumably influences subjects' temporal set, thereby altering cognitive processes involved in encoding and retrieving temporal information (see Zakay, 1990).

In the prospective paradigm, subjects know that they will subsequently be asked to make a duration judgment, so they presumably allocate attention to processing temporal information. Researchers usually test this assumption by varying the attentional demands of a nontemporal information-processing task and observing the effects on duration judgment (e.g., Thomas & Weaver, 1975).

F. Macar et al. (eds.), Time, Action and Cognition, 141–152.

In the retrospective paradigm, subjects have no advance knowledge that they will subsequently be asked to make a duration judgment, so they presumably do not deliberately attend to temporal information. Variables that affect attention, such as information-processing demands, should produce little or no direct effect on retrospective duration judgment. Other factors may directly influence retrospective judgments. For example, if a primary task produces stronger, more numerous, or more durable memories for events from the time period, the judged duration of it may lengthen (James, 1890; Ornstein, 1969).

Many studies have used a prospective paradigm, but relatively few have used a retrospective paradigm, perhaps because ordinarily only one retrospective duration judgment can be obtained from a subject.[1] To my knowledge, only 15 experiments, reported in 9 articles, have used temporal paradigm as a between-subjects variable (Bakan, 1955; Block, George, & Reed, 1980; Brown, 1985; Brown & Stubbs, 1988; Hicks, Miller, & Kinsbourne, 1976; Kikkawa, 1983; McClain, 1983; Miller, Hicks, & Willette, 1978; Zakay & Fallach, 1984).[2] Most of them focused on whether or not nontemporal variables (e.g., information-processing task) differentially influence prospective and retrospective duration judgments.

1.1. INTERACTIONS OF PARADIGM AND TASK

Several researchers have reported significant effects or interactions involving temporal paradigm. Hicks (1976; cited in Hicks et al., 1976) found that "the psychophysical function is somewhat flatter [for retrospective] than for prospective judgments" (p. 726). Hicks et al. (1976) reported that increased response uncertainty shortens prospective verbal estimates of duration but does not influence retrospective estimates. Miller et al. (1978) found that when subjects rehearse information, prospective estimates increase across trials whereas retrospective estimates decrease. Block et al. (1980) discovered that if there are stimulus changes, reproductions of the duration shorten in the prospective paradigm but lengthen in the retrospective paradigm; and a task-unrelated interruption has different effects in the two paradigms. McClain (1983) reported an interaction of processing level, list length, and paradigm on reproductions. In the prospective paradigm, Zakay and Fallach (1984; Zakay, 1989) concluded that immediate estimates show an effect of task complexity that reflects an attentional process, whereas remote (i.e., delayed) estimates show an effect that reflects a memory storage process; in the retrospective paradigm, they found no effect or interaction involving task complexity. Brown and Stubbs found that compared to retrospective judgments, prospective judgments are more closely related to actual duration, are longer, and are less variable; nevertheless, they concluded that "a common timing process may underlie judgments under prospective and retrospective conditions" (1988, p. 307).

In agreement with this conclusion, several experiments have found no significant effect or interaction of temporal paradigm on duration judgments. Neither Bakan (1955) nor Kikkawa (1983) found a significant effect of paradigm on verbal estimates of duration. Brown (1984; cited in Brown, 1985) found that expending cognitive effort disrupts both prospective and retrospective judgments. Brown reported that prospective judgments are longer than retrospective ones; however, his main conclusions are that "both types of time judgments [become] increasingly inaccurate as attention [is] more broadly deployed" and that "nontemporal task demands disrupt or interfere with timing in both prospective and retrospective situations" (1985, p. 115).

1.2. MEMORY FOR NONTEMPORAL (STIMULUS) INFORMATION

The present experiments investigate memory for nontemporal (stimulus) information presented during a time period. Only a few previous experiments comparing prospective and retrospective judgments have also measured memory. Kikkawa (1983) found no significant influence of paradigm on several measures of recall. McClain (1983) also found no significant influence of paradigm on free recall of words processed during a time period. Brown (1985, Experiment 2), however, reported a differential effect on memory: In his most difficult task, one which required subjects to divide attention in a dichotic listening situation, memory was worse in the prospective paradigm than in the retrospective paradigm. This finding suggests that attending to time may require resources that would otherwise be available for processing nontemporal information.[3]

2. Experiment 1

Experiment 1 seeks evidence on whether attentional demands and memory for nontemporal information processed during a time period influence duration judgments differently in the two paradigms. It uses two tasks that have not been compared in duration-judgment studies, although other research (e.g., Posner, Petersen, Fox, & Raichle, 1988) has used the tasks.

Attentional models of prospective duration judgment predict that a more attention-demanding task will be judged as shorter than a less attention-demanding task (Harton, 1938; Thomas & Weaver, 1975; Zakay, 1989). This follows from the assumption that attention is shared between two mechanisms, a temporal information processor (called a *timer*) and a nontemporal (stimulus) information processor. To the extent that a task more heavily engages the nontemporal information processor, the timer registers less and more variable temporal information. These models also assume that subjects allocate more attention to the timer in a prospective than in a retrospective paradigm. As a result, subjects have fewer attentional resources available to process nontemporal information, and memory for nontemporal information should be worse in a prospective than in a retrospective paradigm.

Models of retrospective judgment make different predictions. Memory-storage models, such as the storage-size model (Ornstein, 1969), predict that a more attention-demanding task will be judged as longer in retrospect if it leads to increased memory for stimulus information. Memory-change models, such as the contextual-change model (Block, 1990; Block & Reed, 1978), predict that two differentially attention-demanding tasks may lead to equivalent retrospective judgments if contextual elements associated with the performance of one task do not change any more rapidly than those associated with the performance of the other task. According to this model, memory for stimulus information is not necessarily correlated with, or causally related to, duration judgment.

[1] An exception is recognition memory for event duration (Boltz, this volume).

[2] Hicks (this volume) presents additional data of considerable relevance and interest.

[3] See also Casini, Macar, & Grondin (this volume); Grondin & Macar (this volume).

Experiment 1 tests these differing predictions of attentional, memory-storage, and memory-change models.

2.1. METHOD

Subjects were 120 students who received introductory psychology course credit for participating. A total of 30 subjects were randomly assigned to each of four combinations of conditions in a 2 × 2 factorial, combining paradigm (prospective vs. retrospective) and task (easy vs. difficult). They were run individually.

The experimenter told subjects that they would see words presented, one at a time. Subjects in the easy condition were told simply to pay close attention to each word. Subjects in the difficult condition were told to name an action associated with each word. For example, if the word is *beer*, the subject could say *drink* or *pour*. (This task is more difficult in the sense that it requires additional mental operations.) Pilot subjects could quickly produce an action associated with each word. The experimenter then gave instructions defining the temporal paradigm. Prospective instructions told subjects to pay attention to how much time elapses during the task but not to count. Retrospective instructions simply said that the experimenter would later ask some questions about the words.

The experimental duration contained a random selection and ordering of 34 words from a pool of 68 common nouns. The words were presented at a 4.9-s rate for a total duration of 165 s. At the end, the experimenter gave duration-reproduction instructions: The subject was told to say *start*, "sit quietly for as long as the series of slides seemed to you," then say *stop*. The experimenter told the subject not to count seconds during the reproduction. Finally, the experimenter gave standard *yes/no* recognition instructions. The recognition test followed, with the 68 words presented in a random order at a subject-paced rate.

2.2. RESULTS

Table 1 displays means on several measures of performance; a 2 × 2 (Paradigm × Task) ANOVA was performed on each.

2.2.1. *Duration Judgment.* Reproductions are longer in the prospective than in the retrospective paradigm [$F(1, 116) = 9.22, p < .01$], and they are longer for the easy task than for the difficult task [$F(1, 116) = 4.71, p < .05$]. The Paradigm × Task interaction is also significant [$F(1, 116) = 5.06, p < .05$]. In the prospective paradigm, reproductions are longer for the easy task than for the difficult task ($p < .001$). In the retrospective paradigm, task difficulty did not significantly influence reproductions ($p > .05$).

Inaccuracy of duration judgments was assessed by expressing the absolute value of the difference between each reproduction and the actual duration (165 s) as a percentage of the actual duration (cf. Brown & West, 1990). Nearly all reproductions were underestimates, so absolute error is negatively correlated with reproduction length ($r = -.83, p < .0001$). To a considerable extent, therefore, the absolute-error data mirror the reproduction data. Absolute error is greater on retrospective than on prospective judgments [$F(1, 116) = 13.0, p < .001$]. However, neither the main effect of task nor the Paradigm × Task interaction is significant (both $Fs < 2.85$).

Table 1
Means in each condition on several performance measures, Experiment 1

Task	Reproduction	Absolute Error	Absolute Deviation	Corrected Recognition
	Prospective paradigm			
Easy	140.4 ± 6.7	23.2	20.3	.66
Difficult	107.6 ± 5.8	34.8	25.1	.92
Mean	124.0	29.0	22.7	.79
	Retrospective paradigm			
Easy	101.2 ± 9.0	42.2	38.4	.71
Difficult	101.8 ± 7.9	41.7	33.0	.93
Mean	101.5	41.9	35.7	.82

Note. Each reproduction mean appears with its standard error.

Intersubject variability of duration judgments was assessed by expressing the absolute deviation of each reproduction from its condition mean as a percentage of the condition mean. Across all conditions, absolute deviation is not significantly correlated with reproduction length ($r = .13$). The absolute deviation is greater in the retrospective than in the prospective paradigm [$F(1, 116) = 10.2, p < .01$]. Neither the main effect of task nor the Paradigm × Task interaction is significant (both $Fs < 1.62$).

2.2.2. *Recognition Judgments.* The mean false-alarm rate is less than .10 in all conditions. Recognition performance was assessed by using a standard correction for guessing: The false-alarm rate was subtracted from the hit rate. Corrected recognition performance is better on the difficult task than on the easy task [$F(1, 116) = 126.2, p < .001$]. Neither the main effect of paradigm nor the Paradigm × Task interaction is significant (both $Fs < 1.35$).

2.3. DISCUSSION

Experiment 1 reveals that information-processing demands (i.e., task difficulty) influence prospective and retrospective judgments differently. In the prospective paradigm, reproductions were shorter following a more difficult task; in the retrospective paradigm, reproductions were not influenced by task difficulty. Compared to the retrospective judgments, the prospective judgments were longer, were more accurate, and showed less intersubject variability. Paradigm did not influence recognition performance; see section 4.2 for discussion of this finding. In both paradigms, the difficult condition produced better recognition memory but was not reproduced as longer. This finding is not consistent with memory-storage models; I propose an explanation for it in section 4.4.

3. Experiment 2

Block and Reed (1978) found that the remembered duration of a categorical ("deep") processing task does not differ from that of a structural ("shallow") processing task. If subjects alternate between these two kinds of processing tasks, however, they remember the duration as being longer than if they perform either kind of processing task by itself. In contrast, Hanley and Morris (1982) reported that the remembered duration of a semantic processing task is longer than that of a phonemic processing task. Experiment 2 attempts to resolve the differences between the Block and Reed (1978) and Hanley and Morris (1982) findings, as well as to extend the generality of the conclusions into the domain of experienced duration. Arlin (1986) reported that children's prospective judgments are longer following a shallow-processing task than following a deep-processing task.

3.1. METHOD

Subjects were 120 students who received introductory psychology course credit for participating. A total of 30 subjects were randomly assigned to each of four combinations of conditions in a 2 × 2 factorial, combining paradigm (prospective vs. retrospective) and processing type (unmixed vs. mixed). In the unmixed-processing condition, subjects processed information at the same level throughout the experimental duration; in each cell, 10 of the 30 subjects were randomly assigned to each of three levels—structural, rhyming, and category. In the mixed-processing condition, subjects alternated between the three levels, processing five items at a given level before alternating to a different level. (Thus, each processing level was performed on two occasions, for a total of ten items.) Three different alternation orders were used; in each cell, 10 of the 30 subjects received each order.

The experimenter described the task, showing subjects examples of the three types of questions that might be asked. Subjects were told to answer each question quickly and accurately. The experimenter then gave prospective or retrospective instructions as in Experiment 1.

The processing task was presented in a series of screens on a computer monitor. Each screen showed a question, which the subject answered by saying *yes* or *no*, depending on whether or not it correctly described a word, such as *bear*, which appeared below the question (cf. Craik & Tulving, 1975). Across conditions, an attempt was made to use questions of about the same difficulty. In the structural condition, the question concerned the color and size of the letters forming the word, such as "Is the word in small blue letters?" In the rhyming condition, it concerned whether or not the word rhymes with another word, such as "Does the word rhyme with affair?" In the category condition, it concerned whether or not the word is a member of a particular semantic category, such as "Is the word a type of animal?" In all conditions, each word was randomly assigned to appear in red, green, or blue letters, either upper-case (large) or lower-case (small). Sixty words were selected such that pairs of words shared rhyming or category membership; one word from each pair was presented during the duration, and the other word appeared only on the recognition test. For half the questions of each type, the correct response was *yes*; for the other half, it was *no*.

The first screen showed the word *START*; it was followed by 30 question screens; the last screen showed the word *END*. The 32 screens were presented at a 5.0-s rate for a total experimental duration of 160 s. The experimenter monitored each subject's responses to ensure accurate responding. At the end of the duration, the subject reproduced the duration, as in Experiment 1. The recognition test followed, with the 60 words presented in a random order at a subject-paced rate.

3.2. RESULTS

Table 2 displays means on several measures of performance. For each, data were first analyzed by performing a 2 × 2 (Paradigm × Processing Type) ANOVA. Then a 2 × 3 (Paradigm × Processing Level) ANOVA was performed to assess possible effects of paradigm and processing level within only the three unmixed-processing conditions.

3.2.1. *Duration Judgment.* Neither the main effect of paradigm ($F < 1$) nor the main effect of processing [$F(1, 116) = 1.89$] is significant. The Paradigm × Processing Type interaction is significant, however [$F(1, 116) = 8.76, p < .01$]. In the prospective paradigm, reproductions do not differ between the two processing types ($p > .05$). In the retrospective paradigm, reproductions are longer for mixed than for unmixed processing ($p < .01$).

Considering only unmixed-processing levels, reproductions are longer in the prospective than in the retrospective paradigm [$F(1, 54) = 5.54, p < .05$]. Mean reproduction in the structural, rhyming, and category conditions are 105.0 s, 126.8 s, and 102.1 s for the prospective paradigm and 95.7 s, 85.2 s, and 87.5 s for the retrospective paradigm. Neither the main effect of processing level nor the Paradigm × Processing Level interaction is significant (both *F*s < 1.17).

Table 2
Means in each condition on several performance measures, Experiment 2

Task	Reproduction	Absolute Error	Absolute Deviation	Corrected Recognition
		Prospective paradigm		
Unmixed	111.3 ± 7.0	53.5	30.9	.53
Mixed	101.1 ± 6.4	62.9	24.6	.55
Mean	106.2	58.2	27.8	.54
		Retrospective paradigm		
Unmixed	89.4 ± 6.0	70.9	27.1	.55
Mixed	117.3 ± 6.2	46.2	27.6	.53
Mean	103.4	58.5	27.4	.54

Note. Data from the unmixed conditions are combined. Each reproduction mean appears with its standard error.

The absolute error and absolute deviation of each reproduction were calculated as in Experiment 1. As before, nearly all reproductions were underestimates, and absolute error is negatively correlated with reproduction length ($r = -.93, p < .0001$). The absolute-error data, therefore, mirror the reproduction data: Neither main effect is significant (both $Fs < 1.97$), but the Paradigm × Processing Type interaction is significant [$F(1, 116) = 9.84, p < .01$].

As in Experiment 1, the absolute deviation of each reproduction is not significantly correlated with the reproduction length ($r = .15$). The absolute-deviation data show no significant main effects or interaction (all $Fs < 1$).

3.2.2. *Recognition Judgments.* The mean false-alarm rate is not appreciably different in the prospective and retrospective conditions. The overall mean false-alarm rate is highest in the structural condition (.26), lower in the rhyming condition (.15), and even lower in the category condition (.05); it is intermediate following mixed processing (.12).

Recognition performance was assessed as in Experiment 1. The 2 × 2 ANOVA reveals no significant main effects or interaction (all $Fs < 1$). The 2 × 3 ANOVA reveals an effect of unmixed processing [$F(2, 54) = 75.0, p < .0001$]. Mean corrected recognition performance is excellent following category processing (.83), intermediate following rhyming processing (.53), and poor following structural processing (.26). Neither the main effect of paradigm nor the Paradigm × Processing Level interaction is significant (both $Fs < 1.28$).

3.3. DISCUSSION

The major finding of Experiment 2 is that retrospective judgments are longer for the mixed-processing task than for the unmixed-processing task, but prospective judgments are unaffected by this manipulation. Memory-storage models cannot explain the finding in either the prospective or the retrospective paradigm. Large differences in memory for stimulus information did not influence duration judgments, and as in Experiment 1 paradigm did not influence recognition memory. In contrast to Experiment 1, prospective judgments were neither longer, nor more accurate, nor less variable than retrospective judgments.

4. General Discussion

4.1. INTERACTIONS OF PARADIGM AND TASK

The results of both experiments reveal that paradigm and task interact to influence reproduction of a moderately long duration. In Experiment 1 a task variable (easy vs. difficult processing) influenced prospective but not retrospective judgments, and in Experiment 2 a different task variable (unmixed vs. mixed processing) influenced retrospective but not prospective judgments. This pattern of results is similar to what neuropsychologists refer to as a "double dissociation," and it provides strong evidence that different processes or systems are involved (see Schacter, 1989). Specifically, the present findings support previous research suggesting that different processes subserve duration judgment in the prospective and retrospective paradigms (e.g., Block et al., 1980; Hicks et al., 1976). These data do not support Brown and Stubbs' claim that "a common timing process may underlie judgments under prospective and retrospective conditions" (1988, p. 307).

In Experiment 1 prospective judgments were longer for an easy task than for a difficult task. This finding is consistent with previous reports (e.g., Harton, 1938), as well as with models of experienced duration in which attention is shared between two different processors (e.g., Thomas & Weaver, 1975) and a variety of other models (see Block, 1990). In the retrospective paradigm, task difficulty did not influence reproductions. This clarifies previous findings that the overall amount of attentional demand plays little or no role in remembered duration (see Gray, 1982; Underwood & Swain, 1973).

In Experiment 2 retrospective judgments were longer for a mixed-processing task than for an unmixed-processing task, but level of processing of the unmixed task did not influence reproductions. These findings replicate earlier work (Block & Reed, 1978, Experiment 2) and call into question other, apparently contradictory findings (Hanley & Morris, 1982, Experiment 1). Experiment 2 also extends previous findings by showing that neither processing type (unmixed vs. mixed) nor unmixed-processing level (structural vs. rhyming vs. category) necessarily influence prospective judgments. Arlin's (1986) apparently contradictory finding may be attributable to task difficulty rather than level of processing per se.

4.2. MEMORY FOR NONTEMPORAL (STIMULUS) INFORMATION

In both experiments the recognition data show a pattern different from that of the reproduction data. Thus, there is no necessary relationship between memory for nontemporal (stimulus) information and either prospective or retrospective duration judgment, and memory-storage models of both experienced duration and remembered duration (e.g., Ornstein, 1969) are rejected. Memory-change models are needed to handle this finding (Block, 1990; Block & Reed, 1978; see also section 4.4).

Neither experiment reveals an effect of paradigm on recognition memory. A possible explanation is that attending to time does not require sufficient (or similar) resources to interfere with the encoding of nontemporal information. However, others (Brown, 1985; Casini et al., this volume; Grondin & Macar, this volume) have found that processing temporal information interferes with performing an attention-demanding nontemporal task. Perhaps the present tasks were not sufficiently attention-demanding to cause temporal processing to interfere with nontemporal (stimulus) processing.

4.3. MAIN EFFECT OF PARADIGM

Some experiments have found that prospective judgments are longer than retrospective judgments (Block et al., 1980, Experiments 2 and 3; Brown, 1985; Brown & Stubbs, 1988; Miller et al., 1978), whereas others have reported no significant effect of paradigm (Bakan, 1955; Block et al., 1980, Experiment 1; Hicks et al., 1976; Kikkawa, 1983; McClain, 1983; Zakay & Fallach, 1984, Experiment 3). No well-designed experiment has found an effect in the opposite direction.[4] In Experiment 1 prospective judgments were longer than

[4] Dobson (1954) reported that subjects "tended to overestimate the [retrospective] conditions, while underestimating the [prospective] conditions" (p. 285). However, this conclusion must be discounted, because (a) all subjects made retrospective estimates before they made prospective estimates, and (b) all retrospective estimates were verbal estimates, whereas all prospective estimates were productions.

retrospective judgments; in Experiment 2 this finding was not replicated. Clearly, additional research is needed to reveal the conditions under which prospective judgments are longer than retrospective judgments.

To my knowledge, only one study comparing prospective and retrospective paradigms has reported absolute-error data. Brown (1985) found more absolute error in the retrospective paradigm than in the prospective paradigm. Absolute-error data from the present Experiment 1 also show an effect of paradigm, and data from Experiment 2 show an interaction of paradigm and task. The strong correlation between absolute error and reproduction indicates that, in the present data and perhaps also in Brown's data, the absolute-error analysis is simply reflecting effects on reproduction length. An absolute-error analysis may be enlightening only if there is no consistent difference between conditions in underestimation or overestimation of duration.

Evidence on intersubject variability of judgments is not definitive. Although no significance tests were reported, some studies (Bakan, 1955; Hicks et al., 1976) found that prospective judgments are less variable than retrospective judgments, whereas others found little or no difference in variability (Block et al., 1980; Brown 1985; Kikkawa, 1983). Experiment 1 reveals an effect of paradigm on intersubject variability of judgment. Ordinarily, an increase in mean judgment is accompanied by greater variability of judgments; Experiment 1 data show the opposite. Experiment 2 failed to replicate the effect, however, so additional research is needed to resolve this issue.

4.4. CONTEXTUAL-CHANGE MODEL

A contextual-change model can explain the findings of Experiments 1 and 2, as well as of similar experiments. In both paradigms, the contextual-change model assumes that duration judgments are based on encoded contextual information available in memory. Contextual information, whether from external or internal sources, is encoded in associations with concurrent nontemporal (stimulus) information. At the time the duration is judged the person selectively retrieves nontemporal (stimulus) information and estimates the amount of contextual information that was encoded in association with that nontemporal information. Thus, the retrieval process presumably involves use of an availability heuristic (cf. Tversky & Kahneman, 1973).

An important assumption is that the prospective and retrospective paradigms differ in the amount of various types of contextual information that is encoded. In the prospective paradigm, the person attends to time on numerous occasions, and on each occasion contextual information concerning the previous act of attending to time is automatically retrieved. Whenever this occurs, the previous time-tag is automatically retrieved, and a new time-tag is encoded as part of the record of the retrieval event (Hintzman & Block, 1971; Hintzman, Summers, & Block, 1975). These changes in time-tags, or what I call *temporal context changes*, form the most available type of contextual information involved in prospective duration judgment. Prospective duration judgment primarily involves estimating the availability of these temporal context changes. Other contextual information, such as that involved in retrospective judgment, is not as salient as temporal context changes, and changes in these other contextual elements, although involved to some extent, are overwhelmed in their effects by temporal context changes.

In the retrospective paradigm, a person rarely attends to time, so changes in temporal context are not encoded as frequently as in the prospective paradigm. However, the encoding of stimulus information is accompanied by changes in process context, environmental context, emotional context, and other contextual elements, some of which may change as a function of time (Block, 1982; Block & Reed, 1978; Hintzman, Block, & Summers, 1973). Although these contextual changes may be encoded intentionally, they are also encoded automatically. To the extent that there are changes in these types of contextual information, a greater variety of contextual information is available in memory. In the process of making a retrospective duration judgment, a person retrieves and estimates the availability of these various types of contextual change.

5. Acknowledgments

I thank Fusako Matsui, Lynn Maulding, Patricia Hart, and Ron Bodine for conducting the experiments; Douglas Wells for programming the experiments; and Robert Hicks and Janet Jackson for refereeing the manuscript.

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