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Does Time Fly When You Are Having Fun? A Day Reconstruction Method Analysis

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Abstract

Duration-based measures of happiness from retrospectively constructed daily diaries are gaining in popularity in population-based studies of the hedonic experience. Yet experimental evidence suggests that perceptions of duration – how long an event lasts – are influenced by individuals' emotional experiences during the event. An important remaining question is whether observational measures of duration outside the laboratory setting, where the events under study are engaged in voluntarily, may be similarly affected, and if so, for which emotions are duration biases a potential concern. This study assesses how duration and emotions co-vary using retrospective, 24-hour diaries from a national sample of older couples. Data are from the Disability and Use of Time (DUST) supplement to the nationally representative U.S. Panel Study of Income Dynamics. We find that experienced wellbeing (positive, negative emotion) and activity duration are inversely associated. Specific positive emotions (happy, calm) are not associated with duration, but all measures of negative wellbeing considered here (frustrated, worried, sad, tired, and pain) have positive correlations (ranging from 0.04 to 0.08; $p < .05$). However, only frustration remains correlated with duration after controlling for respondent, activity and day-related characteristics (0.06, $p < .01$). The correlation translates into a potentially upward biased estimate of duration of up to 10 minutes (20%) for very frustrating activities. We conclude that estimates of time spent feeling happy yesterday generated from diary data are unlikely to be biased but more research is needed on the link between duration estimation and feelings of frustration.

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Keywords

Subjective well being; day reconstruction method; measurement; older adults; activity duration; time use

INTRODUCTION

Social and psychological research studies often ask participants to make subjective assessments about time. Yet perceptions of the duration of events can be far from accurate. Indeed, a growing body of experimental evidence suggests that duration judgments may be affected by individuals' feelings elicited during the experience (Droit-Volet and Meck, 2007). In an early study, Thayer and Schiff (1975), for example, asked participants to estimate elapsed time in a neutral condition and in an experimental condition while gazing at another person who was either smiling or scowling. The authors found that scowling faces yielded significantly longer durations than smiling faces. More recently, Droit-Volet et al. (2004) demonstrated that viewing angry faces caused event durations to be perceived as longer than normal and Yamada and Kawabe (2011) showed that this phenomenon holds even when the negative emotional stimuli are subliminal. Other studies have focused on overestimation of elapsed time as a consequence of experimental conditions that may elicit negative emotion, such as facing a barrier to a desired goal, task interruption, waiting watchfully for an event to occur, or being challenged with unfamiliar, cognitively challenging tasks (Quigley et al., 1984; Schiffman and Greist-Bousquet, 1992; Block et al., 1980; Liu & Wickens, 1994). On face value, such evidence appears consistent with the old adage "time flies when you're having fun"; yet, interpretation and generalizability of such findings remains limited given that the triggering of *particular* emotions (e.g., happiness, worry, frustration) has not been a focus *per se*.

Other experiments suggest that individuals with depressive symptoms perceive time as passing more slowly (Kitamura and Kumar 1982), less accurately discern longer intervals (Sévigny et al., 2003), and judge signal durations in inverse proportion to their depression scores (Gil and Droit-Volet, 2008). Several potential mechanisms have been put forth to account for these findings (Block, 1990; Droit-Volet and Meck, 2007): activation of different feelings may, for example, impair the ability to maintain attention to elapsing time, may fundamentally distort the internal mechanism perceiving time (one's "internal clock"), and/or may influence the memory of the experience.

Irrespective of the underlying mechanism, if positive and negative feelings influence how long events seem to last in experimental settings, there may be implications for observational studies interested in measuring duration in general, and duration of specific states of wellbeing in particular. Indeed, increasingly, population-based studies are using retrospective daily diaries based on the Day Reconstruction Method (DRM; Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004) to generate duration-based measures of experienced wellbeing. The DRM was designed to facilitate the recall of details of autobiographical events over the past day, including experienced emotions. The approach first asks respondents to recall what they did yesterday, for how long, where they were, and

with whom; after reinstating the memory of the activity, respondents are asked to recall how they felt while engaged in the activities they had recalled. Assessments of experienced wellbeing from the DRM have been found to be highly correlated with ecological momentary assessments in which participants are contacted at random intervals, usually via mobile timers, and asked to report on how they feel at that moment (Dockray et al., 2010).

The DRM is a powerful tool in part because it provides measures of the proportion of the day spent in various moods (Stone et al. 2006; Krueger, 2007; Schwarz et al., 2009; Freedman et al., 2012) or with particular somatic symptoms such tiredness or pain (Krueger and Stone, 2008). However, the experimental evidence to date raises the methodologically important question: are DRM-based measures of experienced wellbeing on the previous day systematically biased? That is, are duration-based measures of positive emotion systematically under-estimated and those quantifying negative experiences overstated? A related question is whether the *type* of emotion matters – in other words, is (positive, negative) valence *per se* linked to duration assessments or do specific feelings matter?

Unlike experimental methods where the emotions triggered are non-specific, the DRM provides an opportunity to study the link between specific emotions and duration reports. However, in the absence of an experimental design, the events under study are engaged in voluntarily. Hence, the causal direction between the two is not known *a priori*: experienced wellbeing might influence duration reports (one was very frustrated, so the activity seemed to take a long time) or duration might influence experienced wellbeing (it took a long time, which led to high levels of frustration). In addition, actual duration is typically not known in more naturalistic settings, so the accuracy of duration judgments is not possible to establish. Nevertheless, by using modeling techniques that do not impose directionality on the linkage and by controlling for detailed characteristics of the individual, activity, and day, we can explore correlations between experienced wellbeing and activity duration. Statistically significant correlations raise the possibility (although not definitive evidence) of bias in duration estimates.

Using diary data from a national sample of several hundred older adults, we investigate these correlations, before and after controlling for respondent-related and activity-related factors that might influence both. We begin with investigating a non-specific measures of emotion (one that takes into account both strength and valence) and then explore whether there are differences for five specific types of emotions (happy, calm, sad, frustrated, worried) and two somatic symptoms (pain, tiredness). We hypothesize that duration will be inversely associated with positive and directly associated with negative descriptors. Furthermore, we expect that these correlations are observed over and above respondent-, activity-, or day-related characteristics. To the extent that correlations are accounted for by these characteristics, we also explore which sets of factors matter.

DATA AND METHODS

Data

Data for this study come from the Disability and Use of Time (DUST) supplement to the 2009 Panel Study of Income Dynamics (PSID), a longitudinal study of a representative

sample of families in the United States that began in 1968. Between 1968 and 1997 families were interviewed annually and have been interviewed every two years since then. Re-interview rates have been consistently 98% per year (96% over 2 years) and the sample of families now exceeds 8,000. Because adult children who have left their parents' households have been followed, the design produces a nationally representative cross-section of families each year, with sampling weights. (See Freedman and Cornman, 2012, for additional details).

The DUST instrument was administered to couples in the PSID in which at least one spouse was age 60 or older.¹ Couples in which one or both spouses had a chronic condition that limited their daily activities (based on information collected in the 2009 PSID) were oversampled, and strata further divided by the husband's age (<70, 70+). Of the 543 eligible couples who were sampled for DUST, at least one diary was completed with 394 couples, yielding a response rate of 73%.

DUST interviews took place by telephone over a few months following the 2009 core PSID interview. Each respondent was interviewed twice about their activities on one randomly assigned weekday and one randomly assigned weekend day. These activity questions were modeled after the American Time Use Study (Bureau of Labor Statistics, 2011) and the emotion questions were modeled after the Day Reconstruction Method (Kahneman et al., 2004) and Princeton Affect and Time Study (Krueger, 2007). The diary asked about all the activities occurring on the previous day, beginning at 4 am and continuing until 4 am the morning of the interview. The final number of diaries completed was 1,506.

After the diary was completed, respondents were asked more detailed questions about how they felt for up to three randomly selected times during the day (hereafter referred to as detailed wellbeing). The times were randomly selected from three windows (8 am–11:59 am; 12:00 pm–3:59 pm and 4:00 pm–8:00 pm), ensuring distribution throughout the waking day. Across all diaries, 4,365 activities had information on detailed wellbeing.²

Outcomes

Information on duration of activities was collected in the diary. Respondents could either report the exact time activities ended (e.g., until 2:30 pm) or they could report for how long they were doing an activity (e.g., 30 minutes). For the former, durations were calculated by subtracting the activity end time from its start time. Duration was known (60% of activities) or calculated (40%) for all activities for which detailed wellbeing was collected. For approximately 6% of activities (N=250), start time, end time or duration was assigned during the editing process. Most often this information was filled in because two sequential activities were erroneously recorded on one line (e.g. showered and got dressed) or because travel to an activity was included with the activity (e.g. went to get gas). Both types of errors required splitting a single activity into multiple activities, and thus filling in an end time for the first and start time for the second activity. We investigated the sensitivity to the omission

¹Both spouses had to be at least age 50 as of December 31, 2008 and at least one spouse age 60 or older at that time. Because the vast majority of married men and women ages 60 and older have spouses that are age 50 and older, the sample essentially represented married people ages 60 and older and their spouses.

²<1% of activities (N=27) were omitted because the respondent was sleeping or did not report what they were doing.

of cases with edited times and found essentially identical results regarding correlations before and after control variables were introduced, so we present results for the full sample here.

Additional detail on how the respondent felt was collected for up to three randomly selected activities. The diaries included details on five emotions (calm, happy, sad, frustrated, and worried) and two common somatic symptoms (how tired and how much pain). The items were chosen with the aim of obtaining more negative than positive descriptors (because negative emotions are less correlated than positive) and making sure each quadrant of the emotion circumplex (positive/negative and high/low activation) was represented (Russell, 2003). Respondents were asked to report how intensely they each emotion and symptom on a scale from 0 to 6, where 0 meant not feeling the emotion at all and 6 meant the feeling was very strong. In the few cases where a respondent reported that they don't know or refused to provide a number (N=14), we assigned the modal value for that descriptor.

From the detailed information we created a nonspecific measure that reflected the score for the strongest emotion. Cases with the strongest emotion calm or happy received positive scores and those with negative descriptors (sad, frustrated, worried, pain, tired) the strongest were reverse coded. For example, for a respondent whose strongest emotion was happy with a rating of 4, the summary measure was coded as +4. However, if the strongest emotion was frustration and the respondent rated the emotion a 5, the summary measure was reverse coded as -5. Ties were given to the negative emotion. We also examine separately each of the individual measures of experienced wellbeing.

Controls—We controlled for characteristics of the respondent, the activity, and the previous day that could account for the correlation between detailed wellbeing and duration of activities. Respondent characteristics included sex, age (<60, 60–69, 70–79, and 80+), an indicator of economic status (wealth quartile), and a dichotomous indicator of whether the respondent reported having a disability. Disability was defined as reporting difficulty hearing, seeing, concentrating/remembering, walking and climbing, dressing and bathing, or doing errands alone (Weathers, 2005).

We also included characteristics of the randomly selected activity, including type of activity (in 20 categories, with travel the omitted category in models for ease of interpretation); whether duration was reported using the exact time (vs. the length of time the activity took); with whom the activity was done (with a spouse, with others, alone); the time of day (morning, afternoon, or evening); where the activity took place (at home, other places); and whether another (secondary) activity was reported at the same time.

Variables that described the previous day included whether it was a weekend day or weekday; whether the respondent considered the day to be a typical day; the total number of activities reported yesterday; and whether the respondent reported their sleep as poor the night before the interview (which might influence emotions and durations on the diary day) and the night before the diary day (which might influence recollection of the previous day).

Analytic Strategy

We first examine bivariate correlations among duration and the strongest emotion as well as each individual emotion. Next, we use the seemingly unrelated regression (SUR) model framework (Zellner, 1962) to produce estimates of the correlations after controlling for respondent-, activity-, and day-related characteristics. SUR models consist of two or more regression equations each with their own outcome variable and a set of explanatory variables. For example, our first system of equations include two ordinary least squares (OLS) models, one for activity duration (in minutes) and one for the strongest emotion (−6 to 6). The remaining 7 systems paired the duration model with a model for each detailed measure of experienced well-being (e.g. calm, happy, etc.).

Unlike independent regression models, the SUR model provides an estimate of the correlation of the residuals from the two models, ρ , which may be interpreted as the correlation between duration and wellbeing, net of factors in the models. We calculated ρ as:

$$\rho = \frac{\text{cov}(r_1 r_2)}{\sqrt{\sigma_{r1} \sigma_{r2}}}$$

where $\text{cov}(r_1 r_2)$ is the covariance of the residuals from the two models, and σ_{r1} and σ_{r2} are the variance of the residuals from the duration and wellbeing models, respectively. We include a test for significance of ρ by calculating its standard error using the delta method. The test statistic,

$$\frac{\rho}{SE(\rho)}$$

approximates a t-test and, therefore, a value of 1.96 is used to determine statistical significance at the 0.05 level. In addition to assessing the residual correlations before and after controlling for all the predictors at once, we also examined models that included subsets of predictors to understand which sets of factors may account for the correlations between duration and detailed wellbeing. Analyses were conducted in Stata 11.0 using MYSUREG (Gould et al., 2010).

Sample weights were used to preserve the external generalizability of results to older married adults. Because longer activities had a proportionately greater chance of being selected for these detailed analyses, the sample weight applied to all analyses includes an adjustment to correct for this length bias. Standard errors were also adjusted for DUST's complex survey design. See the DUST User's Guide for details (Freedman and Cornman, 2012).

RESULTS

Description of Activities

On average, activities are reported to last 50 minutes (see Table 1). The strongest felt emotion has a mean of 4.2. For 86% of activities, respondents report the strongest emotion

during the activity is positive (data not shown). Mean scores for calm and happy are 5.4 and 5.0, respectively, are below 1.0 for frustrated, worried, sad, and pain and is 1.6 for tired.

The most common activities are travel (16.8%), eating (11.1%), watching television/movies (9.1%), food preparation (7.8), and self-maintenance (i.e., grooming) activities (7.7%). A substantial proportion of activities are carried out alone (42%), at home (54%), and are well distributed across the day.

About 70% of activities occur on a typical day and about 20% on days that occur after a poor night's sleep—either the night before the diary or the night before the interview. Only 5.8% of the activities involve another (secondary) activity occurring at the same time. The mean number of diary activities is 28.5.

There is a small but statistically significant inverse correlation between activity duration and strongest emotion (-0.06 ; $p < 0.01$; see Table 2). However, the results of the SUR models for duration and strongest emotion (Table 3) show that after controlling for covariates, the covariance between the residuals is not significant, suggesting that the covariates account for the previously significant relationship between activity duration and strongest reported emotion. Significant predictors of duration include age of respondent, activity type, as well as activity characteristics (i.e., exact time reported, with whom, time of day, where, and whether any secondary activities) and day characteristics (i.e., number of activities). Having low economic resources and a disability is associated with less positive (more negative) emotions. In addition, participating in self-care, eating, shopping, and nonactive leisure other than watching television (vs. traveling) is associated with more positive emotions as is the overall number of activities reported yesterday, whereas doing more than one activity at once was associated with stronger negative emotions.

Turning to individual indicators of wellbeing (Table 4), only measures of negative wellbeing are significantly associated with duration. Feelings of calmness and happiness had small correlations with duration (-0.03) that were not statistically different from 0.0. In contrast, feeling frustrated, worried, sad, tired, and pain are all positively correlated with duration, ranging from 0.04 for pain ($p = .04$) to 0.08 for frustrated and tired ($p < .01$).

In Table 5 results from the 7 sets of SUR models using duration and each of the individual wellbeing measures are presented. The duration model coefficients, which are identical to those reported in Table 3, are not repeated here. Four points about the variability of predictors across models are noteworthy. First, respondent characteristics are associated mainly with tiredness and pain, but few predict happy, calm, frustrated, worried, or sadness. Second, although activity type is strongly associated with duration (Table 3), only two activities affect more than two emotions. Eating, for example, is associated with being calmer, happier, and less frustrated, and waiting is associated with being calmer, less worried, and less tired. Third, activity characteristics, particularly time of day and who is with the respondent, are associated with being calm, happy, worried, tired, and experiencing pain, but not with frustration or sadness. Fourth, coefficients for day characteristics also vary by descriptor. For example, on weekend days respondents report more happiness, less frustration, and less worry than for weekdays and on busier days (more activities)

respondent report less negative emotions/symptoms (but no differences in positive emotions). In addition, poor sleep *before* the diary day is associated with more worry whereas poor sleep *at the end of* the diary day (before the interview) is associated with less calmness and more tiredness and pain on the diary day.

Turning to the last row of the table, the covariance between the residuals of the models is not statistically significant for worried, sad, tired, and pain, meaning that the controls in the SUR models account for the previously significant correlations (shown in Table 4) for these descriptors. In other words, after controlling for respondent, activity, and day characteristics, only frustration remains significantly correlated with duration ($p < 0.01$).

Which sets of covariates account for the correlations between duration and wellbeing? Table 6 demonstrates how these correlations change moving from a null model to the full models in Tables 3 and 5. Activity type and day characteristics account for more of the relationship between strongest emotion and duration than do respondent or activity characteristics. A similar pattern is evident for worried, sad, and tired. However, for pain, the correlation is largely accounted for by characteristic of the day. Note that the correlation between frustration and duration after controlling for respondent, activity, and day characteristics is relatively small, but statistically significant (0.06; $p \leq 0.01$).

DISCUSSION

This study demonstrates, for a nationally representative sample of older married adults, that the strength of experienced wellbeing on the prior day is inversely correlated with activity duration. However, among the specific types of emotions considered here, only measures of negative wellbeing (frustrated, worried, sad, tired and pain) are significantly associated with duration whereas positive emotions (happy, calm) are not. Moreover, with one exception, once contextual considerations are taken into account (e.g. characteristics of the respondent, activities, and the previous day), there is no longer a significant relationship between duration and emotion. Only reports of frustration are significantly correlated with duration before and after introducing extensive controls. This finding, although not evidence that “time flies”, is consistent with the notion that time seems to drag when one is feeling frustrated.

Our study has several limitations. Although generalizable to older married adults in the US for the specific measures explored here, these findings might not hold for younger adults or for other emotions. We speculate that correlations between positive emotions and duration might be stronger for younger adults, because older adults are more likely to underestimate long durations (Craig and Hay 1999; Hancock and Rausch 2010) and are less likely to experience emotional “highs” than younger counterparts (Kunzmann, Little, & Smith, 2000). Together these two phenomena might lead to a lower correlation between positive emotion and activity duration in this population than among younger adults. The recent release of the American Time Use Study’s Wellbeing module offers an opportunity to investigate both age differences in correlations for some of the descriptors here (e.g. happy, sad, pain, tired) and a few additional descriptors (stressed, meaningful).

Second, with these observational data we could not sort out actual from perceived durations. It may be that variations across individuals in perceptions of duration are small relative to variation in actual duration, and thus even if feelings influence duration perceptions, they may be on the order of seconds or minutes, and thus not large enough to amount to measurable biases in the DRM methodology.

Third, although we observe relatively small, persistent associations between frustration and duration even after controlling for a rich and varied set of potential confounders, unlike with experimental designs, we cannot rule out the possibility of another unmeasured confounder generating this correlation. Nor can we definitively conclude in which direction the influence runs. Respondents' frustration may make activities seem like they take longer; alternatively it may be that the longer an activity takes the more frustrated an individual becomes. The only experiment we know of that directly asked whether duration in the context of a time diary influences emotion found that it did not (Fredrickson and Kahneman 1993). Nevertheless, we caution that our findings are consistent with the possibility but not direct evidence that frustration may influence (bias) reports of duration.

Despite these limitations, our analysis has practical implications for investigators who use the DRM methodology to formulate estimates of emotion over the day. Whereas experimental results indicate that positive emotion results in the perception of shorter durations, we find no evidence for a measurable bias in the DRM methodology of positive emotion per se. That is, duration-weighted estimates of positive hedonic experience do not appear to be understated. In contrast, reports of frustration do have small, persistent associations with duration estimates. The latter finding is consistent with the possibility that duration-weighted estimates of frustration may be upwardly biased.

Although we cannot pinpoint the amount of bias, our analysis provides some insight into an upper bound in terms of minutes. The descriptive statistics that we presented suggest that the unadjusted correlation corresponds to a 13 minute difference in duration between those reporting no frustration (46 minutes) and any frustration (59 minutes) during a given activity. A regression model that assumes frustration causes individuals to recall activities as longer (and not vice versa) and controls for activity, respondent, and day characteristics, suggests that an increase from no frustration (0) and to very frustrated (6) adds 10 additional minutes to the estimate of activity duration. In other words, for an average length activity (50 minutes), feeling frustrated can result in an estimate of duration about 20% longer. Although these potential biases may seem small to moderate for a single activity, scientists who accumulate activities over the day to estimate minutes of frustration should be aware that errors may compound across activities.

Finally, for scientists interested in understanding the theoretical relationship between time estimation and experienced wellbeing and how they interact, our findings suggest further investigation of frustration in a laboratory or field setting may be worthwhile. To date, over-estimation has been demonstrated in a number of experimental situations that might be considered frustrating, e.g., encountering a barrier to a desired goal (Quigley et al. 1984), task interruption (Schiffman and Greist-Bousquet 1992), waiting watchfully for an event to occur (the "watched pot" phenomena; see Block et al. 1980); or completing an unfamiliar

cognitively demanding task under time pressure (Liu and Wickens, 1994). But to our knowledge such studies have not asked participants to rate their degree of frustration or other experienced emotions. We conclude from our work that it may be useful to design an experiment (in which true duration may be known and manipulated) focused on frustration per se and how this particular attribute intersects with the duration estimation process—whether it distracts attention from time, slows down the clock, or interferes more than other emotions in the memory-retrieval process. Additionally, it may be worthwhile to explore whether observational studies that use the DRM methodology can be augmented with some measures of actual duration, so that scientists may measure biases more directly in a natural setting. Such investigations may help further unearth the mechanisms behind the old adage “time flies.”

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REFERENCES

- Bureau of Labor Statistics. [Accessed April 9, 2012] American Time Use Survey User’s Guide: Understanding ATUS 2003–2009. 2011. <http://www.bls.gov/tus/atususersguide.pdf>
- Block RA, George EJ, Reed MA. A watched pot sometimes boils: a study of duration experience. *Acta Psychologica*. 1980; 46(2):81–94. [PubMed: 7424547]
- Block, RA. Models of psychological time. In: Block, RA., editor. *Cognitive models of psychological time*. Hillsdale, NJ: Erlbaum; 1990. p. 1-35.
- Craik FI, Hay JF. Aging and judgments of duration: effects of task complexity and method of estimation. *Perception & Psychophysics*. 1999; 61(3):549–560. [PubMed: 10334100]
- Dockray S, Grant N, Stone AA, Kahneman D, Wardle J, Steptoe A. A comparison of affect ratings obtained with ecological momentary assessment and the Day Reconstruction Method. *Social Indicators Research*. 2010; 99(2):269–283. [PubMed: 21113328]
- Droit-Volet S, et al. Perception of the duration of emotional events. *Cognition and Emotion*. 2004; 18:849–858.
- Droit-Volet S, Meck WH. How emotions colour our perception of time. *Trends in Cognitive Sciences*. 2007; 11(12):504–513. [PubMed: 18023604]
- Fredrickson BL, Kahneman D. Duration neglect in retrospective evaluations of affective episodes. *Journal of Personality and Social Psychology*. 1993; 65(1):45–55. [PubMed: 8355141]
- Freedman, VA.; Cornman, JC. The Panel Study of Income Dynamics’ Supplement on Disability and Use of Time (DUST) User Guide: Release 2009.1. Institute for Social Research, University of Michigan; 2012.
- Freedman VA, Stafford FP, Schwarz N, Conrad FG, Cornman JC. Disability, participation, and subjective wellbeing among older couples. *Social Science & Medicine*. 2012; 74(4):588–596. [PubMed: 22226156]
- Gil S, Droit-Volet S. Time perception, depression and sadness. *Behavioural Processes*. 2008
- Gould, W.; Pitblado, J.; Poiv, B. *Maximum Likelihood Estimation with Stata*. 4th Edition. Texas: Stata Press; 2010.
- Hancock PA, Rausch R. The effects of sex, age, and interval duration on the perception of time. *Acta Psychologica*. 2010; 133(2):170–179. [PubMed: 20018272]
- Kahneman D, Krueger A, Schkade D, Schwarz M, Stone A. A survey method for characterizing daily life experience. *Science*. 2004; 306:1176–1780.
- Kitamura T, Kumar R. Time passes slowly for patients with depressive state. *Acta Psychiatrica Scandinavica*. 1982; 65(6):415–420.

- Krueger A. Are we having more fun yet? Categorizing and evaluating changes in time allocation. *Brookings Papers on Economic Activity*. 2007; 2007(2):193–215.
- Krueger A, Stone AA. Assessment of pain: a community-based diary survey in the USA. *Lancet*. 2008; 371(9623):1519–1525. [PubMed: 18456101]
- Kunzmann U, Little TD, Smith J. Is age-related stability of subjective well-being a paradox? Cross-sectional and longitudinal evidence from the Berlin aging study. *Psychology and Aging*. 2000; 15:511–526. [PubMed: 11014714]
- Liu Y, Wickens CD. Mental workload and cognitive task automaticity: an evaluation of subjective and time estimation metrics. *Ergonomics*. 1994; 37(11):1843–1854. [PubMed: 8001525]
- Quigley JJ, Combs AL, O’Leary N. Sensed duration of time: influence of time as a barrier. *Perceptual and Motor Skills*. 1984; 58:72–74.
- Russell J. Core Affect and the Psychological Construction of Emotion. *Psychological Review*. 2003; 110(1):145–172. [PubMed: 12529060]
- Schiffman N, Greist-Bousquet S. The effect of task interruption and closure on perceived duration. *Bulletin of the Psychonomic Society*. 1992; 30(1):9–11.
- Schwarz, N.; Kahneman, D.; Xu, J. Global and episodic reports of hedonic experience. In: Belli, R.; Alwin, D.; Stafford, F., editors. *Using calendar and diary methods in life events research*. Newbury Park, CA: Sage; 2009. p. 157-174.
- Sévigny MC, Everett J, Grondin S. Depression, attention, and time estimation. *Brain and Cognition*. 2003; 53(2):351–353. [PubMed: 14607179]
- Stone AA, Schwartz JE, Schwarz N, Schkade D, Krueger A, Kahneman D. A population approach to the study of emotion: Diurnal rhythms of a working day examined with the Day Reconstruction Method. *Emotion*. 2006; 6(1):139–149. [PubMed: 16637757]
- Thayer S, Schiff W. Eye-contact, facial expression and the experience of time. *Journal of Social Psychology*. 1975; 95(1):117–124. [PubMed: 1113516]
- Weathers, R. *A guide to disability statistics from the American community survey*. Ithaca, NY: Employment and Disability Institute, Cornell University; 2005.
- Yamada Y, Kawabe T. Emotion colors time perception unconsciously. *Consciousness and Cognition: An International Journal*. 2011; 20(4):1835–1841.
- Zellner A. An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association*. 1962; 57(298):348–368.

Table 1

Descriptive statistics

	Weighted Percentage or Mean
Outcomes	
Duration (minutes; mean)	49.9
Wellbeing	
Score of strongest emotion (−6 to +6; mean)	4.2
Individual emotions (0–6; mean)	
Calm	5.4
Happy	5.0
Frustrated	0.9
Worried	0.6
Sad	0.3
Tired	1.6
Pain	0.9
Respondent Characteristics (percentage)	
Sex	
Female	53.0
Male	47.0
Age group	
50–59	10.5
60–69	54.9
70–79	23.1
80+	11.4
Wealth	
First quartile	20.3
Second quartile	24.5
Third quartile	26.5
Fourth quartile	28.7
Disability status	
Yes	38.1
No	61.9
Activity type (percentage)	
Other organizational activities	0.3
Leisure activities at work	0.7
Religious activities	1.0
Care to others	1.2
Waiting	1.9
Food shopping	1.9
Financial management	2.2
Active leisure	2.7

	Weighted Percentage or Mean
Shopping for other	2.7
Household chores	3.5
Computer	3.8
Work	5.3
Socialize	6.5
Household maintenance	6.7
Other nonactive leisure	6.8
Self maintenance	7.7
Food preparation	7.8
Television/movies	9.1
Eating	11.1
Travel	16.8
Activity Characteristics (percentage)	
Exact time reported (vs. duration of activity)	31.0
Who Actively Engaged With	
Alone	41.6
With Spouse	31.3
With other	27.1
Interval for Activity Start Time	
Morning (before 12:00 pm)	39.6
Afternoon (12:00 pm - 3:59 pm)	29.7
Evening (4:00 pm or later)	30.7
Location	
At home	53.8
Elsewhere	46.2
Any secondary activities	5.8
Characteristics of the Diary Day (percentage)	
Yesterday was a weekend day	32.3
Agree Yesterday was Typical Day	69.7
Poor sleep night before diary	18.8
Poor sleep night before interview	19.0
Number of diary activities (Mean)	28.5

N=4365

Table 2

Distribution of and Correlation between Strongest Emotion and Length of Activity in Minutes

	Strongest emotion	
	%	Minutes
strong negative (−6 to −5)	10.5	60
weak negative (−4 to −1)	4.0	50
weak positive (0–4)	3.2	54
strong positive (5 to 6)	82.4	48
Correlation	−0.06	
(p)	(<0.01)	

N=4365

Table 3

Predictors of Length of Activity in Minutes and Strongest Emotion, Seemingly Unrelated Regression Coefficients

	<u>Duration</u>		<u>Strongest emotion (−6 to +6)</u>	
	β	p	β	p
Respondent Characteristics				
Male	1.42		0.37	
Age 50–59 (vs. 80+)	10.53	**	−0.37	
Age 60–69 (vs. 80+)	6.41	**	0.14	
Age 70–79 (vs. 80+)	5.28	*	0.38	
Wealth (vs highest quartile)				
Wealth quartile 1 (lowest)	1.87		−0.49	*
Wealth quartile 2	2.13		−0.46	
Wealth quartile 3	−0.91		0.05	
Has disability	1.02		−0.93	**
Activity code (vs. travel)				
Food shopping	6.55		−0.80	
Waiting	8.16	*	0.13	
Self maintenance	9.23	**	1.41	**
Eating	15.37	**	1.11	**
Financial management	18.31	**	−0.74	
Shopping for other	18.76	**	−0.52	
Food preparation	20.15	**	1.12	*
Household chores	22.35	**	0.41	
Care to others	25.73	**	−0.21	
Socialize	26.25	**	0.87	
Other organizational activities	35.87	*	0.41	
Household maintenance	37.77	**	−0.18	
Other nonactive leisure (nonTV)	38.13	**	1.04	**
Religious activities	39.03	**	0.54	
Active leisure	39.09	**	0.72	
Computer	44.29	**	0.52	
Work	52.28	**	0.22	
Leisure activities at work	54.50	**	0.13	
Television/movies	74.88	**	−0.08	
Activity Characteristics				
Exact time reported	39.46	**	0.10	
Who with (vs. alone)				
Spouse	4.05	*	0.18	
Other	2.97		−0.51	
Time of day (vs. morning)				

	<u>Duration</u>		<u>Strongest emotion (-6 to +6)</u>	
	β	p	β	p
Afternoon	1.43		0.15	
Evening	-4.48	*	0.02	
At home	-13.17	**	-0.35	
Secondary activity	19.63	**	-0.93	*
Day Characteristics				
Weekend day (vs. weekday)	1.63		0.24	
Typical day	0.86		-0.05	
Number of activities	-1.25	**	0.03	**
Poor sleep before diary	-3.29		-0.44	
Poor sleep before interview	-0.02		-0.70	
Constant	43.77	**	3.54	**
<hr/>				
sigma1_1 (var duration residuals)	2069.15	**		
sigma2_2 (var emotion residuals)			13.70	**
sigma1_2 (covariance)			-3.42	

Table 4
Distribution of and Correlation between Detailed Well Being and Length of Activity in Minutes

Detailed wellbeing rank	Calm		Happy		Frustrated		Worried		Sad		Tired		Pain	
	%	Min	%	Min	%	Min	%	Min	%	Min	%	Min	%	Min
0	1	47	1	39	70	46	77	48	86	49	44	46	66	49
1	0	51	0	130	7	57	7	54	5	53	12	46	9	51
2	1	74	1	57	6	57	5	54	3	53	13	50	10	48
3	5	53	8	54	5	62	5	47	3	57	14	53	7	54
4	9	50	15	50	5	60	3	70	1	62	10	62	5	56
5	20	54	30	52	4	58	1	61	1	70	5	59	2	68
6	64	48	44	47	2	57	1	66	1	83	3	51	1	47
Correlation		-0.03		-0.03		0.08		0.06		0.07		0.08		0.04
(p)		(0.14)		(0.14)		(<0.01)		(<0.01)		(<0.01)		(<0.01)		(0.04)

N=4365

Table 5
Predictors of Length of Activity in Minutes and Detailed Wellbeing, Seemingly Unrelated Regression Coefficients

	Calm		Happy		Frustrated		Worried		Sad		Tired		Pain	
	β	p	β	p	β	p	β	p	β	p	β	p	β	p
Respondent Characteristics														
Male	0.09		0.09		-0.13		-0.11		-0.17	**	-0.07		-0.28	*
Age 50–59 (vs. 80+)	-0.19		-0.36		0.22		0.20		0.17		0.81	*	0.52	*
Age 60–69 (vs. 80+)	0.05		-0.20		-0.10		-0.06		-0.06		0.40	*	0.38	**
Age 70–79 (vs. 80+)	0.14		0.08		-0.10		-0.01		-0.01		0.28		0.26	
Wealth (vs highest quartile)														
Wealth quartile 1 (lowest)	0.01		0.08		-0.12		0.02		-0.06		0.19		0.27	*
Wealth quartile 2	0.10		0.16		-0.12		0.18		-0.02		0.14		0.02	
Wealth quartile 3	0.00		0.19		-0.09		0.01		-0.07		0.03		0.02	
Has disability	-0.17	*	-0.21	*	0.04		-0.05		0.10		0.66	**	0.97	**
Activity code (vs. travel)														
Food shopping	-0.16		-0.40	*	0.18		0.32		0.34		0.62	*	0.37	
Waiting	0.30	*	-0.06		0.01		-0.36	*	-0.07		-0.54	*	-0.27	
Self maintenance	0.41	**	0.21		-0.43		-0.34	*	-0.15		0.09		0.13	
Eating	0.26	*	0.27	**	-0.48	**	-0.21		-0.14		-0.11		-0.15	
Financial management	-0.05		-0.35		0.52		-0.18		-0.07		0.32		-0.11	
Shopping for other	-0.30		-0.43	*	0.41		0.09		-0.01		0.10		-0.02	
Food preparation	0.23	*	0.17		-0.37		-0.45	*	-0.19		0.12		-0.20	
Household chores	0.27	*	-0.22		-0.41		-0.46	**	-0.20		-0.14		-0.14	
Care to others	-0.06		0.10		0.07		-0.09		0.13		0.78	*	-0.05	
Socialize	0.30		0.18		-0.05		-0.16		0.02		-0.39		0.04	
Other organizational activities	-0.10		-0.86	**	-0.06		-0.21		0.96		-0.13		0.13	
Household maintenance	-0.11		-0.27		0.21		-0.17		-0.04		0.38		0.25	
Other nonactive leisure (nonTV)	0.38	**	0.15		-0.18		-0.15		0.03		-0.02		-0.15	
Religious activities	0.15		0.20		-0.27		-0.28		0.20		-0.16		-0.06	
Active leisure	-0.07		0.05		-0.19		-0.11		-0.22	*	-0.09		0.43	
Computer	0.14		-0.05		-0.04		-0.19		-0.18		-0.14		-0.30	

	Calm		Happy		Frustrated		Worried		Sad		Tired		Pain	
	β	p	β	p	β	p	β	p	β	p	β	p	β	p
Work	-0.12		-0.30		0.06		-0.07		-0.16		0.07		0.16	
Leisure activities at work	0.16		0.29		-0.47		-0.14		-0.06		0.68		1.04	*
Television/movies	0.16		-0.01		-0.08		0.28		0.14		0.36		-0.19	
Activity Characteristics														
Exact time reported (vs. duration)	0.04		0.00		0.10		-0.02		0.05		0.00		-0.07	
Who with (vs. alone)														
Spouse	0.00		0.19	**	-0.11		-0.10		-0.02		0.13		0.00	
Other	-0.17		0.09		0.04		0.01		-0.02		0.13		-0.20	*
Time of day (vs. morning)														
Afternoon	-0.12	*	-0.02		0.09		-0.18	*	0.04		0.29	**	0.10	
Evening	-0.12	*	0.01		0.07		-0.17	*	0.05		0.59	**	0.16	*
At home	-0.17	**	-0.21		0.09		0.06		0.03		0.14		0.16	
Secondary activity	-0.16		-0.17		0.06		0.20		0.14		0.34		0.08	
Day Characteristics														
Weekend day (vs. weekday)	0.02		0.13	**	-0.21	**	-0.18	**	-0.03		-0.03		-0.06	
Typical day	0.13		0.05		0.11		-0.13		-0.04		-0.13		-0.07	
Number of activities	0.01		0.01		-0.01	*	-0.01	**	-0.01	*	-0.01	*	-0.02	**
Poor sleep before diary	0.00		-0.08		0.20		0.30	*	0.14		0.10		-0.06	
Poor sleep before interview	-0.32	**	-0.15		0.18		0.14		0.12		0.41	*	0.30	*
Constant	5.20	**	4.89	**	1.27	**	1.27	**	0.68	**	0.84	*	0.69	*
sigma1_1 (var duration residuals)	2069.15	**	2069.15	**	2069.15	**	2069.15	**	2069.15	**	2069.15	**	2069.15	**
sigma2_2 (var emotion residuals)	1.14	**	1.30	**	2.38	**	1.48	**	0.96	**	2.74	**	1.72	**
sigma1_2 (covariance)	-1.16		0.23		3.98	**	0.41		1.02		2.31		0.86	

N=4365

* p<0.05

** p<0.01

Table 6

Correlation of Duration and Wellbeing by Control Variables

		Strongest Emotion -6 to +6)		Calm		Happy		Frustrated		Worried		Sad		Tired		Pain	
		rho	p	rho	p	rho	p	rho	p	rho	p	rho	p	rho	p	rho	p
Residual correlation of duration and affect controlling for:																	
Null model		-0.06	**	-0.03		-0.03		0.08	**	0.06	**	0.07	**	0.08	**	0.04	*
Respondent characteristics		-0.05	*	-0.03		-0.02		0.08	**	0.06	**	0.07	**	0.07	**	0.03	
Activity type		-0.04		-0.02		0.00		0.07	**	0.03		0.05	**	0.06	**	0.04	*
Activity characteristics		-0.05	*	-0.04	*	-0.03		0.07	**	0.05	*	0.05	**	0.07	**	0.05	**
Day characteristics		-0.04	*	-0.03		-0.02		0.08	**	0.04		0.05	**	0.06	**	0.01	
All		-0.02		-0.02		0.00		0.06	**	0.01		0.02		0.03		0.01	

N=4365

*
p<0.05**
p<0.01