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Philippe Verduyn, Francis Tuerlinckx & Kirsty Van Gorp

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Measuring the duration of emotional experience: the influence of actual duration and response format

Philippe Verduyn · Francis Tuerlinckx · Kirsty Van Gorp

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Abstract In a number of retrospective studies it has been found that the duration of emotional experience is highly variable and several determinants that account for this variability have been identified. However, two issues that may have consequences for the measurement of emotion duration have been left unaddressed. First, it is unclear whether people are capable of remembering the duration of their actual emotional experience. Second, it is uncertain whether estimates of the duration of emotional experience are influenced by the format of the response scale. Participants watched joy- and sadness-sustaining movie fragments of different durations. At the end of the day they were asked to estimate the duration of each fragment or the duration of their emotions during each fragment on a relatively short-range or long-range scale. Regardless of whether fragment or emotion duration was estimated, estimates were (a) largely accurate and (b) higher on long-range compared to short-range scales.

Keywords Emotion duration · Measurement · Accuracy · Response format · Scale range · Non-linear categorical data analysis

Emotions are inherently time dynamical processes as they change and evolve over time. This implies that the study of the temporal characteristics of emotions is a necessary condition in order to reach a full understanding of them. This claim is being made by an increasing number of authors (e.g., Davidson 1998; Eaton and Funder 2001; Frijda 2007; Hemenover 2003; Schimmack et al. 2000; Verduyn et al. 2009b).

One central temporal characteristic of emotions is their duration. It has been found that the duration of emotional experience is highly variable and a number of determinants that account for this variability have been identified (Scherer and Wallbott 1994; Sonnemans 1991; Verduyn et al. 2009a, 2011). However, two issues that may have consequences for the measurement of the duration of emotional experience have been left unaddressed. First,

P. Verduyn (✉) · F. Tuerlinckx · K. Van Gorp
University of Leuven, Leuven, Belgium
e-mail: philippe.verduyn@psy.kuleuven.be

is unclear whether participants are capable of remembering the duration of their emotions and, consequently, whether estimated emotion duration is related to actual emotion duration. Second, it is uncertain whether estimates of emotion duration are influenced by the format of the response scale. Below, we will elaborate on these two issues in more detail.

1 The relation between actual emotion duration and estimated emotion duration

In previous studies on the duration of emotional experience, participants were asked to recall an emotion and estimate its duration. This implies that in each of these studies a certain amount of time has passed between emotion occurrence and duration estimation. In a number of studies delay could be weeks, months or even years (Scherer and Wallbott 1994; Sonnemans 1991) whereas in other studies delay was limited to 1 day at most (Verduyn et al. 2009a, 2011). Notwithstanding these differences, in each study it was implicitly assumed that respondents were capable of remembering the duration of their emotions.

One may wonder whether this assumption is valid as memory decreases over time (e.g., Schacter 1999). The accuracy of estimates of emotion duration has never been directly examined which gives cause for concern, as it obscures the validity of the findings that were obtained on the duration of emotional experience. Only some indirect evidence is available. In particular, in a number of retrospective time estimation studies it has been found that respondents are rather accurate at estimating the duration of emotional stimuli even though the specific emotional nature of the event may influence duration estimation (e.g., Campbell and Bryant 2007; Kellaris and Kent 1992; Kellaris and Mantel 1994; Loftus et al. 1987).

However, one should be careful when generalizing findings regarding estimation of the duration of emotional events to estimation of the duration of emotional experience for two reasons. First, in studies on emotion duration participants have typically been asked to estimate duration some time after the emotion had occurred, whereas in studies on the estimated duration of emotional stimuli they have typically been asked to provide an estimation almost immediately after stimulus offset. Second, in contrast to emotional events, emotional experiences are internal states, which may be more difficult to estimate the duration of. As such, it is important to study the accuracy of emotion duration estimates per se in addition to the accuracy of duration estimates of emotional stimuli. This is not an easy task as it is impossible to obtain an objective measure of the duration of a subjective state such as emotional experience. However, we reasoned that the duration of an emotional stimulus could serve as a proxy for the duration of an emotional experience provided that the stimulus was constructed to sustain the emotion during exposure. Under such circumstances, a high degree of correspondence between the duration of the emotional stimuli and respondents' duration estimates of their emotional experiences, would reflect their capacity to remember the duration of their emotions.

2 The relation between response format and estimated emotion duration

In studies on the duration of emotional experience, participants were typically asked to estimate duration by indicating a time interval on a response scale (Scherer and Wallbott 1994; Sonnemans 1991; Verduyn et al. 2009a, 2011). In each of these studies, scales consisted of multiple intervals but the values of the intervals differed across studies. For example, duration has been measured on a scale of 2 h divided in eight intervals of 15 min (Verduyn et al.

2009a, Study 1) and on a scale of 1 h divided in six intervals of 10 min (Verduyn et al. 2009a, Study 2).

However, the choice for a particular set of time-intervals may not be without a consequence as respondents may extract information out of the format of the response scale. In particular, respondents assume that researchers construct meaningful scales and, consequently, the midpoint of the scale is typically considered the 'normal' alternative whereas the end points of the scale are considered the 'extreme' alternatives (Schwartz 1999). As a result, higher ratings are sometimes obtained when measuring constructs by long-range scales compared to short-range scales. In particular, scale effects of this nature have been observed for a range of behaviors, including sexual behavior (Schwartz and Scheuring 1988), consumer behavior (Menon et al. 1995) and reports of physical symptoms (Schwarz and Scheuring 1992).

One may wonder whether the format of the response scale also influences estimates of emotion duration. A comparison of the duration distributions that were obtained in previous studies on emotion duration provides indirect evidence that this may indeed be the case. In particular, higher duration estimates were obtained when the scale range was 2 h (Verduyn et al. 2009a, Study 1) compared to 1 h (Verduyn et al. 2009a, Study 2). However, as these studies differed in multiple regards the differences in duration distributions may also be due to other factors (e.g., participant or emotion characteristics). In order to get a better understanding of the influence of response format on emotion duration estimates, this factor needs to be systematically manipulated while other factors need to be controlled for.

3 Overview of the present study

The aim of the present study was twofold. A first aim was to examine the accuracy of estimates of the duration of emotional experience. For this purpose, respondents were exposed to a relatively brief and a relatively long joy-sustaining movie fragment, and a relatively brief and a relatively long sadness-sustaining movie fragment. At the end of the day participants were asked to estimate the duration of each fragment or the duration of their emotions during each fragment. We hypothesized that, regardless of whether fragment or emotion duration was estimated, duration estimates would closely resemble the actual duration of the movie fragments.

A second aim was to examine whether duration estimates are influenced by the format of the response scale. For this purpose, participants were asked to provide duration estimates on a relatively short-range scale or a relatively long-range scale. We hypothesized that, regardless of whether fragment or emotion duration was estimated, duration estimates would be higher on long-range compared to short-range scales.

4 Method

4.1 Participants

Participants were 151 university of Leuven students who participated in order to receive course credits. Eighteen participants did not provide time estimations at the end of the day, leaving a final sample of 133 participants (113 women and 20 men). The mean age of the participants is 18.3 ($SD = 1.1$).

4.2 Materials

4.2.1 Fragments description

Each movie fragment was preceded by a brief description of it. This provided participants the necessary background information to understand what happened from the very beginning such that the target emotion could be elicited immediately after exposure onset.¹

4.2.2 Fragments

Each fragment was constructed with the aim to maximally sustain the target emotion during exposure (non-emotional parts were cut out) such that the duration of the fragment could serve as an approximation of the duration of the target emotion during fragment exposure. A first movie fragment of 4 min was extracted from the movie *when Harry met Sally* (1989) to sustain a feeling of joy for a relatively short amount of time. A second movie fragment of 13 min was extracted from the TV-show *Friends* (2009) to sustain a feeling of joy for a relatively long amount of time. A third fragment of 4 min was extracted from the movie *Titanic* (1997) to sustain a feeling of sadness for a relatively short amount of time. A fourth fragment of 13 min was extracted from the movie *The Champ* (1979) to sustain a feeling of sadness for a relatively long amount of time.²

4.2.3 Emotion ratings

After each movie fragment, participants were asked to indicate to what degree they experienced joy and sadness while watching the movie fragments on a five-point scale (0 = not at all, 1 = a little, 2 = moderately, 3 = strongly, 4 = very strongly).

4.2.4 Duration ratings

Duration ratings were made on a short-range scale or a long-range scale. The short-range scale ranged from 0 to 15 min and was divided in five intervals of 3 min with an additional option of *longer than 15 min*. The long-range scale ranged from 0 to 30 min and was divided in five intervals of 6 min with an additional option of *longer than 30 min*.

4.3 Procedure

Upon arrival in the lab, participants were informed that they would be shown a series of movie fragments on a computer screen. Next, any devices that could provide time information were removed. In particular, they were told to hand in their watch, cell phone and any other devices that could distract them because they were expected to pay full attention when watching the movie fragments. Subsequently, participants were seated in front of a screen and the movie fragments were presented in randomized order. After each movie fragment, participants were first asked to rate to what extent they experienced joy and sadness during the movie fragment and, subsequently, were asked to perform a number of filler tasks (i.e., filling out a number of personality questionnaires) in order to avoid that the emotion elicited by the preceding fragment would interfere with the emotion elicited by the following fragment. After they

¹ The descriptions are available from the corresponding author upon request.

² The fragments are available from the corresponding author upon request.

had seen all movie fragments participants were provided a web address and were asked to surf to that website later that evening (after 8.00 pm). The average delay was 7.5 h. When visiting the website participants were asked to estimate the duration of each movie fragment or the duration of their experience of the target emotion during each movie fragment on a short-range or long-range scale.

4.4 Data analysis

Participants respond with discrete categories. As is common in the statistical treatment of categorical data (see e.g., Agresti 2002; De Boeck and Wilson 2004), we assume that categorical responses emerge as a discretization of an underlying continuous latent variable. In the context of the experiment, we assume there exists a continuous latent subjective duration distribution ranging from 0 to an upper limit such that, for instance, if the duration is between 0 and 3 min the response in the first category is emitted. Because we want to be very flexible with respect to the underlying continuous duration, we consider a scaled beta distribution as the latent subjective continuous duration distribution. The scaled beta can be symmetric around its mean, but also skewed to the right or to the left and this gives sufficient flexibility to model a variety of possible duration distributions. Usually, the beta distribution extends from 0 to 1, but we look at a scaled version that has the rightmost point of the upper category of the long-range scale as its upper limit (i.e., 36 min as an approximation of longer than 30 min). An additional asset of this approach is that the data obtained from the two different response scales are taken into account in a single model.

The scaled beta distribution is characterized by two parameters a and b that determine the mean and the variance of the distribution. These parameters are estimated from the data using maximum likelihood (ML; i.e., optimal values are shown such that the likelihood of the observed frequencies in the interval scale cells is maximal). The significance of the effects is then evaluated using a parametric bootstrap procedure (Efron and Tibshirani 1993): New data are simulated from the estimated parameters, the parameters are re-estimated and the re-estimated parameters are subjected to an ANOVA decomposition.

To make it more tangible, assume for example we want to evaluate whether the effect of the duration factor (short vs. long fragment) is significant. We simulate B new data sets (with $B = 500$) using the ML parameters, we re-estimate for each simulated data set the parameters and then we compute in how many cases for the estimated data sets the mean durations in the long condition are longer than in the short conditions. In order to evaluate the main effect of duration, we have to look at marginal means. However, the model is intrinsically nonlinear: The data cannot be decomposed additively into a grand mean, main effect parameters, interaction parameters and a normally distributed error term. Instead, the observations are truncated manifestations of a beta distributed random variable and depend in a complicated way on the parameters a_j and b_j . In order to cope with this nonlinearity, we subject the natural logarithm of every parameter a_j (resp. b_j) to an ANOVA type of decomposition in main effects and interaction effects. The logarithm is taken because the parameters are restricted to be positive, while an ANOVA decomposition is additive and may lead to negative values. The way we treat the parameters is similar to what is done in generalized linear models (see Agresti 2002) although our model does not belong to this class (because of the beta distribution). In such a way, we can summarize the duration main effect by calculating the expected duration for long and short fragments by taking into account only the main effect parameters that affect $\log(a)$ (resp. $\log(b)$). The proportion of times that the simulated main effect difference is larger than the observed one is the estimated p value. The reported p values can be interpreted in a similar way as for traditional ANOVA applications (with the

only difference that the underlying model is not normal but scaled beta). Another advantage of using the bootstrap method, is that we are also able to examine whether the manipulated factors in the experiment also have an effect on the bias (i.e., difference between estimated duration and actual fragment duration) and the standard deviation of the duration estimates.

5 Results

5.1 Manipulation checks

5.1.1 Presence of target emotion

In the large majority of cases the target emotion was experienced while watching the movie clip (i.e., ratings higher than zero). In particular, while watching (a) the short positive movie in 87% of the cases joy was experienced, (b) the long positive movie in 98% of the cases joy was experienced, (c) the short negative movie in 87% of the cases sadness was experienced, (d) the long negative movie in 95% of the cases sadness was experienced. If the target emotion was not felt during the movie fragment, the data were excluded from all further analysis.

5.1.2 Intensity of target emotion if present

The mean and standard deviation of the intensity of joy and sadness during the movie fragments is presented in Table 1 if the target emotion was experienced while watching. In each case the target emotion was of moderate to strong intensity.

5.2 Duration estimates

The means, biases and standard deviations of the estimated fragment and emotion duration are presented in Table 2. First, we will focus on the estimated duration of the fragments and subsequently on the estimated duration of the target emotion experienced during the fragments.

5.2.1 Fragment duration

5.2.1.1 Statistics calculated over cells Inspection of the mean, bias and standard deviation shows that fragment duration is overall accurately estimated. Indeed, the difference between the average duration estimate and the actual average fragment duration was not significant (95% confidence interval: $[-0.71$ to $0.26]$)

Table 1 Ratings of intensity of joy and sadness if the target emotion was experienced while watching the movie fragment

	Short movie				Long movie			
	Positive		Negative		Positive		Negative	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Joy	2.37	0.78	0.24	0.54	3.04	0.78	0.17	0.42
Sadness	0.06	0.30	2.28	1.03	0.07	0.28	2.75	1.02

Table 2 Mean, bias and standard deviation of estimates of fragment and emotion duration calculated over cells, by factor level and by cell

				Estimated duration					
	Factor			Fragment			Emotion		
	Emotion	Duration	Scale-range	Mean	Bias	SD	Mean	Bias	SD
<i>Over cells</i>									
	–	–	–	8.28	–0.22	3.27	8.24	–0.26	4.94
<i>By factor level</i>									
	Joy	–	–	8.23 _a	–0.27 _a	3.28 _a	9.06 _a	0.56 _a	4.66 _a
	Sad	–	–	8.32 _a	–0.18 _a	3.05 _a	7.47 _b	–1.03 _b	4.93 _a
	–	Long	–	11.73 _a	–1.27 _a	3.50 _a	10.77 _a	–2.23 _a	5.51 _a
	–	Short	–	5.60 _b	1.60 _b	2.68 _b	6.15 _b	2.15 _b	4.04 _b
	–	–	Long	9.08 _a	0.58 _a	4.70 _a	10.42 _a	1.92 _a	6.59 _a
	–	–	Short	7.52 _b	–0.98 _b	2.09 _b	6.40 _b	–2.10 _b	3.36 _b
<i>By cell</i>									
	Joy	Long	Long	13.17	0.17	4.58	14.43	1.43	7.32
	Joy	Long	Short	10.88	–2.12	2.70	9.67	–3.33	3.83
	Joy	Short	Long	5.55	1.55	4.86	7.92	3.92	4.56
	Joy	Short	Short	5.22	1.22	1.85	5.61	1.61	3.61
	Sad	Long	Long	12.57	–0.43	5.48	12.32	–0.68	8.26
	Sad	Long	Short	10.42	–2.58	2.42	7.43	–5.57	3.82
	Sad	Short	Long	6.72	2.72	3.95	7.89	3.89	6.84
	Sad	Short	Short	5.04	1.04	1.63	3.96	–0.04	2.53

Note Numbers in consecutive rows that do not share subscripts differ at $p < 0.05$

5.2.1.2 Statistics calculated by factor level Inspection of the means shows no main effect of valence, a main effect of fragment duration and a main effect of scale type. In particular, estimates were similar for positive and negative fragments, higher for long compared to short fragments and higher on long-range compared to short-range response scales. Inspection of the biases further shows that (a) the duration of long fragments is underestimated (95% confidence interval: [–1.96 to –0.55]) whereas the duration of short fragments is overestimated (95% confidence interval: [0.93–2.17]), and (b) estimates provided on long-range scales reflect non-significant overestimations (95% confidence interval: [–0.49 to 1.49]) whereas estimates provided on short-range scales reflect underestimations (95% confidence interval: [–1.42 to –0.50]). Finally, differences in standard deviation depending on fragment duration and scale type were also observed. In particular, the standard deviation was higher for long compared to short fragments and higher on long-range scales compared to short-range scales.

5.2.1.3 Statistics calculated by cell Inspection of the means and biases calculated by cell shows no interaction between valence and fragment duration ($p = 0.12$), no interaction between valence and scale type ($p = 0.77$) and no interaction between fragment duration

and scale type ($p = 0.89$). As such, the main effects reported above can be interpreted straightforwardly.

5.2.2 Emotion duration

5.2.2.1 Statistics calculated over cells Inspection of the mean, bias and standard deviation shows that estimated emotion duration corresponds on average closely to actual fragment duration. Indeed, the difference between the average emotion duration estimate and the average fragment duration was not significant (95% confidence interval: $[-1.04$ to $0.37]$).

5.2.2.2 Statistics calculated by factor level Inspection of the means calculated by factor level shows a main effect of valence, a main effect of fragment duration and a main effect of scale type. In particular, estimates were higher for positive than negative fragments, higher for long compared to short fragments and higher on long-range compared to short-range scales. Inspection of the biases further suggests that (a) the duration of positive and negative emotions tends to be respectively slightly overestimated (95% confidence interval: $[-0.39$ to $1.46]$) and underestimated (95% confidence interval: $[-1.99$ to $0.02]$) even though these biases are not significantly different from zero, (b) the duration of short and long emotions is respectively overestimated (95% confidence interval: $[1.28$ – $3.06]$) and underestimated (95% confidence interval: $[-3.38$ to $-1.19]$), and (c) estimates provided on long-range scales and short-range scales are respectively overestimations (95% confidence interval: $[0.49$ – $3.21]$) and underestimations (95% confidence interval: $[-2.74$ to $-1.41]$). Finally, differences in standard deviation depending on fragment duration and scale type were also observed. In particular, the standard deviation was higher for long compared to short fragments and higher on long-range compared to short-range scales.

5.2.2.3 Statistics calculated by cell Inspection of the means and biases calculated by cell shows no interaction between valence and fragment duration ($p = 0.17$), no interaction between valence and scale type ($p = 0.76$) and no interaction between fragment duration and scale type ($p = 0.89$). As such, the main effects reported above can be interpreted straightforwardly.

6 Discussion

In studies on the duration of emotional experience (Scherer and Wallbott 1994; Sonnemans 1991; Verduyn et al. 2009a, 2011) it has implicitly been assumed that respondents are capable of remembering the duration of their emotions as in each of these studies a certain amount of time passed between emotion occurrence and duration estimation. A first aim of the present study was to examine the validity of this assumption.

6.1 The relation between actual emotion duration and estimated emotion duration

Respondents' capacity to remember the duration of emotions can be inferred from two sources of information. A first source of information is the accuracy of respondents' estimates of the duration of emotional stimuli. In the present study it was found that respondents are largely accurate at estimating the duration of emotional stimuli at the end of the day during which

they were confronted with the stimulus. Indeed, the average estimated stimulus duration closely corresponded to the actual average duration.

However, closer inspection of the results shows that respondents have a tendency to somewhat overestimate the duration of relatively short emotional stimuli and slightly underestimate the duration of relatively long emotional stimuli. A similar relation between actual duration and estimation duration was already found by Vierordt (1868) for non-emotional stimuli more than one century ago and has been called Vierordt's law. More recently, the validity of Vierordt's law was again demonstrated in a study by Yarmey (2000). The present findings show that Vierordt's law also hold for the estimated duration of emotional stimuli and, more important in the present context, suggests that the duration of relatively short emotions may in general be somewhat overestimated whereas the duration of relatively long emotions may be somewhat underestimated.

A second source of information is the accuracy of respondents' estimates of the duration of their emotions during emotional stimuli that were constructed to sustain an emotion during exposure. In the present study it was found that, on average, estimates of emotion duration closely correspond to actual fragment duration. This suggests that respondents are capable of remembering the duration of their emotions.

However, similarly to estimated fragment duration, it seems that the duration of short emotions is somewhat overestimated whereas the duration of long emotions is somewhat underestimated. This provides further evidence that Vierordt's law may also hold for estimated emotion duration. This claim should be made cautiously though especially the part regarding the underestimation of long emotions as fragment duration is only an approximation of emotion duration. The observation that emotion duration estimates during long fragments are lower than actual fragment duration may reflect actual underestimation of emotion duration but also that the target emotion was not constantly activated during fragment exposure. This may further also imply that the observation that emotions during positive fragments are remembered as longer than emotions during negative fragments reflects that positive emotions were better sustained during fragment exposure than negative emotions (especially since no difference in estimated fragment duration between positive and negative fragments was found).

In sum, respondents seem capable of accurately remembering the duration of their emotions. Even though the present findings suggest that short emotions are somewhat overestimated and long emotions somewhat underestimated, it was found that estimates were largely accurate. However, duration estimates were not only influenced by actual duration but also by response scale format. The results regarding the influence of this factor on emotion duration will be discussed below.

6.2 The relation between response format and estimated emotion duration

In previous studies on the duration of emotional experience participants were typically asked to estimate duration by indicating a time interval on a response scale. The values of the intervals differed across studies and a second aim of the present study was to investigate whether response format influences remembered emotion duration especially since some indirect evidence is available that this may be the case (Verduyn et al. 2009a). In line with our expectations, it was found that the choice for a particular response scale is not without a consequence. In particular, even though respondents remember differences in duration between relatively short and long fragments or emotions regardless of scale range, both relatively short and long estimates are higher on long-range compared to short-range scales.

The present finding that absolute estimates of emotion duration are influenced by scale range implies that one should be careful when interpreting emotion duration distributions and comparing these over studies. Differences between studies do not necessarily only reflect actual differences in experienced emotion duration but may partially be caused by differences in response scales. However, the observation that participants are capable of remembering differences in duration regardless of the nature of the response scale implies that the use of interval scales poses no major problems when studying determinants of emotion duration as correlations are not affected by horizontal shift of the distribution of the dependent variable.

6.3 Conclusion and future studies

The present study contains evidence that estimates of emotion duration are influenced by both actual emotion duration as well as response format. Obviously, this study is only a first step on the road towards a better understanding of the accuracy of emotion duration estimates. One way to extend the present findings, would be to use a broader set of emotional stimuli covering a larger range of durations.

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