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The Relationship Between Arousal and the Remembered Duration of Positive Events

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Summary: The relation between affect and retrospective duration estimation has hardly been examined. In this paper, we contribute to filling this gap by studying the influence of arousal on the remembered duration of positive events. On the basis of the contextual change model, we expected that high-arousal positive events would be remembered as longer compared with low-arousal positive events. To test this hypothesis, we set up a naturalistic study in which participants were asked at the end of a pleasant amusement park ride at the local fair to rate how pleasant and aroused they felt during the ride as well as to estimate the ride's duration. Feeling more aroused during a ride was associated with longer estimates of the ride's duration. Results are discussed within the framework of retrospective time estimation models. Copyright © 2013 John Wiley & Sons, Ltd.

Duration estimation is central to proper human functioning as reflected by the many actions and decisions that require us to accurately estimate time. In some cases, duration is estimated largely automatically. For instance, crossing a busy street involves making an implicit comparison between the time needed to cross the road and the time it will take an approaching car to reach the crosswalk. In other cases, duration estimates are the outcome of a deliberative process. For example, a witness may mentally reconstruct events when asked to provide an estimate of how much time elapsed between two incidents in the context of a criminal investigation. Given the obvious importance of time estimation, it should come as no surprise that it has been a central topic in psychology from the very start (Grondin, 2008)

An important challenge for researchers studying time estimation is to identify factors that may lead to distortions in perceived duration (Block & Zakay, 2008). One important factor in this regard is affect (Gil & Droit-Volet, 2009; Grommet et al., 2011). Two orthogonal dimensions are assumed to underlie our affective experiences, namely valence and arousal (Russell, 2003). Valence is a dimension that ranges from feeling pleasant to unpleasant, whereas arousal ranges from feeling active to passive.

Several studies have investigated how valence and arousal influence time estimation. These studies typically used prospective designs in which participants are aware before the start of the target time-interval that an estimate of its duration is expected (e.g., Droit-Volet et al., 2004; Gil, & Droit-Volet, 2012; Gil et al., 2009; Grommet et al., 2011). For instance, Angrilli, Cherubini, Pavese, & Manfredini, 1997 showed participants images that varied on valence and arousal for a number of seconds and asked participants after viewing each image to estimate the duration for which each image had been displayed. A cross-over interaction between valence and arousal was found, such that for images low in arousal, negative images were judged to be of shorter duration than positive images, whereas the opposite was true for high-arousal images.

In contrast, retrospective designs—in which participants are only told that they will have to estimate the duration of an event after the target time-interval has ended—have rarely been used to examine the relation between affect and duration estimation (Block & Zakay, 2008). This is problematic as different cognitive mechanisms underlie prospective and retrospective time estimation (Block & Zakay, 1997) and affect may have a distinct influence on these different mechanisms. Consequently, findings regarding the influence of affect on prospective time estimates cannot simply be assumed to generalize to retrospective estimates. Given that people often need to estimate the duration of events after they have already occurred, this represents a notable gap in our knowledge. The aim of the present study was to contribute to a better understanding of the relation between affect and retrospective duration estimates.

Cognitive theories of retrospective time estimation, such as the contextual change model, concentrate on the role of non-temporal information that is encoded during the target time-interval (Block & Zakay, 2008), with time estimates being especially high if one remembers the occurrence of many events or contextual changes during the time-interval. As such, models of retrospective time estimation usually emphasize the role of memory. Although some studies have examined the effect of valence on memory (e.g., Denny & Hunt, 1992; Kensinger & Schacter, 2006), most research has focused on the role of arousal. These studies have generally found that high arousal is strongly related to enhanced memory (Cahill & McGaugh, 1995; Bradley et al., 1992). As such, on the basis of the contextual change model, one would expect that high arousal leads to longer retrospective duration estimates, as more contextual changes or events may be available for retrieval. Partial evidence for this claim has been found in previous research, namely Loftus et al. (1987) found a positive relation between arousal and estimated duration for negative stimuli.

Whereas the relation between arousal and retrospective duration estimates has been studied for negative stimuli, it remains to be seen what effect arousal has on duration

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estimates of positive stimuli. In the present paper, we contribute to filling this gap by reporting the results of a study examining the effect of arousal on estimated duration of positive events. Drawing on the contextual change model, we expected to find a positive association between arousal and remembered duration, such that high-arousal positive events would be remembered as longer compared with low-arousal positive events. To test this hypothesis, we conducted a field study in which we asked people immediately after stepping off an amusement park ride at the fair—which is typically a highly positive experience—to rate how pleasant (i.e., valence) and active (i.e., arousal) they felt, as well as to estimate how long the ride took. Such a real life setting allows for natural variation in arousal and is therefore ideal for studying our research question.

METHOD

Participants

Participants were 116 people who attended the annual fair in Leuven, Belgium. Participants ranged in age from 11 to 76 years ($M = 28.15$; $SD = 13.38$). The sample included 44 men and 71 women. One person did not report his/her gender. Participation was voluntary.

Measures and procedure

To ensure sufficient variability in arousal levels and objective duration, we selected four rides that we expected to be experienced as pleasant: the 'Octopus', the 'Moviestar', the 'Dragon' and the 'Gravitron'. The objective duration of each ride was unobtrusively recorded by two experimenters using stop-watches. If there was a discrepancy between the two recorded durations, we took the mean to the nearest second. Immediately after the ride, people were randomly approached as they were leaving the ride and asked to complete a short questionnaire. We collected the data with nine people simultaneously, so each time the ride stopped, we questioned nine people (we did not ask people to wait after the ride, if people declined to participate, which rarely happened, we waited for the next ride). As such, the time between the end of the ride and filling out the questionnaire was at most 1 minute. The questionnaire comprised five items: Affective experiences during the ride were rated on two nine-point self-assessment manikin scales measuring arousal and valence (Lang, 1980). The arousal scale ranged from 1 (*very calm*, *passive or relaxed*) to 9 (*very active*, *tense or aroused*) and the valence scale ranged from 1(*very bad*, *negative or unpleasant*) to 9 (*very good*, *positive or pleasant*). Participants provided an estimate of the ride's duration in minutes and seconds; and finally, participants indicated their gender and age. The order of the affect ratings and duration estimates was randomized.

RESULTS

Descriptive statistics for valence, arousal and objective duration

The number of observations varied by ride: 59 participants were interviewed after riding the Octopus, 31 after the Moviestar, 20 following a ride on the Dragon and only five after riding the Gravitron (because it was much less popular than other rides, which slowed down data collection). One person did not report the name of the ride. In the next paragraph we present the descriptive statistics for valence, arousal, and objective duration collapsing data across all rides.

Valence ratings ranged from mildly to highly pleasant. On average, people felt highly positive ($M = 8.017$) during rides, with little variation in these ratings ($SD = 1.358$). As such, we may safely conclude that we are indeed examining positive events. Arousal ratings showed greater variation, with ratings ranging from very calm to very active. On average, people felt moderately aroused during rides ($M = 5.017$; $SD = 2.442$). Finally, the mean objective duration of a ride was 302.086 seconds, with a standard deviation of 69.624 seconds.

Descriptive statistics for duration estimates

We calculated the duration judgment ratio for each participant by dividing their subjective duration estimate by the objective duration of the ride. The mean duration judgment ratio is 0.996, with a standard deviation of 0.607. A value of one indicates a perfectly accurate estimation, whereas values higher and lower than one reflect overestimation and underestimation, respectively. The duration judgment ratios were logarithmically transformed to correct for positive skew. After this transformation, the distribution of the duration judgment ratios was close to a normal distribution (Keene, 1995). A logarithmically transformed value of zero reflects a perfectly accurate estimation (i.e., the logarithm of one equals zero), whereas numbers higher and lower than zero indicate overestimation and underestimation, respectively. The mean logarithmically transformed duration judgment ratio across all rides was -0.121, which was significantly less than zero, indicating that on average people underestimated the duration of rides, $t(115) = -2.890$, $p = .005$. All further analyses were conducted using the logarithmically transformed duration judgment ratios and, to ensure the reliability of our results, we collapsed across rides.

Effects on duration estimation

To examine whether and to what extent the different predictors included in our study (i.e., valence, arousal, age, gender and objective duration) accounted for the observed variability in duration judgment ratios, we conducted a series of simple and multiple regression analyses. A positive regression weight indicates that a higher score on the predictor was associated with a higher duration judgment ratio, whereas a negative regression weight indicates that higher scores on the predictor were related to lower duration judgment ratio. Results of the simple regression analyses showed that the duration judgment ratio was significantly related to the following: (i) gender, with women providing longer estimates than men ($B = .196$, $SE = .085$, $\beta = .212$, $p = .023$); (ii) age, with older people providing shorter estimates than younger people ($B = -.006$, $SE = .003$, $\beta = -.187$, $p = .045$); (iii) objective duration, with longer episodes being more underestimated than shorter episodes ($B = -.002$, $SE = .001$, $\beta = -.304$, $p = .001$); and (iv) arousal, with highly arousing rides being estimated as longer in duration than rides lower in arousal ($B = .036$,

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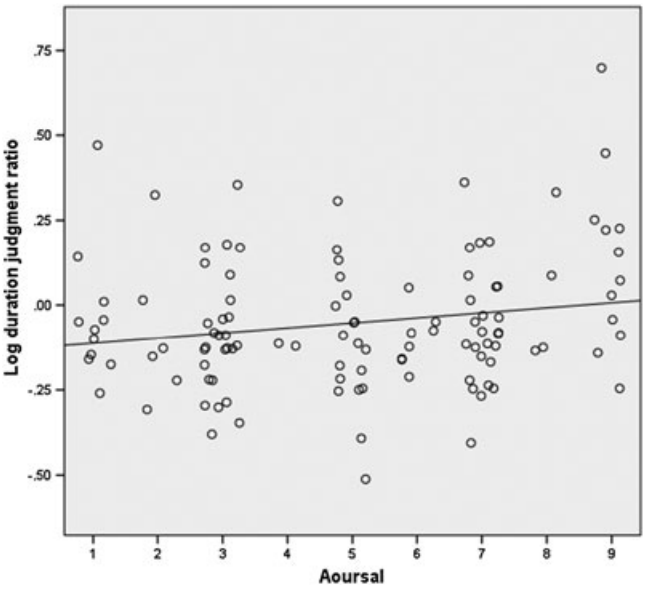


Figure 1. The logarithmically transformed duration judgment ratio as a function of arousal. As arousal was measured using a nine-point scale, we added jitter to the arousal values to circumvent overlap of the scatter points. The jitter was randomly drawn from a uniform distribution with boundaries [−.30 .30]

$SE = .017$, $\beta = .192$, $p = .040$) (see also Figure 1). The effect of valence was not significant ($B = .003$, $SE = .031$, $\beta = .008$, $p = .930$), meaning that it had no influence on the duration judgment ratios. When we entered all five predictors simultaneously in a multiple regression analysis, the model was significant overall ($R^2 = .161$, $F = 4.159$, $p = .002$), and (marginally) significant effects were found for gender ($B = .162$, $SE = .088$, $\beta = .174$, $p = .069$), objective duration ($B = -.002$, $SE = .001$, $\beta = -.254$, $p = .006$), and arousal ($B = .029$, $SE = .017$, $\beta = .157$, $p = .091$), showing that each of these predictors made a unique contribution to duration judgment ratio. Age and valence were not significant ($ps > .31$).[1]

DISCUSSION

The present study was the first, to our knowledge, to examine the relationship between arousal and retrospective time estimation for positive stimuli. Results showed that people are fairly accurate when estimating the duration of positive events. Indeed, the average estimated duration closely resembled the actual objective duration. However, people do have the tendency to somewhat underestimate the duration of positive events that last for several minutes. This result is in line with previous research that has shown that in general people tend to underestimate the duration of relatively long episodes (i.e., Vierordt's law, see later).

Furthermore, we examined the influence of a set of background variables on estimated duration. Three of these variables appeared to influence retrospective time estimation. First, women provided longer duration estimates than men, which is consistent with previous research (e.g., Block et al., 2000; Yarmey, 1993). This gender difference in duration estimation may be accounted for by the fact that women are more likely to store a larger quantity of information about positively valenced stimuli (Rothkopf & Blaney, 1991). Second, we found suggestive evidence that older people provided shorter estimates than younger people. Studies investigating the association between age and retrospective duration estimates are rare, and the few existing studies have found no relationship (e.g., Yarmey, 1993; Yarmey & Yarmey, 1997). As such, the present finding is a first indication that age-related differences may exist in retrospective duration estimation. However, future research is needed to replicate this effect, especially as age was no longer (marginally) significant when controlling for the other duration predictor variables under study. Within the prospective duration estimation domain, age-related differences in time estimation have been widely studied, showing that older adults have higher duration judgments ratios than younger participants (Block et al., 1998). As such, these findings are opposite to our results, stressing again the fact that results found within the prospective domain cannot just be generalized to the retrospective domain. Last, relatively long episodes were more underestimated than relatively short episodes. A similar relationship between objective and perceived duration of non-emotional stimuli was described more than a century ago by Vierordt (1868). The validity of Vierordt's Law, as it has become known, was recently confirmed in a study by Yarmey (2000). The present findings show that Vierordt's Law also holds for the estimated duration of positively valenced stimuli.

The central challenge of the present article was to examine the relationship between arousal and retrospective duration estimation for positive events. In support of our initial hypothesis, we found a main effect of arousal such that feeling more aroused during a ride predicted higher retrospective duration estimates. An explanation for this effect may be found in the contextual change model (Block & Zakay, 2008), which states that retrospective duration estimates are positively related to the amount of non-temporal information that is encoded and that is available for retrieval at the moment of estimation. As it has been shown that high arousal leads to memory enhancement (Cahill & McGaugh, 1995; Bradley et al., 1992), more information is likely to be encoded during a highly arousing event, leading to greater availability of information at the moment of estimation.

The present study is only a first step towards a better understanding of the association between the emotional content of events and retrospective estimation of their duration. Two limitations of our study deserve mention. First, as our study was correlational in nature, no causal relationships can be drawn. At this point, it would be interesting for future research to replicate our results within an experimental context. Second, a number of variables that could also have influenced the duration estimates were not controlled for. One potential important variable in this regard is the amount of experience people have with rides on a fair. People who often go to fairs may be better at estimating the duration of rides and/or become less aroused because of their familiarity with the rides. Future research should control for such variables. Finally, studies are needed to replicate the current findings across a broader range of durations and events, and to examine more directly the

[1] We also tested the effect of all possible two-way interactions between the predictors on the logarithmically transformed duration judgment ratio; none of these interactions were significant.

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processes underlying the relation between affect and retrospective time estimation.

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