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# REMEMBERING RETROSPECTIVELY THE DURATION OF JOYFUL AND SAD MUSICAL EXCERPTS: COMPARISON OF THREE ESTIMATION METHODS


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## Abstract

*Sixty participants were asked to listen to two musical excerpts, one expected to generate joy and the other to generate sadness, and to complete a cognitive task between the musical excerpts. The task and excerpts lasted 180, 300, or 420 seconds. After listening to the excerpts and completing the cognitive task, the participants were asked to estimate retrospectively the duration of each excerpt and the cognitive task on the basis of three methods: verbal estimates (chronometric units), relative estimates of the three tasks based on the segmentation of a line, and estimates with line drawing in comparison with a standard line. Participants judged the duration of the joyful musical excerpt as longer than that of the cognitive task and systematically underestimated the duration of the cognitive task, i.e., judged it to be much briefer than it really was. This basic finding was consistent over the three methods. The sadness excerpt led to longer perceived duration than the cognitive condition only with the verbal and relative estimates methods. Also, there were systematic underestimations of long intervals and overestimations of short intervals in all conditions, except with the method involving a standard in the specific case of sadness. In general, there was more consistency between the verbal and relative methods than between the verbal method and the one based on the comparison with a standard.*


In spite of the ecological relevance of research on *retrospective timing*, this field has been neglected considerably in comparison with research on *prospective timing*. Retrospective timing refers to conditions where participants do not know in advance, i.e., before a period filled with various activities, that the duration of the period will have to be estimated (see for instance Brown & Stubbs, 1988; Eisler, Eisler & Montgomery, 2004; Zakay & Block, 2004). In most time perception research, participants are placed in conditions where they know in advance (prospective condition) that they will have to estimate intervals, which are usually very brief—from ms to a few seconds. However, in everyday life, people are often in situations where they try to estimate, from memory, the duration of certain past events. In the present study, we propose to assess the consistency of different methods for studying the retrospective timing of long intervals.

In addition to verbal estimates based on conventional chronometric units—a method limited by the tendency of participants to use rough approximations—the durations of the past periods to be estimated will be compared directly by dividing a line into three segments representing each of the three periods' length and will be estimated by drawing lines to contrast their length with a line segment representing a given time interval. It is important to test the appropriateness of different methods when studies involve a certain range of durations. When intervals are very short (say < 1 minute), it is reasonable to rely on the reproduction method, but with longer ones—especially when multiple durations are to be remembered—it easily becomes a boring task. As well, with very long intervals (say > 30 minutes), it is reasonable to rely on verbal estimates, i.e., on the use of chronometric units if intervals are long, but if they are short, the tendency of participants to round up to the nearest

10 seconds, if not to the nearest half minute, causes a large imprecision in estimates. The reader will find in Boltz (1995) an example where the estimation method in two experiments is changed as a function of the duration under investigation. Indeed, it was shown that, for retrospective timing, the reproduction method leads to much shorter estimates of time than the verbal estimate method when the investigation involves intervals lasting 48 or 144 s (Schiff & Thayer, 1968) or 200 s (Schiff & Thayer, 1970).

The literature on retrospective timing reveals that participants can recognize or reproduce the durations of sound sequences quite accurately, even when unaware at the moment of listening that judgments about duration will have to be made. Indeed, this finding applies well to natural sounds or melodies (see for instance Boltz, 1995). In the present experiment, music will be used to fill intervals to be remembered in retrospective timing conditions (Glicksohn & Cohen, 2000). Indeed, two types of music excerpts will be used, and will be contrasted with a "cognitive" condition (counting backward). Because there are, unlike music, no environmental cues in the cognitive task, it is expected that retrospective judgments about the duration of this task will be less accurate. The two music excepts will differ in their capacity to generate different emotions. One should generate joy, and the other sadness. It is expected that the cognitive task will not generate any specific emotion.

The purpose of the present experiment was to test the consistency of the results when obtained with three different methods for estimating retrospectively multi-minute intervals (3 to 7 minutes). The experimental design adopted will provide a comparison between musical and cognitive conditions, and a test of the influence of the emotional influence on remembered duration. The study was not designed to bring a final answer regarding the relative influence of these factors on time experience. We chose conditions that were expected to exert influence on retrospective judgments, and wanted to know to what extent different methods would reveal these effects consistently.

The present study was based on a strategy where participants first took part in three different activities, and only then were asked to estimate time. Such a strategy proved useful for investigating the mechanism involved in retrospective timing (e.g., Boltz, 2005; Brown & Stubbs, 1988; Grondin & Plourde, 2007).

## Method

*Participants*

Sixty (60) Laval University students, 47 females and 13 males, between 18 and 28 years of age volunteered to take part in the experiment. They received $7 for their participation. It should be noted that participants have the right to know, before an experiment, how long the experiment will last and what monetary compensation they will receive. In this case, they were informed that the experiment would last between 5 and 90 minutes and that they would receive $7 regardless of the duration. The experiment actually lasted about 55 minutes. Participants did not know in advance that they would have to judge durations, and they all signed a post facto participation form revealing the real purpose of the experiment.

*Material*

Participants were tested individually in a dimly lit room where they sat in a comfortable chair. Music was transmitted using an IBM computer and a CD and delivered through ear-phones (Technics, EAH-120). The computer was also used to complete the duration estimations. The cognitive task was timed by the experimenter with a chronometer (Timex CR 1620), and the participant was given a piece of paper and a pencil to write down the final score of the cognitive task (counting backward in steps of 3, starting at 3000).



Following Mayer, Allen and Beauregard (1995), joy was induced with three excerpts of different lengths from Bach's Brandenburg Concertos (No. 2, 1st movement). Because the longer target duration (420 s) was longer than the Bach piece we used (323 s), the piece was cut after 276 s and then resumed for 144 s. Following some pilot experimentation, Samuel Barber's Adagio for String, Op. 11, was chosen to induce sadness. Each excerpt was recorded on a CD. The Brief Mood Introspection Scale (BMIS) was used to estimate the emotional state.

*Procedure*

The research assistant first explained each of the conditions of the experiment to the participants. For the purposes of the experiment, the participants were asked to remove all jewelry, watches, mobile phones, and any other sources of distraction. The BMIS had to be completed at the beginning of the experiment, and after each condition. The retrospective estimates of duration were made only at the end, once each task (musical excerpts and cognitive) was completed.

There were three interval lengths to be estimated, 180, 300 and 420 s, and three emotional state conditions, joy, sadness and neutral (the cognitive task). The cognitive task was always presented between the joy and sadness conditions, and the presentation order of these two emotional conditions was balanced. The presentation order of interval lengths was also balanced (six possibilities). Therefore, there were 12 possible presentation orders, and 5 of the 60 participants were assigned to each of the 12 conditions.

In order to favor the emergence of an emotional mood, participants were invited, as recommended by Mayer et al. (1995), to use other techniques when they would be listening to music. For the joyful musical excerpts, they were invited to adopt strategies like smiling, humming, foot tapping and finger snapping; and for the sad ones, staying still, bending the head forward, sighing and frowning.

*Dependent variables*

In addition to the BMIS scores, four dependent variables (DV) based on three types of estimates were completed in the following order. The first estimate was based on a comparison of the tasks. On the computer screen, a 28.5-cm horizontal line, which was reported to be the total duration of the three tasks, was presented to participants. They were then asked to draw, with mouse clicks, two small vertical lines in order to divide the horizontal line into three segments, each representing, from left to right, the relative duration of the three portions of the experiment, i.e., the first musical excerpt, the cognitive task and the second musical excerpt. Each segment was then converted into chronometric units. The total length of the three segments represents the total duration of the three tasks: 180 + 300 + 420 s (i.e. 900 s). If the line was divided into three equal parts, they would each represent 300 s. For instance, for the activity lasting 180 s, the ratio of estimated time to real time would be 1.67.

The second type of estimate was based on the use of a 7-cm standard. Each participant assigned a numerical value (in chronometric units, seconds or minutes) to this standard, and was asked to draw 3 lines, each representing the duration (in comparison with the standard) of one of the three activities (music, calculation, music). More specifically, participants were asked to indicate two points on each line (the left end representing the 0 point), the first of which indicated the certainty that the activity was not shorter (minimal estimated duration), and the other the certainty that it was not longer (maximal estimated duration). It was possible to derive two DVs from these two points on each line: perceived duration, which resulted from the mean of the two points; and the variability of estimates, i.e., the difference between the points. Such a two-point strategy was applied in Grondin and Plourde (2007) with verbal estimates.

The last type of estimate was actually based on a verbal estimate of duration (in minutes and seconds, to the nearest 10 s) of the duration of each of three tasks.

## Results

The four BMIS estimates show that the higher scores—which indicate more joy—were obtained as expected after participants listened to the Bach excerpt, while the lowest scores were obtained after they listened to the other excerpt. An ANOVA with repeated measures confirmed that the differences between the conditions were significant, $F$ (3, 177), = 35.41, $p$ < .01, $\eta^2$= .38. The post hoc analysis ($t$ tests with Bonferroni corrections) revealed that the mean score after the sad excerpt ($M$ = 20.80, $SE$ = 0.57) was significantly lower than the three other scores, and that the mean score after the joyful excerpt ($M$ = 28.28, $SE$= 0.50) was significantly different from the baseline (before testing, $M$ = 25.78, $SE$ = 0.54) and from the results obtained after the cognitive task ($M$ = 24.57, $SE$ = 0.55). In brief, it is reasonable to assume that the emotional states were manipulated successfully.

To place the target durations on a common basis, a ratio of the estimated duration to the target duration was calculated to account for the perceived duration. Ratios higher than 1 indicate that time was perceived as being longer than the real duration. Because of the small sample in each cell ($n$ = 5) that would result from a full factorial design, we decided to analyze the effect of the emotional state separately from the effect of the duration length, on the basis of these ratios.

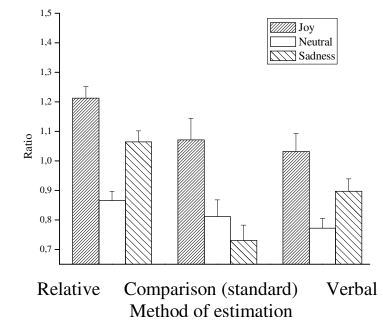
The ratios for each emotional state, with each method, are reported in Figure 1. First, and most importantly, for the verbal estimates and relative estimates conditions, the pattern was essentially the same: the duration was perceived as shorter in the neutral condition than in the other two conditions. For the standard method, the neutral task is underestimated, as is the case with the other methods, but time is more underestimated in the sadness condition than in the neutral condition, which was not the case with the other methods. Moreover, with all methods, the duration of the musical excerpt associated with joy was overestimated (ratio > 1), but for sadness, there was an overestimation only with the relative method.

Three ANOVAs with repeated measures, one for each method, conducted with the ratio revealed that the differences were significant, $F$(2, 118) = 35.08 (Relative estimates), 7.45 (Standard comparisons), and 8.85 (Verbal estimates) (all $p$s < .01, and $\eta^2$ = .37, .11 and .13, respectively). The post-hoc tests revealed that with relative estimates, both joyful and sad musical excerpts led to longer perceived durations than the neutral (cognitive) task, and the joyful excerpt was perceived as longer than the sad one. With the verbal estimates, duration was also estimated as shorter in the neutral condition than in the other two conditions, but there was no difference between joy and sadness. For the comparisons with a standard, duration was estimated as longer in the joy condition than in the other two conditions. Finally, note that a series of three 2 (emotions) x 2 (order) ANOVAs according to a split-plot design, one per method, revealed no significant order effect.

The ratios for each target length are presented in Figure 2 in order to illustrate, for each of the emotional conditions, the differences between methods. A series of nine one-way ANOVAs conducted to compare target length conditions indicated that there were significant differences in each case, except for the cognitive task (neutral condition) in comparison with a standard condition (see Table 1). Beyond the details of the post-hoc analyses, it is the general patterns that might be more informative. In 8 out of 9 conditions, the ratio for short intervals is much higher than the ratio for long intervals. The only exception is observed in the sadness condition with the Standard estimates.

Finally, although it is not possible to provide comparisons amongst methods, it is possible to report an estimate of the Weber fraction (WF). The estimate is based on the standard method. The WF was derived from the difference between maximum and minimum





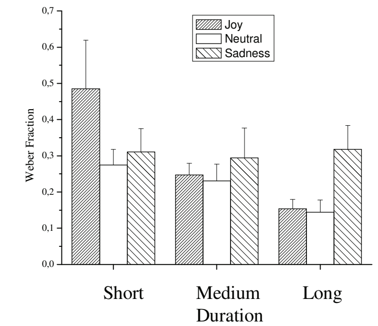




**Figure 1** (Left). The estimated duration to real time ratio for each emotional condition obtained with each estimation method. Bars are SE.
**Figure 3** (Right). The Weber fraction (Max-Min/Target duration) in each experimental condition estimated on the basis of the comparison with a standard method. Bars are SE.

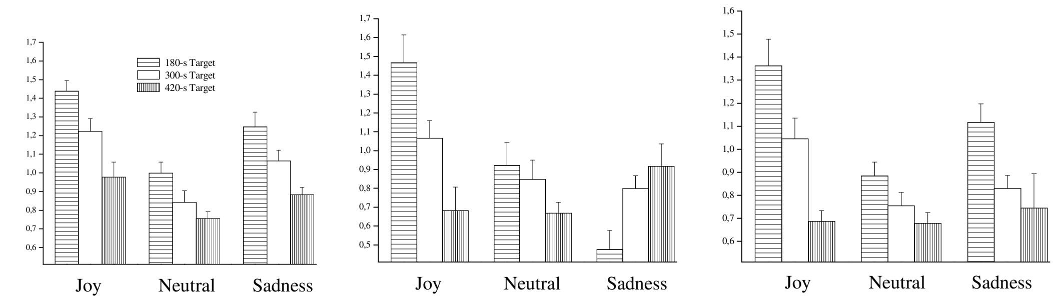



**Figure 2**. The estimated duration to real time ratio for each target duration (short = 180 s, mid-value = 300 s and long = 420 s) obtained in each emotional condition (Left : Relative estimates; Middle: Comparisons with a standard; Right: Verbal estimates). Bars are SE.

estimates, divided by the target duration (180, 300, and 420 s), and was estimated for each emotional condition. The WFs were .30 ($SE$ = .05) in the joy condition, .22 ($SE$ = .02) in the neutral condition, and .31 ($SE$ = .04) in the sadness condition, but the ANOVA revealed that the differences are not significant. On the other hand, for each emotional condition, the WFs (one for each target duration) were compared (see Figure 3). The ANOVAs revealed that there was a significant duration effect in the joy condition, $F$(2, 38) = 4.68, $p$ < .05, $\eta^2$ = .198, but not for the sadness condition. For the neutral (cognitive) condition, the effect was marginally significant, $F$(2, 38) = 2.83, $p$ = .071, $\eta^2$ = .130.

Finally, note that a 2 (emotions) x 2 (order) ANOVAs according to a split-plot design revealed no significant effect due to emotions, but the order effect, $F$(1, 58) = 15.36, $p$ < .01, $\eta^2$ = .21, and the order by emotion interaction, $F$(1, 58) = 5.93, $p$ < .05, $\eta^2$ = .09, were significant. The WF for joy and sadness are respectively .33 and .49 when presented first, and .26 and .12 when presented second.

**Table 1.**
Results of the ANOVAs ($F$ and $p$ value), with eta squared values ($\eta^2$), for the comparison of the ratios for each target length for each of nine case (3 emotional conditions by 3 methods)

| | Joy | | | Neutral | | | Sadness | | |
|---|---|---|---|---|---|---|---|---|---|
| | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ |
| Relative | 18.14 | .000 | .389 | 5.70 | .006 | .167 | 10.61 | .000 | .271 |
| Standard | 13.92 | .000 | .328 | 1.87 | .163 | .062 | 7.87 | .001 | .216 |
| Verbal | 14.50 | .000 | .337 | 3.32 | .043 | .104 | 9.04 | .000 | .241 |

## Conclusion

The duration of the joyful excerpt (ratio > 1 with each method) was estimated as longer than that of the sad excerpt. This tendency is consistent with previous results on the effect of music on time estimation. For intervals lasting 2.5 minutes, Kellaris and Kent (1992) showed that the positively valenced music leads to an over-estimation of time. However, from a more global perspective, these findings are inconsistent with those reported by Hornik (1992), where an elated mood led to an underestimation of time. Clearly, more work is needed to clarify the impact of emotions on retrospective timing.

Moreover, compared to real time, the duration of the cognitive task was systematically underestimated, with an estimated duration to real time ratio much lower than 1 (approximately .8). This feature of the findings, as well as the relative estimated duration of joyful and sad excerpts, applies with each method used to estimate duration. However, the data also reveal some differences between methods. First, the duration in the sadness condition was estimated as longer than that in the neutral (cognitive) condition with the relative and verbal estimates conditions, but not with the standard condition. Moreover, the mean estimates for the three tasks are much lower than 1 with the judgments based on a standard and with the verbal estimates, and slightly above 1 with the other (relative estimates) method.

The present study showed that the method of relative estimates can be used and will reveal, as do verbal estimates, the main effects under investigation and the same type of distortions when used in a context where unequal intervals are to be estimated by the same participants. The method based on comparisons with a standard might lead to slightly different results.

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# TEMPORAL LIMITS OF MEMORY FOR TIME


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## Abstract


*To further explore how memory influences time judgements, we will address the question of the life span of temporal representations in memory using the "memory-mixing" account of visual/auditory differences as a framework (Penney, Allan, Gibbon & Meck, 1998). In bisection tasks, these authors reported that the perceived duration of intervals differs according to the modality of the signals used for marking time. Modality differences only show up when there is a direct comparison of different marker-type intervals. In other words, the memory trace of previously processed intervals influences the perception of upcoming ones. In the present experiment, we manipulated the delay between auditory/visual signal presentations. In Condition 1, signals from the same modality were grouped by blocks of 60 trials; in Condition 2, visual and auditory signals were randomized across trials. Results show that the auditory/visual difference decreased when modalities were grouped by blocks, but remained present. In brief, 1) Penney et al.'s results were successfully replicated; 2) the critical role of memory for auditory/visual differences was highlighted by manipulating the delay; and 3) in this experimental context, the life span of a memorized interval is most likely inferior to the duration of a 60-trial block.*


Researchers in the time perception field have recently shown increasing interest in the memory mechanisms that underlie time judgements (e.g. Droit-Volet, Tourret & Wearden, 2004; Ivry & Spencer, 2004; Penney, Allan, Gibbon & Meck, 1998; Penney, Gibbon & Meck, 2000). Indeed, memory representations of temporal information could explain an important part of the variability of time judgements (Gibbon & Church, 1984; Grondin, 2005; Jones & Wearden, 2004), even if some authors have reported that the suppression of memory demands during a time perception task does not eradicate all scalar variability (Allan & Gerhardt, 2001; Rodriguez-Girones & Kacelnik, 2001; Wearden & Bray, 2001). Although the importance of memory in time processing is well established, little is known about one of its potential, critical limitations: the decay of memorized temporal representations.

The importance of the persistence of the memory trace is highlighted in the memory-mixing model account of auditory (A) vs. visual (V) perceived duration differences, as described by Penney et al. (1998, 2000). These authors reported a series of temporal bisection tasks using A and V signals. Participants were assigned to one of two modality-mixing paradigms: 1) both modalities mixed within a session or 2) different subjects for different modalities. In the latter paradigm, no perceived duration difference was observed according to the signals' modality. However, when participants experienced both types of signals, psychometric functions were shifted toward the right for visual signals compared to those in the auditory mode. In other words, participants tended to judge auditory signals as being longer than visual ones for equivalent physical durations.

This subjective duration distortion is argued to depend on two factors: the differential effects of the signal's input modality on the accumulation process, and the creation of an amodal memory distribution used as a reference (Penney, 2003). The underlying cause of the first factor remains unclear. The longer perceived duration of auditory signals relative to visual ones would be due to a greater temporal accumulation in the former case. This greater