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Memory markers: How consumers recall the duration of experiences

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Abstract

In the present article, we propose a three-stage memory marker model of memory for experience. The human mind generates and encodes "memory markers" of specific episodes, stores them in memory, and after a temporal delay retrieves these markers to reconstruct the experience and make relevant judgments. Rich experiences characterized by vivid stimuli seem to pass by quickly, yet feel longer when recalled after a period of time because the number of retrieved memory markers is large. We also examine situations in which key predictions of the memory marker model can be moderated. A field study and five laboratory experiments were conducted to test various aspects of the memory marker model and provide process support.

The field of marketing has evolved away from the discipline of selling products to the discipline of creating experiences for consumers (Schmitt, 2003). In this article, we focus on one important aspect of experiences that influences consumer satisfaction and subsequent decision-making — its duration (e.g., Antonides, Verhoef, and Aalst, 2002).

Past research suggests that subjective duration judgments of objectively identically long experiences might be influenced by changes in the environment (e.g., Kellaris and Kent, 1992). In particular, periods of time spent in rich environments with lots of distractions might be seen to have passed by quickly. The subjective duration of an experience has been measured either as perceived speed (e.g., "How quickly do you think time was passing by") or as perceived duration (e.g., "what is your best estimate of the duration?"). The simplest and most intuitive relationship between these two variables is that the faster time seems to pass, the smaller should the duration of the experience be. We propose, however, that rich experiences in which time seems to move quickly might also be reported to be longer in duration when recalled after a temporal delay. If time passes quickly in a rich experience, why should a consumer believe it had a greater duration when asked after a delay?

We resolve this seeming discrepancy by proposing that duration judgments made after a delay arise from a process that is fundamentally different from judgments made online or immediately at the conclusion of the episode. In particular, we propose a model of consumers' memory for experiences that we call the "memory marker model." Similar to the Czech author Milan Kundera who wrote that "memory does not make films, it makes photographs" (Kundera, 1999) we propose that the human brain generates mental memory markers of the environment when there are cognitive or sensory changes that occur around us. These markers could be visual (for instance, the memory of a beautiful painting or a human face), auditory (the memory of the notes of one's favourite symphony piece), tactile — and indeed occur in any sensory or cognitive form. These memory markers are categorized and stacked in memory bins, much like sheets of paper in an office tray (Wyer and Srull,

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1989). While recalling events, consumers retrieve the memory markers from the appropriate bin and view them to retrieve the experience. The number of memory markers serves as a cue to delayed duration judgment. Consequently, in the case of rich stimuli where the environment changes frequently (like the themed ride), there are significantly more memory markers, resulting in a longer duration judgment.

We further show that factors that inhibit encoding or retrieving (e. g., ego-depletion and cognitive load) might limit the number of markers encoded and retrieved respectively, and hence shorten the delayed duration judgment. On the other hand, factors that facilitate the encoding of markers (e.g., sensitivity to changes in the environment) should increase the number of markers recalled, hence prolonging the estimated duration.

The rest of this paper is organized into three sections. First, we review relevant literature and describe our proposed three-stage memory marker model. We also examine situations in which the key predictions of the memory marker model can be moderated. Second, we describe a field study and five laboratory experiments designed to test various aspects of the memory marker model and provide process support. Finally, we conclude with a general discussion and propose directions for future research.

The memory marker model: a theoretical framework

Research has studied various aspects of the memory of past experiences. One such aspect relates to the gestalt evaluation of experiences at their conclusion. Fredrickson and Kahneman (1993) found that salient features of affective experience (e.g., the best or worst part of the experience, the rate of change of the experience, and the end state) seem to influence judgment more than their objective duration, and called this phenomena "duration neglect" (see also Kahneman, Fredrickson, Schreiber, and Redelmeier, 1993; Redelmeier and Kahneman, 1996). Clearly, right at the end of the experience, the salient features of the experience are immediately available as an input into judgment, while an "evaluation that incorporates duration must be constructed more laboriously" (Ariely, Kahneman, and Loewenstein, 2000, p. 524).

Another aspect of the memory for experiences relates to how individuals judge its duration (e.g., Block, 1990; Block and Zakay, 1997; Glicksohn, 2001; Stroud, 1967; Treisman, 1984). There are three common themes in prior work in the area of time perception. First, the work explicitly or implicitly implies the existence of an internal timer to mark the passage of time. Second, duration judgment is often flexible and inaccurate (as compared to objective time), and influenced by multiple factors like emotions, mental engagement, novelty, and variety in activity, among others. Third, prior models are mostly paramorphic in nature and do not provide much evidence for the underlying processes.

In our research, we study the duration judgment of an experience made after a significant delay (in our experimental work, the delay is to the order of a few days). Unlike past research which uses the term "retrospective judgment" to refer to a judgment made immediately at the conclusion of an experience, we use "delayed judgment" to refer to a judgment made after a significant delay such that visceral factors and salient features of the experience are not immediately accessible. Before describing our memory marker model, we offer a metaphor to illustrate its basic features. Imagine that last year Laurel and Hardy each went on an identical trip with family. Laurel took photographs of every family member he met and every event he participated in. Hardy did not take as many photographs. Several months later, when both men were asked to recall this otherwise unremarkable trip, they each went back to their digital photo album marked "family trip" and viewed their trip pictures as a slideshow. After viewing his 100 photographs, Laurel seemed to recall that he had a longer and more eventful trip than did Hardy who had viewed his 20 photographs.

This story captures the basic intuition underlying our memory marker model. The following elements of the story are key variables in our model: a) photographs that served as memory markers were taken by the two men during their trip, b) the photographs were all stored in an album which was tagged with the name of the experience, and c) the number of photographs was used as a cue to judge duration. These correspond to the three stages of our memory marker model: the encoding of markers, filing them in appropriate memory bins, and retrieving them after a delay.

Encoding refers to the process by which certain slices or moments of the experience are recorded for later retrieval, typically when the environment changes. Not all changes in our cognitive and sensory environment result in a marker. For instance, Laurel and Hardy might watch the same exact movie and encode different parts of the movie. These differences could be due to differences in attention caused by preoccupation with other thoughts or due to competing stimuli (lower attention would result in a smaller number of memory markers), differences in whether each stimulus is particularly unusual for each consumer (unusual stimuli are more likely to be encoded as memory markers), or differences in the rate of change of the stimulus (frequent changes are more likely to result in the encoding of a larger number of memory markers).

In the filing stage, the encoded memory markers are categorized and stacked in memory bins, a process consistent with Wyer and Srull's (1986, 1989) bin model of memory. This model conceptualizes memory as bins, or storehouses of individual pieces of information about people, objects, and events. The output of information processing is transmitted to and stored in a relevant bin as a separate information representation, in the order it is generated.

During the retrieving stage, the memory markers stored in memory bins are reviewed and used to make judgments. Given that a larger number of markers would result in greater time needed to review them, we expect that the number of memory markers will serve as a cue to infer the duration of the recalled experience. Note, however, when an experience is rich in cognitive and sensory changes, time might have flown by faster (Kellaris and Kent, 1992). However, such an experience will result in a greater number of memory markers, and as a result, it will be remembered as a long experience. This prediction of the memory marker model is consistent with the paradox noted by

William James (1890, Chapter 15) that "in general, a time filled with varied and interesting experiences seems short in passing, but long as we look back. On the other hand, a tract of time empty of experiences seems long in passing, but in retrospect short." We use the terms "rich" and "impoverished" to refer to situations in which a consumer encodes a) a number of memory markers of "varied and interesting experiences" and b) very few memory markers from a "tract of time empty of experiences" respectively and formally hypothesize:

H1. The delayed duration judgment of a rich experience will be longer than that of an impoverished experience of the same objective duration.

We also note the conceptual difference between the drivers of the perceived duration in James' (1890) view and ours. James notes that the perception of duration is a function of the properties of the stimulus, while in our model it is the property of the interaction of the consumer and the stimulus. Specifically, we believe that a time filled with varied experience may not appear longer after a delay if the consumer fails to encode the changes as memory markers.

Factors which influence encoding, filing and retrieving of markers should also impact our delayed duration judgments. Factors that inhibit [facilitate] encoding or retrieving might limit [enhance] the number of markers encoded and retrieved respectively and hence shorten [lengthen] the delayed duration judgment. We therefore hypothesize that:

H2. The effect of richness of experience on the delayed duration judgment of the experience will be weakened when consumers are under a cognitive load at the time of retrieval.

H3. The effect of richness of experience on the delayed duration judgment of the experience will be weakened when consumers are ego-depleted during the experience.

H4. The effect of richness of experience on the delayed duration judgment of the experience will be enhanced when consumers are sensitized to changes in the environment during the experience.

We next present the results of several studies designed to test these hypotheses.

Field study

We conducted a field study in two international locations of a theme park. Participants were compensated with souvenir gifts and tickets to other local attractions. Participants (and their families) typically went on a number of rides on a given day, and had all purchased a three day pass. Data were collected from each participant at three points in time — a) on the first day of their visit to the park, we asked them to simply list each of the rides they went on, b) on the second day, we also asked them to answer one question at the end of each ride they went on, and c) at the end of their second day, they were asked questions about the duration of rides they had gone on for the first day. The average participant went on 6 rides on each of the two days; and no participant went on the same ride on the two successive days.

On the second day, at the immediate end of each ride that they went on, participants were asked to circle a number on a scale to indicate their response to "How quickly do you think time was passing by during the ride" (1 = Very slowly, 9 = Very fast). And at the end of the second day, they were reminded of the rides they took on the first day and asked two questions — a) "How long do you think the ride was?" (HOWLONG: 1 = Very short, 9 = Very long), and b) "Provide your best estimate of the duration of the ride" (___ minutes ___ seconds). The dependent measure we used was the ratio of their estimate to the actual duration (RATIO).

In analyzing our data, we only looked at one factor along which to compare these different measures; the nature of the ride. Three of the eight rides we studied were what we called "repetitive" rides. An example of such a ride is a carousel, where the motion is primarily circular and the ride is made up of an aggregation of identical elements (e.g., revolutions). The remaining rides were what we call "storyline" rides. These took the rider from one location to another, each depicting a new piece of information or part of a story. In the language of hypothesis 1, the repetitive rides were relatively impoverished, while the storyline rides were relatively rich.

We first consider the data collected immediately at the end of each ride. Participants reported that time seemed to have passed more slowly for the repetitive rides ($n = 30$, $M = 4.57$) than for the storyline rides ($n = 29$, $M = 6.21$, $t\ (57) = 2.96$, $p < .01$). This might have implied that repetitive rides seemed longer than storyline rides. However, we found the opposite pattern of data for the rides where evaluations were collected after a time delay (i.e., for first day rides as recalled at the end of the second day). For delayed evaluations, participants reported that repetitive rides appeared shorter ($n = 32$, HOWLONG: $M = 4.34$; RATIO: $M = 1.018$) than storyline rides ($n = 31$, HOWLONG: $M = 5.71$, $t\ (61) = 2.45$, $p < .01$; RATIO: $M = 1.306$, $t\ (61) = 3.44$, $p < .01$).

These results were consistent with hypothesis 1. That said, we were also acutely aware of the limitations of field studies in general. Our goal was to replicate these effects in the laboratory in a more controlled setting. In all of our experimental studies, participants viewed stimuli in the form of photographs or video clips under an appropriate cover story, and were asked to remove all devices like watches, jewelry, cell phones — absolutely anything that had any rhythmic component that participants could use to estimate time duration. This is common in research on time perception (Block and Zakay, 1997; Vohs and Schmeichel, 2003).

Experiment 1

In this experiment, we created rich vs. impoverished experiences by exposing our participants to slideshows with photographs of various landscapes and natural scenery. We used a particular sequence of photographic slides as the experience that we wanted participants to recall, and manipulated the number of slides in the slideshows while holding the actual duration constant.

Participants, design, stimuli and procedure

Sixty students were paid for participating in this experiment. They were then told that they would be watching a slideshow with several photographs in various domains (we used pictures of fish, flowers, mountains, a lake, a bird, balloons, and a dog). They were randomly assigned to one of two conditions; participants in one condition watched a slideshow that consists of six different slides (i.e., fish, mountain, balloon, bird, horse, wild flowers) with each slide displayed for 30 s. Participants in the other condition viewed thirty different slides, with each slide displayed for 6 s. The slideshow in this second condition contained all six photographs from the first slideshow, and these were placed on 1st, 6th, 11th, 16th, 21st, and 26th position respectively. While the objective duration of both slideshows was the same, the show with 30 slides was richer since it gave participants more information to encode.

After watching the slideshow, some participants in the immediate judgment condition were asked to fill out a questionnaire that measured their subjective judgment of the duration of the slideshow. In addition, participants also were asked to rate their mood, boredom and nervousness (Depressed–Cheerful, Unhappy–Happy, Bad–Good, Bored–Excited, Nervous–Relaxed).

The remaining participants (in the delayed judgment condition) were told that they would receive the [same] questionnaire by e-mail three days later, and were asked to respond to it upon receipt. This experiment therefore employed a 2 (slideshow: [6 slides × 30 s] vs. [30 slides × 6 s]) × 2 (timing of judgment: immediate vs. delayed) between-participant design.

Results and discussion

To test hypothesis 1, we conducted a 2 (slideshow) × 2 (timing of judgment) ANOVA with duration judgment as the dependent variable. The results are plotted in Fig. 1, and show a significant interaction effect of the slideshow with the timing of evaluation ($F(1, 56) = 94.3$, $p < .001$). As the figure shows, participants in the immediate condition reported a longer

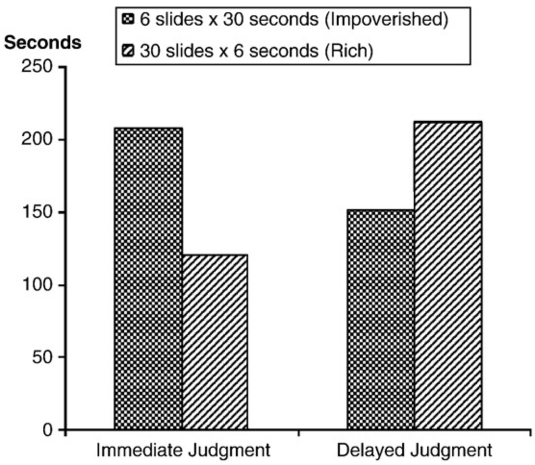

Fig. 1. Duration as a function of timing of judgment and slideshow: Experiment 1.

duration when the number of slides was small ($M = 208.0$) compared with large ($M = 120.7$; $F(1, 28) = 61.64$, $p < .001$). However, participants in delayed condition perceived the duration to be longer when the number of slides was large ($M = 212.7$) compared with small ($M = 151.7$; $F(1, 28) = 33.94$, $p < .001$). Mood, nervousness and boredom were used as covariates in the 2 (slideshow) × 2 (timing of judgment) ANCOVA and did not influence participants' duration judgment.

The results of this experiment were consistent with H1. When individuals engage in delayed judgments, individuals who have viewed the larger number slides perceived the duration of the experience to be longer. This is in contrast to situations where individuals are asked to make judgments immediately after the event, where they seem to be drawn by the richness of the experience and perceive time passing quickly and duration is short.

In this experiment, we used the number of slides as a manipulation to induce cognitive changes. In doing so, participants in one condition simply saw a larger variety of pictures as compared to participants in the other condition, and it may be argued that this extra sensory input might influence duration judgments. A cleaner test would hold the total content of the pictures constant, and Experiment 2 was conducted with this in mind.

Experiment 2

Participants, design, stimuli and procedure

Sixty students were paid for participating in this experiment. They saw a total of five separate photographic slides (specifically, five different species of butterflies varying in colors, size, etc.). Each repeated five times in either a cyclical or repetitive manner, with each exposure lasting for 5 s. Hence the total slideshow lasted 125 s.

For some participants (in the repetitive transition condition), each slide was displayed for 5 s, and was repeated five times. We used different animation effects during each successive transition (e.g., picture flying in from the left, right, bottom, top, and top left). At the end of the first slide, the next slide was presented for five repetitions in the same manner till all five pictures had been shown (specifically, if the slides were labeled 1, 2, 3, 4 and 5, participants saw 11111/22222/33333/44444/55555). The remaining participants (in the cyclical transition condition) viewed the slideshow in a sequence that can be represented as 12345/32154/13524/31542/54321. We used the same animation effects during each successive slide in the cyclical transition condition. The cyclical transition condition was richer because each transition represented a different photograph.

After watching the slideshow, participants filled out a questionnaire either immediately or three days later as the procedures in experiment 1. This experiment therefore used a 2 (slide transition: repetitive vs. cyclical transition) × 2 (timing of judgment: immediate vs. delayed) between-participants design.

Results and discussion

The mean subjective duration judgments are plotted in Fig. 2. A 2 (slide transition) × 2 (timing of judgment) ANOVA showed a significant two-way interaction between sequence and timing of judgment ($F(1, 56) = 6.6$, $p < .05$). Participants in the immediate condition estimated a longer duration in the repetitive transition ($M = 123.7$) compared to the cyclical transition ($M = 106.7$; (F (1, 28) = 3.42, $p < .1$). In contrast, participants in delayed condition reported a longer duration when the slide transition was cyclical ($M = 120.7$) vs. repetitive ($M = 109.3$; $F(1, 28) = 3.46$, $p < .1$).

Across the first two experiments, we manipulated the relative richness of the slideshow experience in two different ways. In both cases (and in the field study reported earlier), the results supported H1 and William James' observation (1890, p. 624). In the following three experiments we tested the moderators on the delayed duration judgments with regard to the encoding and the retrieval stage in the memory marker model.

Experiment 3

The goal of experiment 3 was to test the memory marker model at the retrieval stage, and in particular to test H2. Each participant saw both repetitive and cyclical slideshows at the first session (rather than this being a between-subjects variable). Also, a number-memorizing task was used to manipulate the cognitive load at the time of estimating duration.

Participants, design, stimuli and procedure

In the first session, fifty-eight participants watched two slideshows (repetitive and cyclical) separated by a filler task. One slideshow had pictures of birds, while the other had pictures of butterflies (same stimuli used in experiment 2). The type of the slideshow (i.e., butterflies vs. birds) and the order of slideshows (repetitive one first vs. cyclical one first) were counterbalanced across slide transition. Neither the type of slideshow nor the order had any effects on the dependent measures, and hence are not discussed further.

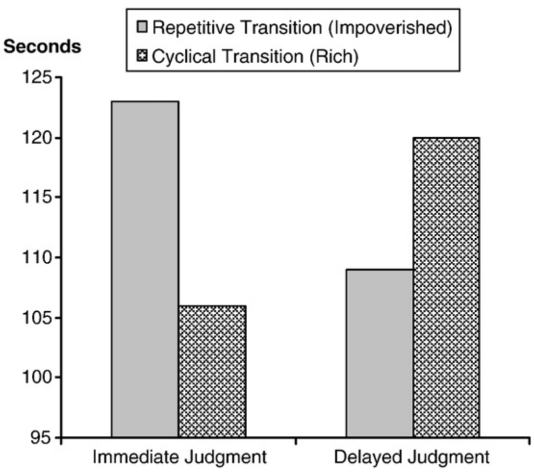

Fig. 2. Duration as a function of timing of judgment and slide transition: Experiment 2.

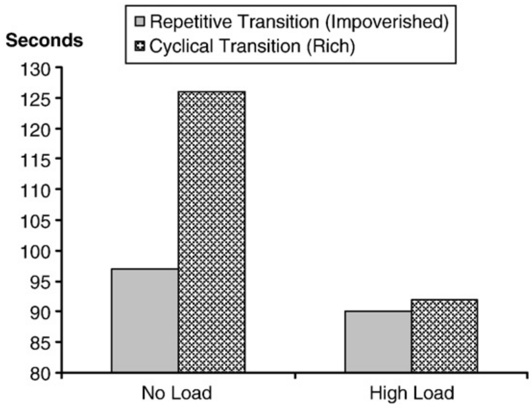

Fig. 3. Duration as a function of cognitive load and slide transition: Experiment 3.

In the second session, participants were randomly assigned to one of two conditions (high cognitive load vs. no-load). Participants in high cognitive load condition were asked to memorize a random 9-digit number (i.e., 937852965) and were told they if they could recall the number accurately at the end of the session, they would receive an extra $2. Participants in the no-load condition were simply asked to fill up the questionnaire. This experiment therefore employed a single factor — cognitive load (high vs. no) design.

Participants were asked to indicate which slideshow they recalled as being longer (LONGER: 1 = Bird, 6 = Equally Long, 11 = Butterfly). We also measured each participant's best judgment of the duration on each slideshow. We recoded the data as the LONGER variable (i.e., 1 = Repetitive, 6 = Not Sure, 11 = Cyclical).

Results and discussion

In order to test hypothesis 2, we conducted a one-way ANOVA with participants' reported judgment about which slideshow was longer as the dependent variable, and cognitive load as the independent variable. The mean of LONGER score indicating that participants found the cyclical slideshow longer than the repetitive one in the high cognitive load condition ($M = 5.5$) was not significantly different from the midpoint of the scale ("Equally Long" = 6, $p = .21$). In contrast, participants in the no-load condition indicated that the cyclical slideshow was longer than the repetitive slideshow ($M = 7.9$; $F(1, 56) = 20.49$, $p < .001$).

As a secondary analysis, we also conducted a 2 (slide transition: repetitive vs. cyclical transition) × 2 (cognitive load: high vs. control) ANOVA with the duration judgment of each slideshow as the dependent variable. Like previous experiments, participants estimated a shorter duration in the repetitive transition ($M = 93.5$) of the slideshow than in the cyclical transition ($M = 108.7$; $F(1, 56) = 12.53$, $p < .005$). Moreover, those under high cognitive load condition ($M = 90.7$) estimated a shorter duration of each slideshow than those in the no-load condition ($M = 111.5$; $F(1, 56) = 7.06$, $p < .05$). The ANOVA results also showed a significant two-way interaction between slide transition and cognitive load ($F(1, 56)=9.12$, $p<.005$). The results are plotted in Fig. 3 and show that participants in the no-load condition felt the duration of the slideshow with the repetitive transition ($M=97.4$) was shorter than the cyclical transition ($M=125.5$). However, participants in the high cognitive load condition reported that the repetitive transition ($M=89.6$) and the cyclical transition ($M=91.9$) were not significantly different, implying that the slide transition had no effect. This pattern of data supported H2. The results in this experiment show that inhibiting mental capability at the retrieval stage inhibits the retrieval of memory markers, and therefore leads to shorter duration judgment.

Experiment 4

Participants, stimuli, procedure and measurement

Sixty-four female participants (age 18–60) participated in a food tasting study in exchange for cash compensation. The two slideshows used in experiment 2 were fully crossed by a second factor, ego-depletion. Upon arrival, participants were told that they were going to participate in two different studies: a food taste study and a visual perception study. Following the procedures from Baumeister, Bratslavsky, Muraven, and Tice (1998), two types of food were displayed on the table at which participants were seated: chocolate chip cookies and red radish. Participants were randomly assigned to taste one type of food, and were asked to eat at least one unit (and as many as they liked) of either cookie or radish, but not eat the other. Participants were asked to take their time to taste the assigned food (average time of food tasting about 5 min) before filling in a "Food Taste Questionnaire" as a manipulation check for ego-depletion. In the questionnaire they were asked to list down the instructions they had remembered, as well as to report difficulty in following the instructions and in resisting eating the other group's food on a nine-point scale (1=very easy, 9=very difficult), then the participants rated the taste and quality of the food they tasted. Participants who ate radish but could not consume the cookies were expected to form the ego-depleted group.

Participants then watched the butterfly slideshow as in experiment 2. Three days later, they received and responded to a questionnaire asking the slideshow duration judgment by e-mail. This experiment therefore employed a 2 (slide transition: repetitive vs. cyclical)×2 (ego-depletion: depletion vs. no-depletion) between-participants design.

Result and discussion

As a manipulation check for ego-depletion, we followed Vohs and Schmeichel (2003) and compared the ease of following instructions and difficulty in resisting the disallowed food. The radish-eating group found it much more difficult to follow instructions ($M_{radish\ eaters}=3.41$, $M_{cookie\ eaters}=1.67$, $F(1, 59)=9.19$, $p<.01$) and found it more difficult to resist eating the disallowed food ($M_{radish\ eaters}=3.71$, $M_{cookie\ eaters}=1.44$, $F(1, 59)=20.48$, $p<.001$). Hence our manipulation of ego-depletion was successful.

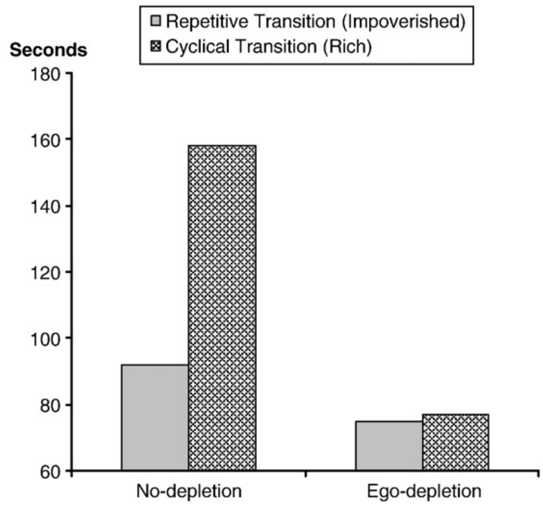

Fig. 4. Duration as a function of ego-depletion and slide transition: Experiment 4.

The mean subjective duration judgments are plotted in Fig. 4, and were analyzed using a 2 (slide transition)×2 (ego-depletion) ANOVA. We found a significant two-way interaction between the slide transition and ego-depletion ($F(1, 60)=5.54$, $p<.05$) and significant main effects of slide transition ($F(1, 60)=6.10$, $p<.05$) and ego-depletion ($F(1, 60)=12.93$, $p<.01$). The main effect of slide transition was qualified by the two-way interaction between the slide transition and ego-depletion. For participants in the no-depletion condition, the repetitive transition group ($M=92$) estimated a shorter duration than the cyclical transition group ($M=158$; $F(1, 29)=7.32$, $p<.05$). However, under the depletion condition, both the cyclical transition group ($M=77$) and the repetitive transition group ($M=75$) estimated much shorter durations for the slideshow and the mean difference between both groups was not significant ($F(1, 31)=0.02$, $p>.9$).

This experiment provided support for H3 by demonstrating that when individuals had limited cognitive resources at encoding stage, the number of memory markers taken and recorded in our memory would be restricted, resulting in a lower duration judgment.

Experiment 5

The objective of experiment 5 was three folds. Firstly, we tried to replicate findings that support H1 with a different type of stimuli; a video clip. Secondly, we tested H4; that the level of sensitivity to the details of the external stimuli could moderate the number of memory markers taken during the experience, thereby impacting the delayed duration judgment. Thirdly, we collected and coded unaided memory of the experience to determine if it mediated the effects of our manipulations on delayed duration judgments.

Participants, stimuli, procedure and measurement

One hundred and twenty-three university students participated in the study for cash compensation. The experimenter

Table 1
Duration judgment (in seconds) as a function of timing judgment, video clip, and sensitivity.

		Immediate judgment		Delayed judgment	
		Sound effect video	No sound effect video	Sound effect video	No sound effect video
High sensitivity	Mean	158.13[a]	155.38[a]	358.89[b]	278.57[b]
	SD	61.23	66.90	111.12	107.32
Low sensitivity	Mean	186.67[a]	210.00[a]	308.82[b]	173.75[a]
	SD	76.78	93.39	148.79	102.10

Note. Cells with a different superscript differ significantly from each other ($p<.05$).

explained that they would be watching a video clip and randomly assigned them to one condition in a 2 (video clip: sound effects vs. no sound effects) by 2 (timing of judgment: immediate vs. delayed) by 2 (sensitivity level: high vs. low) between-participants design. The video clip without sound effects used in the experiment was a short documentary film in which the Harry Potter movie production team explained the making of the fireworks sequence in the movie. The video clip with sound effects used the same video clip, but inserted various sound effects whenever fireworks appearing in the video (15 times in total) to accentuate the memory for the fireworks. Further, half of the participants were told to pay attention to every single detail in the video as much as they could and to write down suggestions on how the production could be improved (the high sensitivity condition); while the other half were told to think about the general theme of the video and to write down possible titles for the video (the low sensitivity condition). As in experiments 1 and 2, participants were either asked to estimate the duration of the video right after they watched the video clip in the immediate condition, or three days later via e-mail in the delayed condition. In this questionnaire, participants were also asked to list whatever they could recall about the video. The open-ended responses were coded into individual memories, and the number of fragments of memory (NUMMEM) was used as a surrogate for the number of memory markers.

Result and discussion

The mean subjective duration judgments were analyzed using a 2 (video clip) × 2 (sensitivity) × 2 (timing of judgment) ANOVA. The mean and standard deviation scores of duration judgment in each condition were listed in Table 1.

Firstly, sensitivity was shown not to have a significant main effect ($F(1, 115)=.95$, $p>.1$), and hence we combined the high sensitivity and low sensitivity groups for the analysis. We found a significant two-way interaction of video clip by timing ($F(1, 115)=10.45$, $p<.01$). The video clip with sound effects was estimated to be shorter ($M=171$) than the one without sound effects when the judgment was made immediately after viewing the video ($M=184$); while the video clip with sound effects was estimated to be longer ($M=335$) than the one without sound effects when the judgment was made three days later ($M=223$). This result was essentially a replication of findings in experiment 1 and 2 with a different type of stimuli. However, the three-way interaction of 2 (video clip) × 2 (sensitivity) × 2 (timing) was not significant ($F(1, 115)=1.21$, $p>.2$).

Second, when looking at the delayed duration judgment only, we found that sensitivity had a moderating role on the effect of video clip on duration judgment. When viewing the video clip without sound effects, participants with a high sensitivity were expected to encode more memory markers, hence estimate a longer duration ($M=279$) than participants with a low sensitivity ($M=174$, $F(1, 28)=7.50$, $p<.05$). When viewing the video clip with sound effects, participants with a low sensitivity might take as many memory markers ($M=309$) as participants with a high sensitivity, hence there was no difference in the duration judgment ($M=359$, $F(1, 33)=2.98$, $p>.1$).

Third, for the delayed conditions, there is a significant two-way interaction of sensitivity by video clip on the number of items recalled [NUMMEM] ($F(1, 60)=7.53$, $p<.01$). Sensitivity moderates the effect of video clip on recalled items. When viewing the video clip without sound effects, participants with a high sensitivity recalled more items ($M=7.90$) from the video than those with a low sensitivity ($M=5.00$); while when viewing the video clip with sound effects, participants with a high sensitivity recalled as many items ($M=7.27$) as those with a low sensitivity ($M=7.58$). The effect of sensitivity and video clips on recalled items is consistent with the effect of sensitivity and video clips on duration judgment, providing a compelling evidence for the underlying process of how individuals memorize time.

We further tested the number of recalled items from the video as a mediator of the effect of video clip and sensitivity on duration judgment. Four cases were omitted from the analysis for missing data. Three regressions were conducted: (1) video clip and sensitivity as predictors of duration judgment ($F(2, 59)=11.03$, $p<.001$; (2) video clip and sensitivity as predictors of the number of recalled items from the video ($F(2, 59)=8.83$, $p<.001$) and (3) video clip, sensitivity, and the number of recalled items as predictors of duration judgment ($F(3, 58)=49.85$, $p<.001$). The coefficient of video clip dropped from .43 ($t(59)=3.78$, $p<.001$) to .10 ($t(58)=1.22$, $p=.23$) and the p-value became insignificant when the number of recalled item is included in the regression. Similarly, the coefficient of sensitivity dropped from .26 ($t(59)=2.36$, $p<.05$) to .13 ($t(58)=1.84$, $p=.07$) and the p-value became insignificant when the number of recalled item is included in the regression. We then run the Sobel Test of the significance of the indirect effect of the mediator (MacKinnon, Warsi, and Dwyer, 1995; Sobel, 1982). The Sobel statistics for sensitivity was computed as 1.50 ($p=.07$) and the Sobel statistics for video clip was 3.56 ($p<.001$). The Sobel Test showed the number of recalled item as a significant mediator of the effect of video clip on duration judgment, and a marginally significant mediator of the effect of sensitivity on duration judgment.

This result demonstrated that sensitivity could moderate the number of memory markers taken during the experience, thereby impacting the delayed duration judgment. Combined with the finding of experiment 4, we could argue that duration judgment was heavily influenced by either increasing or inhibiting the mental capacity during the encoding process, thus providing more support to the underlying process of the memory marker model.

General discussion and conclusions

In this article, we present a model of consumers' judgment of the duration of past experiences. The human mind encodes memory markers, stores them in appropriate memory bins, and later retrieves them to reconstruct the experience. In rich environments (relative to impoverished ones), when the mind encodes a lot of memory markers in a given objective duration, time passes by quickly during the experience and the duration does not seem very long. However, when the experience is recalled, the larger number of markers serves as a cue for a longer duration judgment. We found evidence for this basic finding across a field study and a series of experiments with different stimuli. We showed that ego-depletion and cognitive load result in shorter delayed duration judgment, and also showed that making participants more sensitive to the experience moderates the effects. These findings are consistent with claims made by prior work. In particular, McGrath and Kelly (1986) argued that humans can distort their sensory input when they are experiencing time and hence experience a different pattern from the objective or "true" time. In particular, they assumed that there might be some kind of standard of expected stimulus rate which may vary with situations and can be subject to adaptation. In this case, individuals are able to notice the stimuli as "many" or "few" based on the rate that they have been adapted. Enriched intervals are remembered as if they were longer, while empty intervals are remembered as if they were shorter than they actually were (as measured by objective clock time). This insight is consistent with our current findings.

Conclusions

The goal of our research was to study processes that affect the manner in which people recall and judge one aspect of an experience, its duration. Another facet relates to the intensity of various elements of the experience. In our model, we manipulated our experiences to be affectively unremarkable to suit our assumption that each memory marker had the same affective intensity as other memory markers. Indeed, the next phase of a research program on how consumers remember experiences should study the effect of intensity on all three stages of the process.

Our model also has an interesting parallel in spatial distance perception. For instance, Downs and Stea (1973) and Sadalla and Staplin (1980) compared two otherwise identical routes, with the difference that one of them had more intersections (crossroads) and features (e.g., shops and signs) than the other one. They found that the route with more intersections and features is recalled as a longer route. This finding was similar to what the memory marker model would predict — when consumers reconstructed the route, the presence of more intersections and features gave them the ability to encode (and later retrieve) more memory markers, which contributes to the judgment of greater length.

At the end of every holiday season, one often hears people remark how short the previous year seemed to be. Our work would suggest that this tendency is higher for people who have routine jobs (e.g., librarian) than those whose job schedules are variant (e.g., advertising team) or work locations are different (e.g., plumber), because the former will have fewer memory markers to code. To test this idea, we measured individuals' perception of the duration of the past year as a function of the variability of their job schedules and work locations (as measured by ratings on nine-point scales). The ratings on both job schedule and work location (median split) were used as independent variables in a two-way ANOVA. The result showed that both work location ($F(1, 95)=127.58$, $p<.001$) and job schedule ($F(1, 95)=152.\ 22$, $p<.001$) have significant effects on the perceived duration of the past year, controlling for how eventful this year is comparing to other years (as measured by a scale). The more routine the job (in terms of both location and schedule), the more likely that individuals will feel time pass quickly and surprised by it.

While the present research has provided some interesting answers to how people remember duration of past experiences, it has also opened up further questions for research. In our experiment, we cleanly manipulated the nature of the stimulus to make it rich or impoverished. How does this process work in the real world? What happens when people have to deal with memory of multiple experiences at the same time? Does the human mind re-categorize memory markers over time? How do emotions associated with the experience influence the three stage research? Future research could investigate some of these questions in further depth.

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