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Qualitative Effects of Rehearsal on Memories for Perceived and Imagined Complex Events

Aurora G. Suengas
Universidad Complutense de Madrid, Spain

Marcia K. Johnson
Princeton University

Three experiments explored the effects of rehearsal and the passage of time on qualitative characteristics of memories for perceived and imagined complex events. Subjects thought or talked about events, focusing on either the perceptual (e.g., colors, sounds) or apperceptive (e.g., thoughts, feelings) aspects of the events (Experiment 1). Thinking about apperceptive aspects of events decreased the salience of context and sensory characteristics of memories and made memories for perceived and imagined events seem more similar in the subjective amounts of thoughts and feelings included in the memories. When the aspects of events subjects thought about were unspecified, thinking about events primarily affected rated clarity (Experiment 2). The clarity of imagined events was more affected than was the clarity of perceived events by whether the memories had been rated previously (Experiments 1 & 3). Over 24 hr, clarity and sensory ratings decreased more for imagined than for perceived events (Experiment 3). Implications for reality monitoring (Johnson & Raye, 1981) are discussed.

In this article we explore the impact of rehearsal on qualitative characteristics of memories for perceived and imagined events and the potential roles of rehearsal and time in producing confusion between perceived and imagined events (or failures in "reality monitoring," Johnson & Raye, 1981). It is commonly believed that thinking and talking about autobiographical events change one's memory for them. Yet there is little experimental evidence to clarify how rehearsal affects memories of complex events. Few studies have analyzed the effects of rehearsal on memories for autobiographical events. One heroic example is Linton's (1975, 1978) study of her own memory, which demonstrated that repeated testing of dates of events increased their apparent durability. (Similar effects are found in laboratory studies [Allen, Mahler, & Estes, 1969; Hogan & Kintsch, 1971].) Rubin and Kozin (1984) found that people's most vivid memories were for events discussed more frequently than other, less vivid, memories. Rubin and Kozin argued that rehearsal itself does not preserve the vividness of memories, but the availability of these vivid memories. Therefore, from a quantitative point of view, rehearsal appears to affect the probability of recall of memories. Clearly, a memory has to be accessible in order for it to be confusable with other memories. Nevertheless, qualitative effects are equally important, and perhaps more so, for reality monitoring decisions.

In contrast with previous quantitative approaches, we focus here on the qualitative changes that occur in remembering as a result of rehearsing memories. The Johnson-Raye (1981) reality monitoring framework proposed that memories contain several types of information (e.g., perceptual, spatial) that are critical in discriminating real from imagined events. Here we are interested in how these characteristics change over time and in how they are affected by rehearsal.

In the experiments reported here, we had people rate characteristics of memories for simulated autobiographical events ("minievents"). Subjects perceived some events and imagined others (e.g., wrapping a package, having coffee and cookies) and then rated various qualitative characteristics of their memories for these events. Across subjects, we counterbalanced which events were perceived and which imagined. Doing so allowed us to compare memories for perceived and imagined complex events under more controlled conditions than are possible with naturally occurring autobiographical events (Johnson, Foley, Suengas, & Raye, 1988; also see Bahrick & Karis, 1982). In Experiments 1 and 2 we were primarily interested in the effects of rehearsal on rated qualitative characteristics of memories and in Experiment 3 in the effects of delay.

Experiment 1

When people think about a past event, they do not necessarily focus equally on all aspects of the event. In particular, they may think more about the facts or they may think more about their reactions at the time. In order to explore the potential impact of such differences in the focus of attention, in Experiment 1 we manipulated the aspects of the events that subjects rehearsed: Some subjects rehearsed perceptual aspects of the events (e.g., colors, voices); other subjects rehearsed apperceptive aspects of the events (e.g., the feelings experienced and the ideas that came to mind at the time of the events). We were interested in the relative effects of these two types of rehearsal (perceptual or apperceptive) on memories for perceived and imagined events: Rehearsal could maintain, reduce, or enlarge the differences between memories for perceived and imagined events, depending on whether both types of rehearsal have an equal impact on both types of memories. Instances in which differences between memories for perceived and imagined events are reduced are of

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Correspondence concerning this article should be addressed to Marcia K. Johnson, Department of Psychology, Princeton University, Princeton, New Jersey 08544-1010.

special interest to us because they suggest the conditions under which confusions between the two types of memories might occur.

In Experiment 1 we also manipulated whether rehearsal was covert or overt. Under natural conditions, events are rehearsed either by thinking or by talking about them. Therefore, for greater generality we instructed half of the subjects to think about the events and the other half to talk about the events.

Method

Subjects

A total of 144 male and female undergraduate students from the State University of New York at Stony Brook received course credit for participating in Experiment 1.

Design and Procedure

Three independent variables were manipulated within subjects: origin of event (perceived vs. imagined), whether the memory for the event was initially rated (rated on Day 1 vs. not rated on Day 1), and how many times subjects were instructed to think about each event (0, 6, or 12 times). The fourth and fifth independent variables—focus and type of the rehearsal—were manipulated between subjects. Half of the subjects ($n = 72$) were instructed to rehearse perceptual aspects of the events; the other half were instructed to rehearse apperceptive aspects of the events. Within each rehearsal-focus group, half of the subjects ($n = 36$) were asked to think about the designated aspects, and the other half were asked to talk about those aspects. Each subject participated in the experiment on two consecutive days.

Day 1: Acquisition and initial ratings. During the first session, subjects were tested in groups of four. Subjects perceived six situations and imagined six situations (see Table 1). On perception trials, subjects actually engaged in the situations. For instance, they were given a box, a piece of paper, and some tape to wrap a parcel; or they were given a cup of coffee and some cookies to eat. On imagination trials, subjects heard a script describing the perceived version of the situation. For example, a portion of the script describing the coffee and cookies goes as follows:

> Imagine that I am offering you a cup of coffee. Please, try to imagine the steaming cup of coffee in front of you as clearly and vividly as possible. I also offer you some milk and sugar. You fix the coffee the way you like it and start drinking it. Imagine carefully the smell and taste that it would have. Imagine the sensation as you drink it. There is a plate with cookies on the table. You take some . . .

Table 1
List of Minievents Used in Experiments 1, 2, and 3

Wrap a parcel[a] (meet an Indian woman)[b]
Have a cup of coffee with some cookies
Look at photographs of two people
Visit a workroom in the psychology department
Introduce oneself
Write a letter of complaint to the president of the university
Write a birthday card to a friend[a] (meet a Korean woman)[b]
Make a pot with clay
Visit a psychology computer laboratory
Make an abstract collage
Look at three pictures of works of art
Have a soda with some munchies

[a] Experiments 1 and 3; [b] Experiment 2.

The scripts were provided to ensure that perceived and imagined versions of the situations were comparable in general content. The use of scripts on imagination trials also helped to equate the time spent either seeing or imagining some of the situations (e.g., examining the photographs of two persons, introducing oneself). On average, however, perceived versions of the situations took longer than their imagined counterparts. The scripts were read slowly, with 10-s pauses between sentences, to allow subjects time to imagine the described situation. Perceived and imagined situations were alternated. Situations were counterbalanced across subjects so that any given one was perceived and imagined by an equal number of subjects.

Subjects then rated their memories for half of the situations (three perceived and three imagined) along various dimensions. Having subjects rate their memories for only half of the events during the first session provided a baseline for evaluating the effects of rating the memories, which is itself a form of rehearsal (quite detailed rehearsal, in fact). Ratings were made with a shortened version of the Memory Characteristics Questionnaire (MCQ) used by Johnson et al. (1988). Using a 7-point scale, subjects rated each memory on several dimensions (e.g., visual detail, feelings). To discourage subjects from filling out the MCQ on the basis of common sense rather than on the basis of their memory for the events (e.g., to avoid artificially high ratings for taste in the memory for the coffee or the soda), subjects were led to believe that accuracy was going to be checked. They were told that in the past we had tested memories for perfumes. Although our (hypothetical) subjects had always rated their memories for the perfumes as high in smell, they rarely could pick out the right perfume in a subsequent test. Therefore, our (hypothetical) subjects did not really "remember" the smell of the perfume and should have given it a lower rating. It was left to our (real) subjects to infer from this example that they should not give high ratings to aspects of events that they could not actually remember, because we might check the veracity of their reports.

Day 2: Rehearsal and final ratings. During the second session, subjects were randomly assigned to one of the four rehearsal conditions, with the restriction that equal numbers of subjects participated in each condition. Subjects were tested individually (except for a couple of subjects in the "think" condition who were tested together because of scheduling conflicts). Each subject was instructed either to think or to talk about the perceptual or apperceptive aspects of the events. The cues for the rehearsal conditions are shown in Table 2.

On each rehearsal trial, subjects were prompted with an event label and a particular aspect of that event to rehearse. For example, subjects in the perceptual-focus group received cues such as "Think about anything that you were touching while looking at the photographs of two people" or "Tell me about the colors of the abstract collage." Subjects in the apperceptive-focus group received cues such as "Think about any comments or remarks that you could have made but you did not while looking at the pictures of works of art" or "Tell me about any positive feelings that you had while writing the birthday card." Subjects were allowed 15 s to think or talk about the designated aspect on each rehearsal trial. Situations to be rehearsed were presented in random order, with the restriction that the same situation was not rehearsed consecutively. Some situations were not rehearsed at all. Some situations were rehearsed 6 times, with each cue listed in Table 2 (i.e., colors, noises, and voices, etc.) presented once. Others were rehearsed 12 times, with each cue listed in Table 2 presented twice. There was one situation in each of the 12 possible combinations of event type, ratings, and rehearsals. Particular events were assigned equally often across subjects to each rehearsal condition.

Table 2
Summary of the Rehearsal Cues Used in Experiment 1

Aspects of situations rehearsed by the perceptual-focus group
The position and spatial arrangement of people
The shape and spatial arrangement of objects
Anything that you were touching
The colors
The noises and voices that you were hearing
Anything that you were looking at
Aspects of the situations rehearsed by the apperceptive-focus group
Any negative feelings that you had
Any positive feelings that you had
Any comments or remarks that you could have made but you did not make
Any other time in which you thought or felt similarly
The difficulties experienced
The ideas that came to your mind

Afterward, participants rated memories for all 12 situations on the MCQ.

Selection of the Dependent Variables

The MCQ used to rate subjects' memories included questions designed a priori to sample a range of memory qualities. The effects of rehearsal on these different memory aspects could be evaluated in two ways: We could look at the changes on each rating scale (e.g., Johnson et al., 1988, Study 1), or we could average across groups of items expected to draw on a common memory characteristic.

Initially, separate analyses of variance (ANOVAS) were performed on each item of the MCQ. These analyses confirmed our expectations that items directed at similar memory aspects produced similar patterns. These initial results encouraged the strategy of grouping items according to general memory characteristics rather than reporting each item individually. Grouping items according to a priori expectations or according to results from factor analyses produced similar patterns. Therefore, for brevity and clarity, in all three experiments reported here, items were grouped according to the factor structure revealed by the principal components analyses conducted on the initial data (i.e., ratings taken on Day 1) provided by the 144 subjects from Experiment 1.

Principal components analyses were conducted separately for memories for perceived events and imagined events. The factor analysis conducted on memories for perceived situations revealed seven factors containing more than one item with eigenvalues greater than 1.0. The factor analysis performed on memories for imagined situations yielded six factors with eigenvalues above 1.0. Overall, the factor structures for perceived and imagined memories were very similar. Thus the following five composite factors were formed: (a) a Clarity factor, collapsed across the six items common to the first factor of both memories for perceived and imagined events: clarity, visual detail, vividness, event detail, comprehensibility of the order of events, and overall memory for the event; (b) a Sensory factor identical to the third factor in memories for imagined events and the fifth factor in memories for perceived ones: sound, smell, and taste; (c) a Contextual factor, collapsed across the three items common to the second factor in memories for imagined events and the third factor in memories for perceived ones: memory for location, spatial arrangement of objects, and spatial arrangement of people; (d) A Thoughts and Feelings factor, collapsed across the three items common to the second factor in memories for perceived events and the fourth factor in imagined ones: memory for thoughts, memory for feelings, and how much the event reveals about oneself; (e) an Intensity of Feelings factor identical to the sixth factor in both perceived and imagined memories: how intense feelings were at the time of the event and how intense feelings are while remembering.

Individual subjects' scores were calculated for each factor by averaging across subjects' ratings on the scales that formed each factor. For example, the simple mean of subjects' ratings on how well they remembered their thoughts at the time of the event, how well they remembered their feelings during the event, and how much the memory revealed about themselves was calculated for each situation for each subject. This mean was used as the subject's score on the factor evaluating thoughts and feelings.

To simplify the results further, we collapsed across thinking and talking as forms of rehearsal because this variable did not contribute any interesting main effects or interactions in preliminary analyses of the data. In addition, we took the fact that there was no difference between the thinking and talking groups as verification that the thinking group was following instructions.

Results

Overview of Analyses

A 2 × 2 × 2 × 3 ANOVA was performed on each composite factor collapsed across situations. The between-subjects factor in the analysis was the rehearsal focus (perceptual vs. apperceptive aspects of the events). The three within-subjects factors were origin (perceived vs. imagined), rating (rated on Day 1 vs. not rated on Day 1), and rehearsal (0, 6, 12). Subjects' ratings for each event entered 1 of the 12 possible combinations of type of event (perceived vs. imagined), rating (rated vs. not rated on Day 1), and rehearsal (0, 6, and 12).

The overall analyses were followed by planned subsequent analyses of each condition (e.g., perceptual focus/imagined events/not rated) separately; in these analyses, there were four levels of rehearsal (initial, 0, 6, 12). (The initial ratings for perceived and imagined events for each subject are each based on the average of three events). These analyses were followed where indicated by Newman-Keuls tests (Keppel, 1973, pp. 420–421) to clarify the results of rehearsal. We report only the results of Newman-Keuls tests comparing ratings after either 0 or 12 rehearsals with initial ratings. The 6-rehearsal condition is omitted (although means are plotted in Figures 1–3). It seems reasonable to focus on the strongest rehearsal manipulation, and doing so simplifies the discussion considerably.

Results of Analyses

Clarity. The pattern of ratings for the Clarity factor is shown in Figure 1. As predicted, memories for perceived events were clearer than memories for imagined events, $F(1, 142) = 271.00$, $MS_e = 2.01$. Memories for situations that were initially rated were also clearer than memories for situations that were not initially rated, $F(1, 142) = 59.98$, $MS_e = 0.77$. As indicated by the significant interaction between origin and ratings, $F(1, 142) = 14.18$, $MS_e = 1.18$, the effect of the initial ratings was greater for memories of imagined events than for

memories of perceived events. In addition, there were interactions of Rehearsal × Origin, $F(2, 284) = 2.35$, $MS_e = 1.76$; and Rehearsal × Origin × Rating, $F(2, 284) = 2.29$, $MS_e = 1.30$, $ps < .10$.

From the Newman-Keuls tests, in the perceptual-focus group, ratings dropped in the absence of rehearsal for imagined events, with an especially large decrease for imagined/not-rated events. After 12 rehearsals, the ratings for imagined/rated events did not differ from initial ratings; rehearsal did not significantly affect imagined/not-rated events. In the apperceptive-focus group, clarity ratings decreased in all conditions, but again especially for imagined/not-rated events. Rehearsal of apperceptive aspects did not offset the decrease in ratings.

Sensory. As expected, memories for perceived events ($M = 2.62$) contained more sensory information than memories for imagined events ($M = 2.22$), $F(1, 142) = 57.71$, $MS_e = 1.19$. In addition, sensory ratings were lower for the apperceptive-focus group ($M = 2.30$) than for the perceptual-focus group ($M = 2.55$), $F(1, 142) = 4.39$, $MS_e = 5.94$. There were no other significant effects.

Context. Figure 2 shows the pattern of ratings on the Contextual factor. As predicted, memories for perceived events contained more contextual information than memories for imagined events, $F(1, 142) = 242.71$, $MS_e = 2.57$. Memories for events that were initially rated also contained more contextual attributes than memories for events that were not initially rated, $F(1, 142) = 38.09$, $MS_e = 1.66$. There was also a main effect of rehearsal focus, $F(1, 142) = 4.13$, $MS_e = 6.66$: After rehearsing apperceptive aspects, subjects gave memories lower contextual ratings than they did after rehearsing perceptual aspects. There was also a Rehearsal × Origin × Rating interaction, $F(2, 284) = 2.58$, $MS_e = .96$, $p < .10$.

From the Newman-Keuls tests, in the perceptual-focus group, contextual ratings dropped in the absence of rehearsal only for the perceived/not-rated events. Rehearsal affected memories only for imagined events that were initially rated; in this case ratings after 12 rehearsals were higher than initial ratings. In the group focusing on apperceptive aspects, contextual ratings dropped in the absence of rehearsal (except in situations that were imagined and initially rated), and rehearsal had no effect.

Thoughts and feelings. The pattern of ratings for this factor is shown in Figure 3. Subjects remembered what they had felt and thought about perceived events better than about imagined ones, $F(1, 142) = 124.13$, $MS_e = 1.66$. Ratings for thoughts and feelings were also higher for events that were initially rated than for events that were not initially rated, $F(1, 142) = 34.29$, $MS_e = 0.94$. As indicated by the significant interaction between origin and rating, $F(1, 142) = 6.96$, MS_e

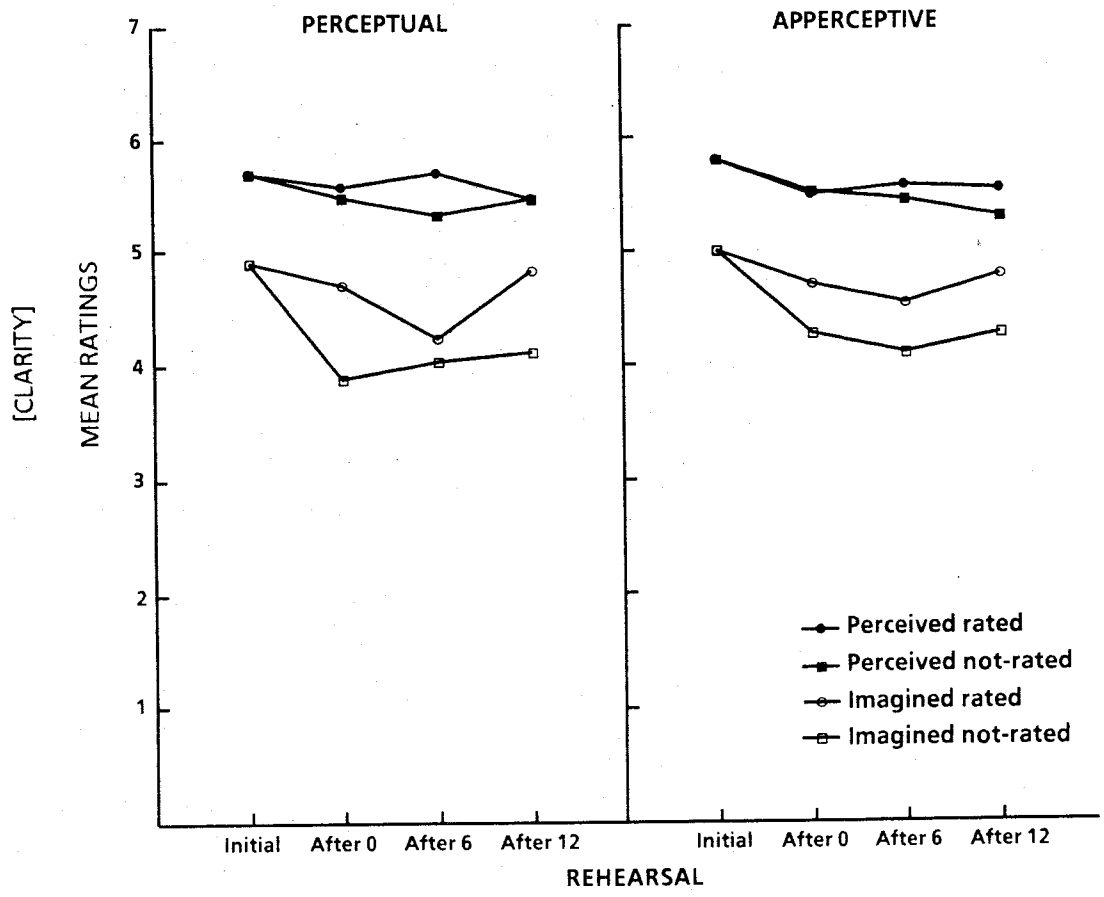

Figure 1. Mean ratings for Clarity factor, Experiment 1. (Group rehearsing perceptual aspects of events is on the left and group rehearsing apperceptive aspects is on the right.)

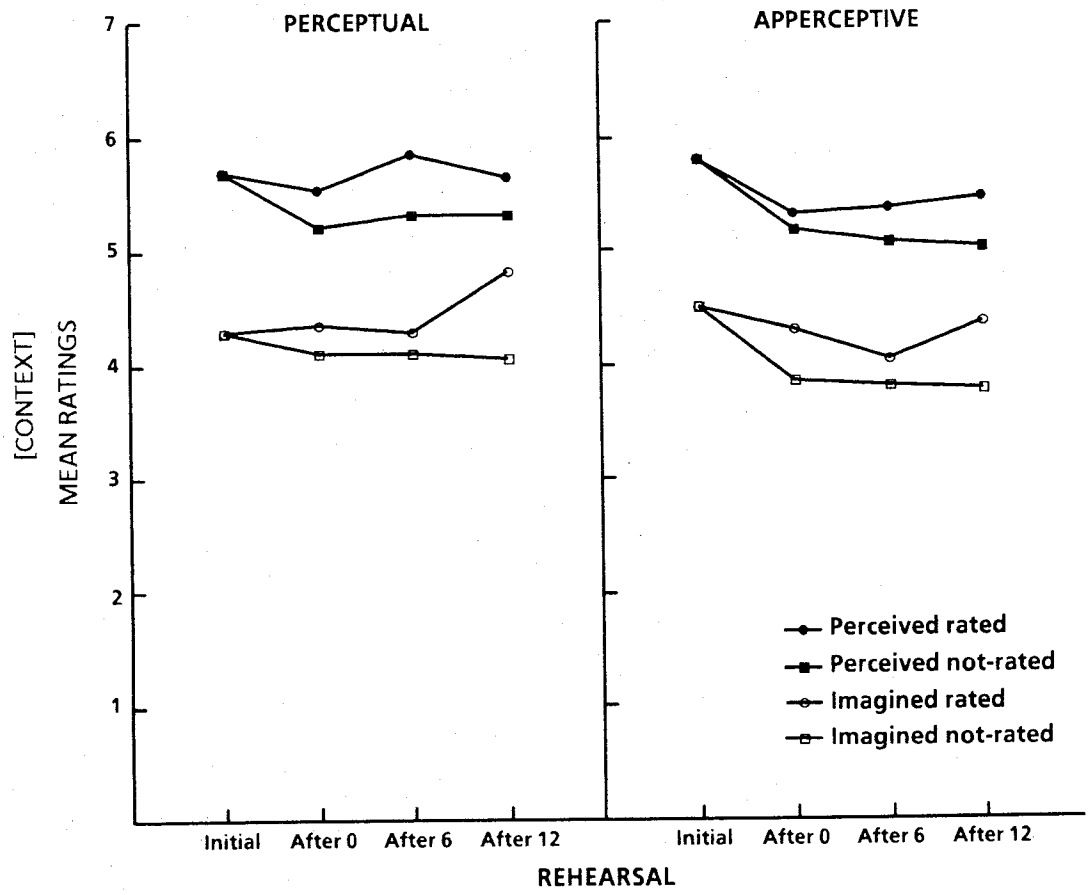

Figure 2. Mean ratings for Contextual factor, Experiment 1. (Group rehearsing perceptual aspects of events is on the left and group rehearsing apperceptive aspects is on the right.)

= 0.98, the ratings had more impact on memories for imagined events than on memories for perceived events. There was also an interaction between origin and focus of rehearsal, $F(1, 142) = 5.30$, $MS_e = 1.66$. As can be seen in Figure 3, ratings were higher after apperceptive rehearsal, especially for imagined events. Finally, there was a Rehearsal × Origin interaction, $F(2, 284) = 2.45$, $MS_e = 1.13$, $p < .10$.

From the Newman-Keuls tests, in the perceptual-focus group, memory for thoughts and feelings decreased if situations were not rehearsed, and rehearsal had little effect (although ratings for imagined/rated events did not differ significantly from initial ratings after 12 rehearsals). In the apperceptive-focus group, memories for perceived and imagined events that had not been previously rated decreased if not rehearsed. As can be seen in Figure 3, rehearsal had a marked impact on imagined events that were initially rated; after 12 rehearsals of apperceptive aspects, ratings for imagined events that were initially rated were actually as high as ratings for perceived events. Note that here is a case in which rehearsal produced convergence between memories for perceived and imagined events in rated qualities.

Intensity. Feelings in memories for perceived situations ($M = 3.50$) were more intense than in memories for imagined situations ($M = 3.28$), $F(1, 142) = 16.44$, $MS_e = 1.26$. There were no other significant effects. Although ratings dropped from initial ratings (Perceived = 3.70, Imagined = 3.50) over the delay, the drop was not significant for either perceived or imagined events in the individual subsequent analyses.

Discussion

Memories for perceived events were given higher ratings than memories for imagined events in all five factors investigated. The advantages for memories of perceived over imagined events in clarity, sensory, and contextual characteristics replicated previous findings for autobiographical events (Johnson et al., 1988) and indicated that differences in clarity, sensory, and contextual characteristics provide reliable bases for reality monitoring (Johnson & Raye, 1981). It should perhaps be noted that in this experiment (and in the work of Johnson et al., 1988, Study 1), some differences between perceived and imagined events, although statistically reliable, were quite small in absolute terms. Could such differences support accurate reality monitoring? It is reasonable to suppose that they could. First, ratings only imperfectly index underlying qualitative characteristics; a more sensitive measuring device might produce larger differences. Second, and perhaps more important, reality monitoring processes very

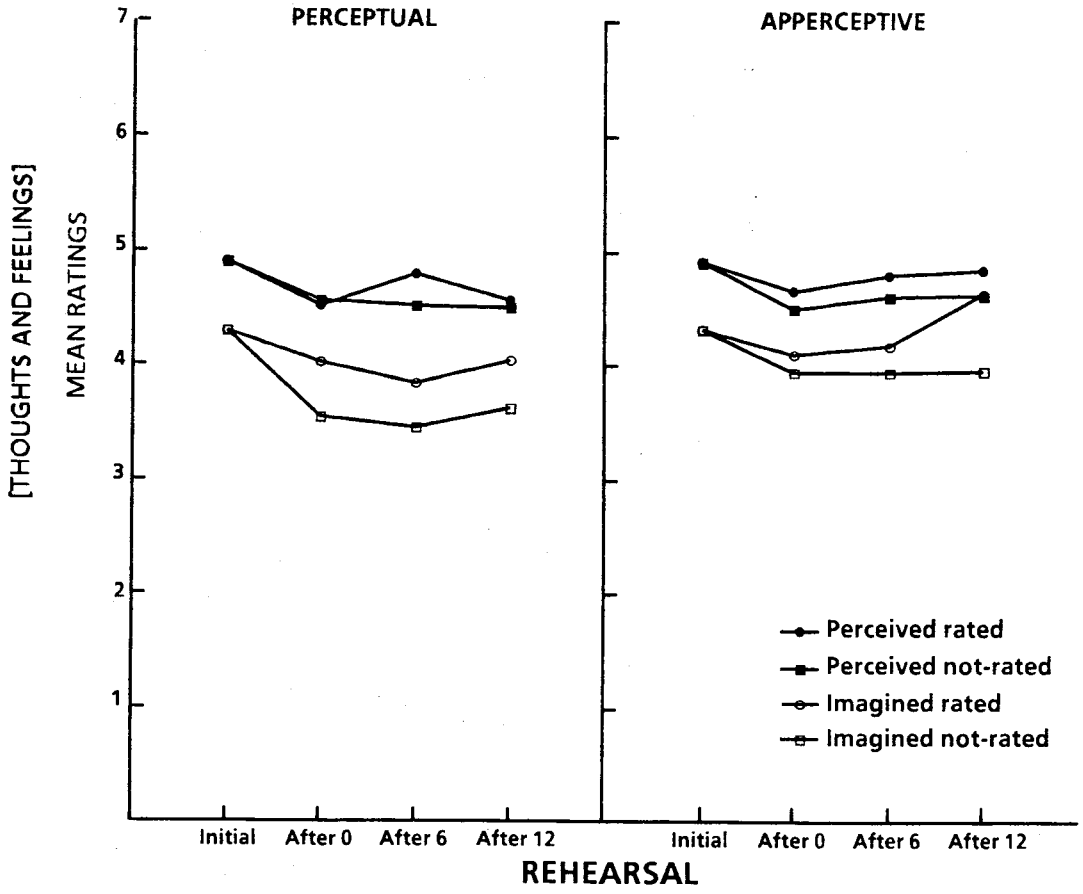

Figure 3. Mean ratings for Thoughts and Feelings factor, Experiment 1. (Group rehearsing perceptual aspects of events is on the left and group rehearsing apperceptive aspects is on the right.)

likely combine information from a number of characteristics (Johnson & Raye, 1981), thus the difference between perceived and imagined events on any particular characteristic would underestimate the overall discriminability between them.

When memories had not been previously rated, the clarity of memories and rated thoughts and feelings seemed to decrease faster for imagined than for perceived events (Figures 1 and 3). The possibility that access to some characteristics of memories decreased faster for imagined than perceived events is further investigated in Experiment 3.

Overall ratings on the Sensory and Contextual factors were higher in the perceptual-focus group than in the apperceptive-focus group, even for events that had not been rehearsed. One possible explanation is that subjects instructed to think or talk about a given aspect of certain situations (e.g., the noises and voices) might have thought they were expected to give high ratings to the rehearsed aspect in all situations, even those previously unrehearsed (i.e., demand characteristics may have affected ratings).

Another possibility is that ratings between rehearsed and unrehearsed memories may be similar because a particular focus "primes" subjects to retrieve certain types of information. For example, thinking about contextual features of some situations might lead subjects to try harder than they would otherwise to remember contextual features of unrehearsed situations. Neither demand characteristics nor priming, however, can account for the differential pattern in ratings between rated and not-rated events and between perceived and imagined memories. For example, neither can account for the drop in rated thoughts and feelings for unrehearsed events in the apperceptive group (see Figure 3); rehearsal of feelings about some events did not prompt subjects to give high ratings to thoughts and feelings in all events.

A third possible reason for lower ratings on sensory and context characteristics when subjects focused on apperceptive aspects of events, compared with when they focused on perceptual aspects, is that rehearsal of apperceptive aspects of events interfered with access to sensory and contextual information. This interpretation receives some support from the results of Experiment 3, to be reported later. In Experiment 3, in the absence of rehearsal, memories for perceived events did not decrease over 24 hr in sensory or contextual ratings, suggesting that, in Experiment 1, rehearsing thoughts and feelings decreased access to these qualities.

Answering the MCQ on Day 1 had greater impact on memories for imagined events than on memories for perceived events (Figures 1 and 3). Memories for imagined

situations that were initially rated decreased in clarity (Figure 1), contextual attributes (Figure 2, apperceptive group), and thoughts and feelings (Figure 3) if they were not rehearsed. Repeated rehearsal of either perceptual or apperceptive aspects produced ratings at initial levels of these aspects in memories for imagined events that were initially rated, but had no effect on unrated memories. Overall, in Experiment 1, rehearsal had the greatest impact on memories for imagined events that were initially rated. The clearest examples are the two instances in which postrehearsal ratings were actually higher than initial ratings for imagined events that were initially rated (Figure 2, perceptual group; Figure 3, apperceptive group).

If memories for imagined events tend to have a faster rate of loss than memories for perceived events, imagined memories would have more room to profit from rehearsal than perceived memories (also, perceived memories might be subject to ceiling effects at relatively short retention intervals). Yet differential loss cannot be the only factor, because, if it were, memories for imagined events that were not initially rated would have benefited from rehearsal, too; after all, these were the memories with the greatest drop in ratings, and thus the most to gain from rehearsal.

Thus we need a combination of factors to explain why memories for imagined events that were initially rated profited the most from rehearsal. One possibility is that the major effect of initially rating imagined events was to stop or slow down an otherwise rapid loss of information. Later, rehearsal could capitalize on the remaining information. Unrated memories would have decreased to such a low point that rehearsal had little to "work on." It is also possible that the rating task itself induced subjects to embellish a previously impoverished imagination and thus later there was more to "reinstate" through rehearsal. In sum, memories for imagined events may have to be reinstated in some detail (or embellished) after they are generated, otherwise rehearsal has little effect.

Regardless of the type of rehearsal, there continued to be substantial differences between perceived and imagined memories in clarity and sensory or contextual information. Differences in clarity and sensory and contextual detail that are maintained across time and rehearsal should help people discriminate the origin of their memories if people typically rely on these aspects to decide whether they are remembering perceived or imagined events (Johnson et al., 1988, Study 2).

Finally, a particularly interesting new finding is that rehearsal of apperceptive aspects of memories made perceived and imagined events more similar in rated thoughts and feelings (Figure 3). Thus, if thoughts and feelings were also taken into account while one is trying to ascertain the origin of memories, the chances of confusing imagined events with perceived events should be greater after rehearsal of apperceptive aspects of the events than after rehearsal of perceptual aspects.

Experiment 2

Experiment 2 further investigated the effects of rehearsal on qualitative characteristics of memories. Here we did not specify which aspects of events the subjects were to rehearse; the students were simply instructed to think about the events. In this case, the impact of rehearsal on various qualitative characteristics of memories should give us some information about which aspects of these events people naturally think about when they remember. In addition, rehearsals were distributed across 2 days rather than allocated to 1 day as in Experiment 1. Distributed rehearsal probably more closely approximates the natural case and might increase the potential effects of rehearsal. Finally, a day elapsed before the first ratings, and then another day before the second ratings. Thus compared with Experiment 1, the overall retention interval was longer, a circumstance that should give us a greater chance of detecting effects of rehearsal on clarity and context for perceived events, which did not show much loss over the 24-hr retention interval in Experiment 1.

Method

Subjects

Thirty-six undergraduate students from the State University of New York at Stony Brook received either course credit or payment for their participation. None of these subjects participated in Experiment 1.

Design and Procedure

Two independent variables were manipulated within subjects: origin of the event (perceived vs. imagined) and rehearsal (initial, 0, 8, 16). Subjects participated in groups of four for three consecutive days.

Day 1: *Acquisition.* During the first session, subjects perceived six events and imagined six events (see Table 1). The general procedure was the same as in Experiment 1.

Day 2: *Ratings and rehearsal.* During the second session, subjects made initial ratings (using the MCQ) for their memories of all 12 situations they had experienced the previous day. They were then instructed to think about some of the situations: "Think about . . .," followed by a particular event label (e.g., making the pot of clay, meeting the Korean woman). Subjects were allowed 15 s to think about each situation. Subjects rehearsed four events (two perceived and two imagined) four times each and four events eight times each. The remaining four events were not rehearsed. Situations to be rehearsed were presented in random order, with the restriction that the same situation not be rehearsed consecutively.

Day 3: *Rehearsal and ratings.* The third session was the reverse of the second one. First, subjects were instructed to rehearse the situations. Thus, at the end of the third session, a particular situation had been rehearsed a total of 0, 8, or 16 times. Afterward, participants again rated their memories for the 12 situations on the MCQ.

Situations were counterbalanced across subjects so that at the end of the experiment all situations had occurred equally often in each origin and rehearsal condition.

Results and Discussion

The factors derived in Experiment 1 were used in Experiment 2. A 2 × 4 within-subjects ANOVA was performed for each factor, collapsed across situations. The two factors in the analysis were the origin of the event (perceived vs. imagined) and rehearsal (initial, after 0, after 8, and after 16 rehearsals). In these analyses, we computed the initial means for perceived

and imagined events by using six perceived and six imagined memories per subject; we computed the individual's means for perceived and imagined events by using two memories per subject in each one of the other levels of the rehearsal factor (0, 8, 16). Planned subsequent analyses were also conducted as indicated to clarify effects of rehearsal.

Clarity

Ratings on the Clarity factor are shown in Figure 4. Events were clearer for perceived than for imagined events, $F(1, 35) = 25.65$, $MS_e = 1.55$. There was also a main effect of rehearsal, $F(3, 105) = 5.58$, $MS_e = .60$, and No Origin × Rehearsal interaction. As can be seen in Figure 4, clarity decreased for both perceived and imagined events if events were not rehearsed. Clarity ratings made after 16 rehearsals were higher than those made after no rehearsal and did not differ significantly from initial ratings.

Sensory

Ratings on the Sensory factor are shown in Figure 5. Ratings were higher for perceived than for imagined events, $F(1, 35) = 16.30$, $MS_e = .63$. There was also a main effect of rehearsal, $F(3, 105) = 2.75$, $MS_e = .57$, and No Origin × Rehearsal interaction. As can be seen in Figure 5, sensory ratings for both perceived and imagined events decreased if events were not rehearsed ($ps < .10$), and rehearsal had little effect.

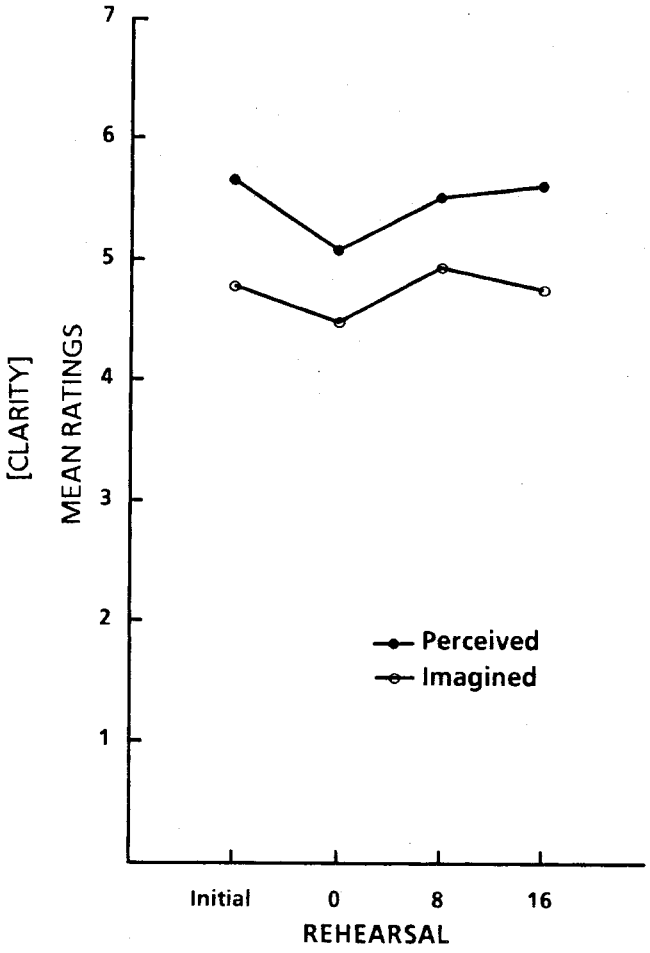

Figure 4. Mean ratings for Clarity factor, Experiment 2.

Context

For the Contextual factor, ratings were higher for perceived ($M = 5.64$) than for imagined ($M = 4.39$) events, $F(1, 35) = 69.23$, $MS_e = 1.62$. No other effects were significant.

Thoughts and Feelings

The ratings on the Thoughts and Feelings factor are shown in Figure 6. Perceived events received higher ratings than did imagined events, $F(1, 35) = 15.18$, $MS_e = .78$. There was a main effect of rehearsal, $F(3, 105) = 3.8$, $MS_e = .57$, and No Origin × Rehearsal interaction. As can be seen in Figure 6, without rehearsal, ratings decreased for both perceived and imagined events. Although rehearsal appeared to have affected ratings for both perceived and imagined events, in the individual comparisons the rehearsal effect was significant only for the imagined events ($p < .10$).

Intensity

The overall mean intensity rating was 3.18. There were no significant effects for this factor.

In summary, in Experiment 2, ratings on the Clarity, Sensory, and Thoughts and Feelings factors decreased if events were not rehearsed. With rehearsal, clarity ratings increased for both perceived and imagined events. Furthermore, rehearsal affected the clarity of memories about equally for perceived and imagined events. Therefore, if people were to discriminate the origin of their memories on the basis of clarity alone (which includes visual characteristics), they should be equally accurate with or without repeated (and equal) rehearsals of perceived and imagined events. For thoughts and feelings, although the Origin × Rehearsal interaction was not significant, the effects of rehearsal seemed somewhat stronger for imagined than for perceived events. This same tendency for rehearsal to affect ratings of thoughts and feelings for imagined events more than for perceived events was clear in Experiment 1 for the groups instructed to think or talk about apperceptive aspects of events (Figure 3). Nevertheless, the fact that rehearsal seemed to have had greatest impact on the Clarity factor in Experiment 2 suggests that, for these events, when the focus of thoughts is unspecified, subjects are quite likely to think of visual characteristics of events (Brewer, 1986).

Finally, the results of Experiment 2 are relevant to the issue of the relation between vividness and event memory. Rubin and Kozin (1984) found that vividness of memories is positively correlated with how often the person has discussed the memory. The inference they drew is that people talk more about those memories because they are more vivid. This may be so, but our results suggest that vivid memories may be

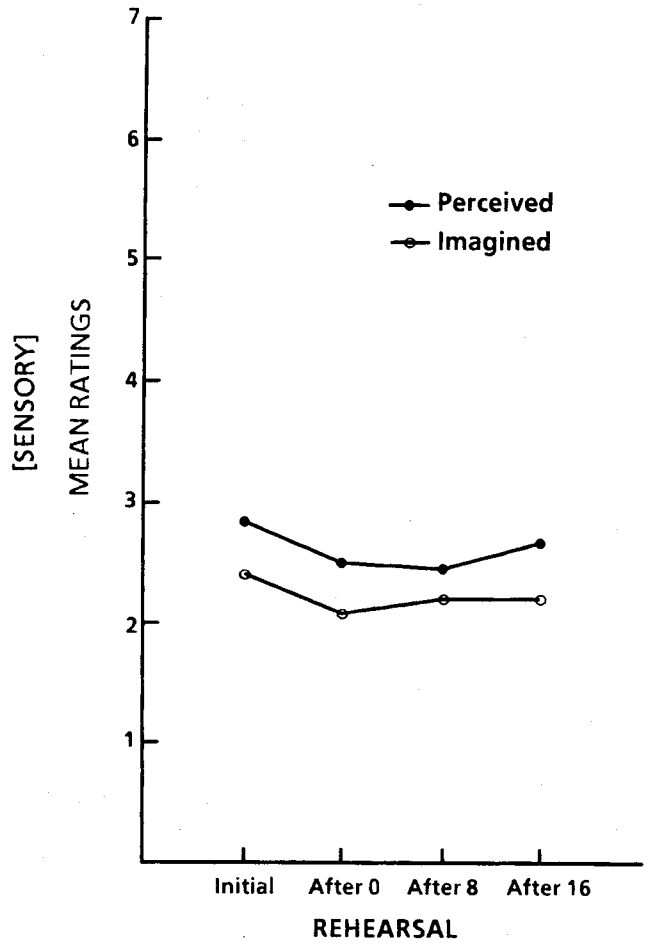

Figure 5. Mean ratings for Sensory factor, Experiment 2.

vivid because they were rehearsed. Thus we agree with Neisser (1982) that vivid memories could very well be ordinary memories that have been frequently thought or talked about.

Experiment 3

In Experiment 2, on the Clarity, Sensory, and Thoughts and Feelings factors, perceived and imagined memories decreased equally between 24 and 48 hr. The results of Experiment 1, however, suggested that over the first 24 hr some types of information become inaccessible more rapidly in memories for imagined events than in memories for perceived events. The possibility of differential forgetting rates for perceived and imagined events deserves further exploration because of its implications concerning the conditions under which confusions between memories for perceived and imagined events are likely to occur. If some memory attributes for imagined events become rapidly inaccessible, the differences between memories for perceived and imagined events will become larger over time. The larger the phenomenal differences between memories for perceived and imagined events, the easier the discrimination between the two. Thus Experiment 3 compared loss rates over the first 24 hr for phenomenal aspects of perceived and imagined events after a retention period during which memories were neither rated nor rehearsed.

In addition, Experiment 3 further investigated the effects of initial ratings on memory for perceived and imagined events.

Method

Subjects

Sixteen male and female undergraduate students from the State University of New York at Stony Brook received either course credit or payment for their participation. None of these students participated in Experiment 1 or 2.

Design and Procedure

Three independent variables were manipulated within subjects: the origin of the event (perceived vs. imagined), whether the event was initially rated (rated vs. not rated), and the time of the ratings (Day 1 vs. Day 2). Each subject participated in the experiment on two

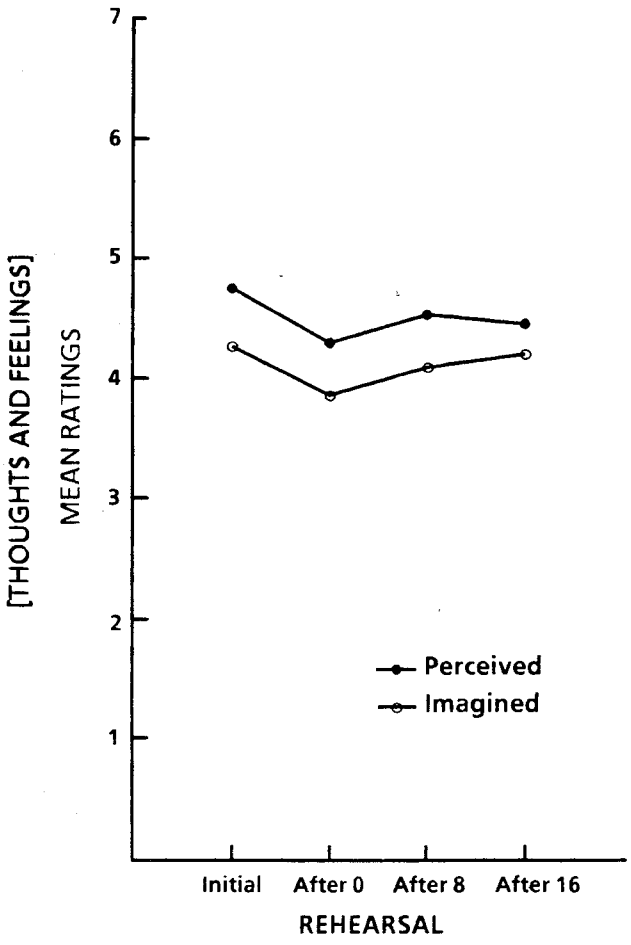

Figure 6. Mean ratings for Thoughts and Feelings factor, Experiment 2.

consecutive days. Materials were counterbalanced across conditions as in Experiment 1.

Day 1: Acquisition and initial ratings. During the first session, subjects were tested in groups of two or three. They perceived and imagined the same 12 situations used in Experiment 1. Afterward, they rated their memories for half of the situations (3 perceived and 3 imagined) on the MCQ.

Day 2: Final ratings. In the second session, subjects rated their memories with the MCQ for all 12 events they had experienced the first day.

Results and Discussion

Effect of Delay

In order to assess changes in accessibility of characteristics over time, we compared ratings made on Day 1 with ratings made on Day 2 for the events that were not initially rated. A 2 × 2 ANOVA was performed on each composite factor derived from Experiment 1. The two within-subjects factors in the analysis were the origin of the situations (perceived vs. imagined) and the time (Day 1 vs. Day 2). The mean ratings for all five factors are shown in Figure 7.

Clarity. There were significant main effects of origin, $F(1, 15) = 15.29$, $MS_e = .59$; and time, $F(1, 15) = 7.65$, $MS_e = .19$; and a significant Origin × Time interaction, $F(1, 15) = 4.49$, $MS_e = 0.34$. After 24 hr, in the absence of ratings and rehearsal, memories for imagined situations decreased in clarity, whereas memories for perceived situations maintained their clarity.

Sensory. The Sensory factor yielded a significant Origin × Time interaction similar to that found for the Clarity factor, $F(1, 15) = 4.65$, $MS_e = 0.14$. There were no initial differences in sensory aspects between memories for perceived events and imagined ones. Memories for imagined events decreased over 24 hr; memories for perceived events did not. Note that more rapid forgetting for imagined events was obtained both when overall ratings were relatively high (clarity) and when they were low (sensory), which increases our confidence in the generality of the phenomenon. (We have not emphasized differences in absolute levels of ratings between factors because the relative salience of the various types of information represented by our five factors should depend on the specific events sampled. For example, sensory ratings would likely have been higher for events involving music or greater physical activity and intensity higher for events involving conflict. Thus our conclusions are limited to the types of events we studied, the particular retention intervals, the specific number and distribution of rehearsals, and so forth. Nevertheless, we would expect the general relations we observed between qualitative characteristics of memories and amount of rehearsal, focus of rehearsal, or time, to hold for events of various types.)

Context. Perceived events received higher ratings than imagined events, $F(1, 15) = 21.29$, $MS_e = .83$. Neither memories for perceived situations nor memories for imagined

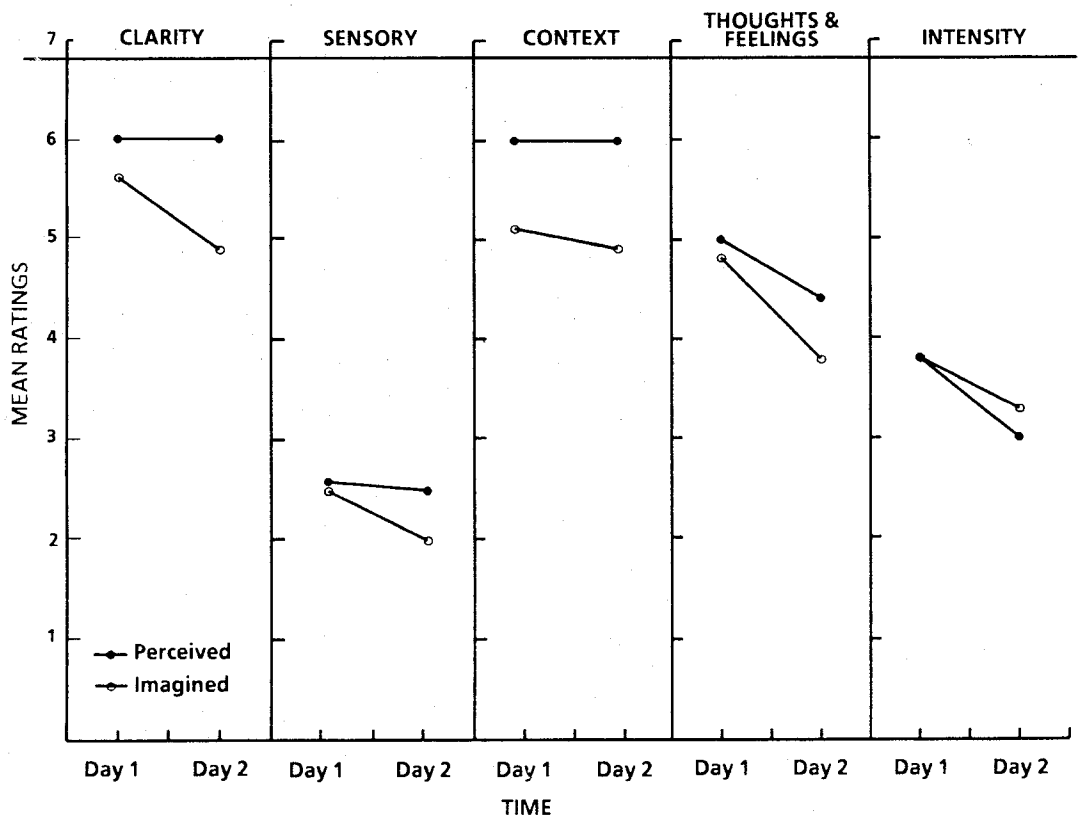

Figure 7. Mean ratings on Day 1 and Day 2 for five factors, Experiment 3.

situations decreased in contextual attributes over the 24-hr period. Contextual aspects may have been particularly resistant to effects of time because several situations shared the same locations during acquisition. To investigate this possibility further, a subsequent analysis was conducted on Experiment 3 data in which contextual ratings for situations that shared the same location ($n = 8$) were compared with contextual ratings for situations that took place in unique locations ($n = 4$) during acquisition. Results simply reconfirmed that memories for perceived situations were higher than memories for imagined ones in contextual attributes. There were no differences in ratings between situations that shared and did not share locations. Subjects did not need to be repeatedly exposed to a location in order to report that they remembered its spatial arrangement 24 hr later.

Thoughts and feelings. There were main effects for origin, $F(1, 15) = 7.84$, $MS_e = .36$; and for time, $F(1, 15) = 24.26$, $MS_e = .45$. Although it appears from Figure 7 that memories for imagined events decreased faster than memories for perceived events in the availability of information about thoughts and feelings experienced at the time of the event, the interaction of Origin × Time was not significant.

Intensity. There was a main effect of time, $F(1, 15) = 8.69$, $MS_e = 0.84$, indicating that memories for both perceived and imagined events decreased in intensity of feelings over 24 hr.

These results indicate that some qualitative characteristics of memories decrease faster for imagined than for perceived events. Over the 24-hr retention interval, ratings dropped more for imagined than for perceived events on the Clarity and Sensory factors. The interaction between origin and time was not significant for the Thoughts and Feelings factor, but the pattern was similar to that found in Experiment 1 in the perceptual rehearsal group.

In addition, the results from Experiment 3 indicated that memories for perceived events that were neither rated nor rehearsed maintained their clarity and the accessibility of sensory and contextual information over 24 hr. In contrast, in Experiment 2, there was a decrease over time in clarity and other sensory qualities of memories for perceived events. The two studies differed, however, in when memories were rated. In Experiment 3, the retention interval was 24 hr. In Experiment 2, the decrease was observed between 24 hr after the events (when the initial ratings were taken) and 48 hr (when the final ratings were taken). Thus the results of these two studies suggest that the specific interval over which characteristics of memories will show loss may vary with both the particular characteristic and the origin of the event. In particular, perceived events did not begin to show reliable decreases on Clarity and Sensory factors until after 48 hr, whereas imagined events showed decreased ratings in the first 24 hr.

Effect of Ratings

A 2 × 2 ANOVA was performed on ratings obtained on Day 2. The factors in the analysis were the origin of the situations (perceived vs. imagined) and whether the situations had been initially rated (rated vs. not rated). As in Experiment 1, on the Clarity factor, there was a significant Origin × Rating interaction, $F(1, 15) = 5.02$, $MS_e = 0.32$. The difference in clarity between memories for imagined events that had been rated initially ($M = 5.5$) and those that had not (4.9) was larger than the difference between rated (5.8) and not-rated (6.0) perceived events. On the Thoughts and Feelings factor, subjects tended to remember what they had felt and thought about rated situations better than not-rated ones, perceived (rated) = 4.7, perceived (not rated) = 4.4; imagined (rated) = 4.3, imagined (not rated) = 3.8; $F(1, 15) = 3.92$, $MS_e = 0.51$, $p < .07$; but the greater impact of ratings on imagined than on perceived events found in Experiment 1 on the Thoughts and Feelings factor was not replicated here. The only other effect of ratings was a significant Origin × Rating interaction in the Intensity of Feelings factor, $F(1, 15) = 4.89$, $MS_e = 0.27$. For perceived memories, feelings were more intense if the events had been initially rated (3.6) than if they had not (3.0). The intensity of feelings about imagined events was not affected by whether they had been initially rated (3.2) or not (3.3). This is the only instance in either Experiment 1 or Experiment 3 in which ratings had a greater impact on perceived than imagined memories, and there is no obvious explanation for it.

In summary, the results from Experiment 3 provided further evidence for the assumption that complex memories comprise several partially independent qualities (Johnson & Raye, 1981). These memory characteristics differ not only in their content and their susceptibility to the effects of rehearsal, but also, as this experiment clearly shows, in their accessibility in memory over time. For the sorts of events we investigated, clarity and sensory aspects of memories decreased more rapidly for imagined than for perceived events.

It would be interesting to determine whether aspects of memories become inaccessible at a faster rate for imagined than for perceived events even when they are equated initially. That this indeed might be the case is suggested by the greater loss for imagined events on the Sensory factor in Experiment 3, in which perceived and imagined events did not differ significantly on initial ratings. It would be informative, however, to have perceived and imagined events equated initially on the Clarity and Contextual factors as well. For example, the retention interval before initial ratings were made on perceived events could be lengthened so that initial ratings of perceived and imagined events matched. Or, the conditions under which subjects perceived events could be degraded to reduce initial differences in ratings of perceived and imagined events. Although the outcomes of such studies would further understanding of properties of memory representations of perceived and imagined events, the current results are useful for understanding the functional consequences of retention interval under the more typical conditions in which perceived and imagined events do differ initially in various qualitative characteristics.

The relatively rapid loss of thoughts and feelings for both imagined and perceived events is interesting. Experiment 1 indicated that rehearsal of thoughts and feelings could reduce differences between memories for perceived and imagined events. A rapid loss of thoughts and feelings would discourage rehearsal of these aspects of memories, thus protecting people from one possible source of reality monitoring errors.

As in Experiment 1, rating memories had a greater impact on subsequent ratings of imagined than of perceived events for the Clarity factor.

General Discussion

These three experiments yield evidence regarding the effects of retention interval and rehearsal on memories for relatively natural, complex events. The results of Experiment 3 indicate that for perceptual characteristics (Clarity and Sensory factors), memories of imagined events decrease at a faster rate than those of perceived events. This finding is interesting because greater loss over time for imagined than perceived events would be especially functional. First, at short retention intervals, memories for even extremely vivid imaginary events can be discriminated from memories for perceived events because one remembers supporting information (such as the circumstances leading to the imagination), which helps identify the source of the memory. As these supporting sources of information about the origin of memories are forgotten, one could become hopelessly confused. A greater loss in perceptual detail of memories for imagined events would help offset the loss of these other sources of information about the origin of memories. Furthermore, even if the difference between perceived and imagined events stayed constant, their discriminability would not necessarily stay constant. As overall qualitative characteristics become less accessible (i.e., as memories "degrade"), it may take a greater difference to differentiate reliably between memories for perceived and imagined events. Thus increases in the difference between perceived and imagined events produced by differential loss rates would help offset any overall degradation of memories over time that might produce confusions.

With respect to the impact of rehearsal, several findings in Experiments 1 and 2 are worth noting. In Experiment 1, rehearsal had its greatest effect on memories for imagined events that were initially rated. This result could be partially due to the differential loss in memories for perceived and imagined events discussed already. Memories for perceived events showed less loss after 24 hr (Experiment 3), so subjects had little room to benefit from rehearsal. Memories for imagined events, on the other hand, decreased more in various characteristics, leaving room for benefits from ratings and rehearsal. The major consequence of the ratings seemed to be to offset otherwise rapid loss in qualities of imagined events so that rehearsal could act on the remaining information. This suggests the existence of some critical threshold in memories for imagined events. If not reinstated in some detail (e.g., by means of the MCQ rating task), memories for imagined events may quickly degrade, and even relatively frequent rehearsal may not affect their qualitative characteristics. Furthermore, the results of Experiment 2 indicate that imagined events can be reinstated (and perhaps embellished) by means of the MCQ even after 24 hr and then show qualitative effects of subsequent rehearsal.

It appears that the effects of rehearsal on memories depend on which aspects of events one rehearses. The results of Experiment 1 suggest that rehearsal of perceptual aspects of events should not increase later confusion between memories for perceived and imagined events, as long as perceived and imagined events receive equal amounts of rehearsal. The results of Experiment 2 are consistent with this conclusion if we assume that undirected rehearsal in this situation largely consists of thinking about perceptual aspects of events. If imagined events were to be disproportionately rehearsed, of course, they might be confused with perceived events. There are a number of conditions (e.g., social isolation, deafness, depression) that might lead to such a pattern of disproportionate rehearsal of imagined events, and, in extreme conditions, such disproportionate rehearsal might contribute to the development of delusions (Johnson, 1988).

The results of Experiment 1 also suggest that thinking or talking about apperceptive aspects of events has two potentially important consequences: It may decrease phenomenal differences between perceived and imagined events in cognitive and emotional content (thoughts and feelings), and it may reduce accessibility of sensory and contextual characteristics of memories for events. Although clearly only preliminary, these findings regarding thinking about thoughts and feelings have interesting implications for understanding the impact of emotion on memory for events. If an event evokes strong feelings or reactions, people may be especially likely to focus on their feelings when they think about it. (Or, again, some conditions, such as social isolation or depression, might increase focus on emotional aspects of experience.) If the event was initially imagined, it may, as a consequence of rehearsal, begin to seem to have as much cognitive and emotional content as memories for perceived events (Figure 3). If the event was initially perceived, the perceptual features of the event might become less accessible than they would have been with an equal number of "unemotional" rehearsals. Thus emotional involvement might reduce one's ability to give an accurate description of perceptual aspects of events later, even if emotion did not disrupt initial encoding of perceptual aspects of the event (see Clifford & Hollin, 1981; Clifford & Scott, 1978; Deffenbacher, 1983; Loftus & Burns, 1982). Furthermore, events that initially had high emotional content often later have an "unreal" quality—we know they happened because we remember reacting, but it is difficult to revive the event itself (dreams are a particularly striking example of this phenomenon, but waking events suffer the same fate). Again, this loss of a sense of reality surrounding an event may be a consequence of earlier rehearsals focused primarily on the emotional qualities of the event. Emotion could produce apparent "repression" because (relative to an unemotional event) perceptual features of the event do not receive the attention they would otherwise have received (Johnson, 1988). In any case, either more emotion in memories for imagined events or less clarity in memories for perceived events would tend to reduce qualitative differences between memories for imagined and perceived events, thus making reality monitoring more difficult.

References

Allen, G. A., Mahler, W. A., & Estes, W. K. (1969). Effects of recall tests on long-term retention of paired associates. *Journal of Verbal Learning and Verbal Behavior, 8*, 463–470.

Anderson, R. E. (1984). Did I do it or did I only imagine doing it? *Journal of Experimental Psychology: General, 113*, 594–613.

Bahrick, H. P., & Karis, D. (1982). Long-term ecological memory. In C. R. Puff (Ed.), *Handbook of research methods in human memory and cognition.* New York: Academic Press.

Brewer, W. F. (1986). What is autobiographical memory? In D. C. Rubin (Ed.), *Autobiographical memory* (pp. 25–49). Cambridge, England: Cambridge University Press.

Clifford, B. R., & Hollin, C. R. (1981). Effects of the type of incident and the number of perpetrators on eyewitness memory. *Journal of Applied Psychology, 66,* 364–370.

Clifford, B. R., & Scott, J. (1978). Individual and situational factors in eyewitness testimony. *Journal of Applied Psychology, 63,* 352–359.

Deffenbacher, K. A. (1983). The influence of arousal on reliability of testimony. In B. R. Clifford & S. Lloyd-Bostock (Eds.), *Evaluating witness evidence: Recent psychological research and new perspectives.* Chichester, England: Wiley.

Hogan, R. M., & Kintsch, W. (1971). Differential effects of study and test trials on long-term recognition and recall. *Journal of Verbal Learning and Verbal Behavior, 10,* 562–567.

Johnson, M. K. (1985). The origin of memories. In P. C. Kendall (Ed.), *Advances in cognitive–behavioral research and therapy* (Vol. 4, pp. 1–27). New York: Academic Press.

Johnson, M. K. (1988). Discriminating the origin of information. In T. F. Oltmanns & B. A. Maher (Eds.), *Delusional beliefs: Theoretical and empirical perspectives* (pp. 34–65). New York: Wiley.

Johnson, M. K., Foley, M. A., Suengas, A. G., & Raye, C. L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General,* 117, 371–376.

Johnson, M. K., & Raye, C. L. (1981). Reality monitoring. *Psychological Review, 88,* 67–85.

Keppel, G. (1973). *Design and analysis: A researcher's handbook.* Englewood Cliffs, NJ: Prentice-Hall.

Linton, M. (1975). Memory for real-world events. In D. A. Norman and D. E. Rumelhart (Eds.), *Explorations in cognition* (pp. 376–404). San Francisco: Freeman.

Linton, M. (1978). Real world memories after six years: An in vivo study of very long-term memory. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 3–24). New York: Academic Press.

Loftus, E. F., & Burns, T. E. (1982). Mental shock can produce retrograde amnesia. *Memory & Cognition, 10,* 318–323.

Neisser, U. (1982). Snapshots or benchmarks? In U. Neisser (Ed.), *Memory observed* (pp. 43–48). San Francisco: Freeman.

Rubin, D. C., & Kozin, M. (1984). Vivid memories. *Cognition, 16,* 1–15.

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