Associations between Subjective Time Perception and Well-Being during Stressful Waiting Periods

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Abstract

The passage of time is a subjective experience and can be easily distorted by concurrent emotions. Specifically, time seems to move particularly slowly when people are in a negative emotional state. The aim of the current studies was to evaluate the bidirectional relationship between subjective time perception and distress during stressful waiting periods, during which the slow passage of time may be particularly distressing. Across studies of undergraduate students awaiting a midterm exam grade (Study 1) and law graduates awaiting bar exam results (Studies 2 and 3), results revealed consistent links between distress and time perception across the waiting periods, with tentative evidence for bidirectional relationships between these experiences. That is, people who perceived time as moving slowly while they waited tended to report greater distress across the waiting period (particularly worry, anxiety, negative emotion, and poor coping), and people who reported greater distress tended to perceive time as moving more slowly. The links between distress and time perception suggest the possibility of downward spirals during stressful waiting periods, such that distress makes time seem to slow down, which then exacerbates distress. We discuss avenues for future research and potential remedies to derail the spiral of distress and time perception.

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Some experiences can make an hour pass in a minute or a minute stretch into eternity. Theories of time perception posit that humans have an internal clock to monitor the passage of time (Droit-Volet & Gil, 2009), yet this clock can stretch or contract the apparent passage of time. Emotional experiences are a particular culprit in creating inaccuracies of time perception, such that pleasant experiences speed the apparent passage of time, and stressful, unpleasant experiences slow its apparent passage. In the current paper, we examine this phenomenon in the context of a stressful experience with the passage of time at its heart: the wait for uncertain news.

Waiting for News

Waiting periods vary in numerous ways, including their domain (e.g., academic, medical, political) and the importance of the outcome. However, they all have one thing in common: time stands between the “waiter” and the often eagerly anticipated news. Whether waiting a week for biopsy results or many months to learn the outcome of college applications, people report considerable anxiety as they face uncertainty about their future (e.g., Sweeny & Falkenstein, 2015). Worse, during the types of waiting periods just described, people have little to no control over their outcome, nor when they will learn their fate.

Given the frustrating paralysis that waiting entails, it is unsurprising that people prefer shorter waiting periods to longer ones, and distress accumulates as waiting drags on (Montgomery & McCrone, 2010; Osuna, 1985). In fact, one effective way to reduce the distress of waiting is to

engage in activities that make people feel as though time is “flying by” (i.e., flow states; Rankin, Walsh, Sweeny, 2018). The latter finding reveals an important feature of waiting periods, and of time perception more generally: One’s perception of the duration of a waiting period is in part subjective, a topic to which we now turn.

The Role of Emotions in Time Perception

Monitoring time is a skill shared by animals ranging from rats to apes (Martin-Ordas, Haun, Colmenares & Call, 2010; Wearden & McShane, 1988; Zhou & Crystal, 2009), suggesting that accurate time perception is a fundamentally adaptive characteristic—yet surely everyone knows how different an hour feels when it is spent trapped on a long flight versus in the company of loved ones. These types of experiences are sufficiently common to have earned the label the “time-emotion paradox” (Droit-Volet & Gil, 2009). People’s current emotional state plays a substantial role in how they perceive time, and negative emotions and experiences are particularly influential in extending a person’s perception of the duration of specific events (novice skydivers who experience fear perceive dropping time to be longer, Campbell & Bryant, 2007; frustrating activities are perceived to last longer compared to non-frustrating activities, Freedman et al., 2014; stimuli paired with aversive sounds are estimated to be presented for longer durations, Droit-Volet, Mermillod, Cocenas-Silva, & Gil, 2010; duration of emotional stimuli are overestimated compared to neutral stimuli, Droit, Brunot & Niedenthal, 2004, Grommet et al., 2011). Similarly, people high in

test anxiety tend to overestimate the duration of waiting for test scores in a contrived lab setting compared to people average or low in test anxiety (Sarason & Stoops, 1978), suggesting that individual differences can enhance or diminishing the relationship between emotion and time perception.

The literature on distorted time perception often uses the metaphor of an internal ticking clock (Droit & Meck, 2007; cf. Droit-volet, 2018 for a review of the literature examining neurobiological mechanisms of shifts in time perception). When something pleasantly captures a person's attention, resources are diverted away from the internal clock. In turn, missing the "ticks" emitted by the internal clock causes an underestimation of how much time has passed. In contrast, physiological arousal induced during stressful moments affects the internal clock by accelerating its apparent progress, accumulating more "ticks" and thus leading to an overestimation of an event's duration (Droit-Volet & Gil, 2009). In fact, people's perception of their internal clock is so easily distorted by emotional stimuli that simply viewing positive or negative faces (angry, happy, and sad; Droit-Volet, Brunot & Niedenthal, 2004) or hearing positive or negative sounds (e.g., crying, laughing; Noulhiane at al., 2007) can lead people to under- and overestimate the duration of those experiences. A similar picture emerges from studies that have examined emotions and perceptions of the passage of time, rather the judgements of the duration of particular events as in the previously cited studies, using experience sampling methods (Droit-Voley & Wearden, 2015;

Tipples, 2018). Over several consecutive days, people rated time as passing more slowly when they were experiencing negative emotions such as sadness or frustration, whereas feelings of happiness were associated with the perception that time was passing relatively quickly.

In contrast, a study examining the relationship between emotion and time perception during a timed task of a longer duration (i.e., varying duration up to 32 minutes) found that arousal was associated with shorter time judgments of the duration of a task, particularly for longer tasks, regardless of the valance of the timed experience (Droit-Volet et al., 2018). The authors of that paper note that emotional states can change quickly, leading to varying levels of arousal (and thus time perception) during a longer duration of time than examined in previous studies (typically only a few seconds or minutes).

Although past research has established a causal link between emotional experience and time perception, previous studies examined experiences that are relatively short in duration, from fractions of a second to a half an hour or at most a few days. The current paper considerably extends this literature to investigate whether similar time distortions occur on a far larger time scale with a predictable emotional trajectory, on the order of months (in Study 2) rather than days. In addition, rather than assessing judgments of the duration of a past activity or how quickly time seems to be passing in typical daily life, we assessed perceptions of how slowly or quickly people were approaching an important and fixed point in

time (i.e., the end of a stressful waiting period). We also assess the subjective passage of time in the context of a common, real-life stressful experiences rather than retrospective judgments of the duration of a completed lab task (Sarason & Stoops, 1978), the subjective passage of time during a highly idiosyncratic stressful experience (i.e., skydiving; Campbell & Bryant, 2007), or the subjective passage of time in typical daily life (Tipples, 2018). In particular, we examined stressful experiences in which the (subjectively) slow passage time is particularly distressing because our participants were anxiously awaiting some news of personal importance.

Finally, we extend the previous work by assessing subjective health and several health indicators and coping, in addition to distress and emotional well-being. Although one previous study found no relationship between subjective time perception and similar measures of distress in typical daily life (worry and anxiety; Tipples, 2018), these states were measured with general measures in that study (i.e., Penn State Worry Questionnaire, Topper et al., 2014; “In the last hour I have been worrying”). In this study, we focus on target-specific worry and anxiety regarding a personally-significant but uncertain future outcome.

Goals of Current Studies and Hypotheses

The goal of the present study is to examine links between subjective perceptions of the passage of time during a relatively lengthy and stressful experience, namely the wait for midterm grades among college students and the wait for bar exam results among law school graduates (see Howell &

Sweeny, 2016; Sweeny & Andrews, 2014; Sweeny et al., 2016). We anticipate that this relationship is bidirectional, and thus our analyses examine cross-sectional relationships and model our longitudinal data with time perception as the outcome in one set of models and emotions/health as the outcome in a second set of models. We hypothesize that waiting will be more distressing when people perceive it to be longer in duration and that waiting will seem longer in duration when people experience greater distress.

Study 1

Study 1 examined links between subjective time perception and emotional experiences in undergraduate students over the course of a five-day wait for a midterm exam grade.

Method

Participants and procedure. Undergraduate students in a psychology course (N = 120; 68% women; 17% White, 40% Asian or Pacific Islander, 36% Latinx, 2% Black, 5% multiple or other) were recruited within two weeks before taking their first midterm exam. All participants who were willing to participate then completed approximately one survey per day, for a total of four surveys, as they waited for their professor to post exam grades. Surveys were sent out on a set schedule[1], and each survey was closed before the subsequent survey link was sent out. We did not have a target sample size; we aimed to recruit all interested students in the relevant

[1]The average lag between the first and second surveys was 30 hours (M = 29.94, SD = 11.72); between the second and third surveys, 46 hours (M = 45.89, SD = 13.98); between the third and fourth surveys, 36 hours (M = 35.57, SD = 10.90).

course. The study was reviewed and approved by the authors' Institutional Review Board.

Measures. Key measures for our investigation include time perception and various indicators of psychological distress. All studies presented here included additional measures (e.g., engagement in coping strategies) not relevant to the current goals of the study. Thus, we will not discuss them further and will instead target the measures that focus on more direct indicators of distress and health. Full measures for Study 1 are available on the Open Science Framework (https://osf.io/fuh5t/).

Time perception. Because our endeavor was quite novel, we created context-specific measures of *in situ* perceptions of time moving relatively slowly or quickly. Specifically, we assessed subjective time perception with two items: "It feels like it's taking forever to get my midterm result back" (time moving slowly; 1 = *strongly disagree,* 5 = *strongly agree*; M = 2.66, SD = 1.04) and "It feels like I'll get my midterm result before I know it" (time moving quickly; M = 2.93, SD = .84). These items were inversely correlated at each time point, rs = -.23, -.13, -.13, and -.08, respectively, and thus we reversed-scored the item capturing time moving quickly and averaged the pair of items, such that higher numbers indicate that participants perceived time to be moving relatively slowly (M = 2.86, SD = .71).[2]

Distress. We aimed to capture a broad set of distress markers to

[2] Although the two items were only weakly negatively correlated, the pattern of results in all studies was nearly identical when treating the two as separate items (with the pattern for time moving quickly the reverse of the pattern for time moving slowly) as it was when reverse-scoring one and averaging them into a composite.

determine the generalizability of our findings, including worry, state anxiety, and positive and negative emotions.

Worry. Worry was assessed with three items, capturing emotional and cognitive components of worry and used commonly in the context of waiting periods (e.g., Dooley et al., in press; “I feel anxious every time I think about my midterm exam”, “I am worried about my midterm exam result”, “I can’t seem to stop thinking about the midterm exam”; 1 = *strongly disagree,* 7 = *strongly agree*; M = 2.53, SD = .90, Cronbach’s αs > .79).

State anxiety. State anxiety was assessed with eight items (e.g., “In the last three days I have felt anxious”, “calm”; 1 = *not at all,* 5 = *extremely; M* = 2.53, *SD* = .70, αs > .88).

Emotions. State emotions experienced over the previous three days were assessed with items adapted from the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988), positive emotions with six items (e.g., inspired, relaxed, grateful; 1 = *very slightly or not at all,* 5 = *extremely*; M = 2.90, SD = .76, αs > .86) and negative emotions with nine items (e.g., upset, hostile, ashamed; M = 1.63, SD = .67, αs > .92).

Results

Time perception predicts distress. We used multilevel modeling to examine the relationship between time perception and distress across the waiting period, nesting measurement point (Level 1) within participants (Level 2), centering variables at the person-mean (within-person effects) and grand-mean (between-persons effects) levels. Analyses were conducted with

the SAS 9.4 PROC MIXED procedure. Because many markers of distress in this study change in a quadratic pattern over time (see Sweeny & Andrews, 2014; Sweeny et al., 2016), we controlled for linear and quadratic time in all models, as well as their interactions with other predictor variables. Although we recognize that correlational data can never speak to causal order, we ran models that treated time perception and distress (separately) as outcome variables in an effort to examine patterns of effects across both sets of models.

Tables 1 and 2 present the key parameters in the multilevel models (full model results are available in Supplemental Materials). Looking first at Table 1, results reveal robust between-persons associations between time perception and distress when time perception was the predictor and distress was the outcome in the models. That is, participants who perceived time to be moving more slowly on average also reported greater worry, state anxiety, and negative emotion. Two within-person effects emerged, such that when time seemed to pass most slowly during the waiting period, participants reported the greatest state anxiety and the lowest positive emotions.

Distress predicts time perception. Turning to Table 2, associations between time perception and distress were similarly robust when distress was the predictor and time perception was the outcome in the models. Participants who worried more and experienced greater state anxiety, greater negative emotion, and less positive emotion (a marginal effect in the

latter case) on average also reported that time seemed to be moving more slowly on average (i.e., between-persons effects). In addition, participants reported the most state anxiety and lowest positive emotion at times when time seemed to pass most slowly (i.e., within-person effects).

Controlling for covariates. Because many of our findings emerged at the between-persons level, the possibility of third-variable explanations for the association between time perception and distress was a concern. To minimize concerns over alternative explanations for our findings, we reran the multilevel models controlling for three trait-like individual differences that were related to both subjective time perception and many of our measures of distress: dispositional optimism (assessed with the LOT-R, minus the filler items; Scheier et al., 1994), defensive pessimism (assessed with 12 adapted items; see Norem, 2001 for original items), intolerance of uncertainty (IUS-12; Carleton, Norton, & Asmundson, 2007), and neuroticism (subscale of the BFI; John & Srivastava, 1999). Tables 3 and 4 present the key results from these models, and full model results are available in Supplemental Materials online.

The substantive findings remained the same with the addition of these covariates, with a few exceptions: time perception became a marginally significant (rather than significant) within-subject predictor of state anxiety and positive emotion, and positive emotion became a marginally significant within-subject predictor and a non-significant between-subjects predictor of time perception.

Study 2

Study 1 provided initial support for our hypotheses. People who tended to perceive time as moving more slowly during the wait for midterm exam results reported greater distress, and people who reported greater distress tended to perceive time as moving more slowly. In addition, time perception seemed to slow down in synchrony with rising state anxiety, and to a less consistent degree, with falling positive emotion. We sought to replicate and extend these findings in Studies 2 and 3, both of which examined a considerably longer waiting period (4 months instead of 5 days) in a context with considerably higher stakes (the bar exam instead of a midterm exam). Given the longer time scale and higher stakes, we were able to include additional measures of distress (i.e., self-reported sleep and health, subjective coping).

Method

Participants and procedure. Law graduates (N = 230; 61% female; M_{age} = 27.6; 67% White, 25% Asian or Pacific Islander, 7% Latinx, 1% Black) waiting for their 2013 California bar exam results, which takes approximately 4 months from completing the exam to receiving results, participated in this study for Amazon gift cards. Relevant to this study, all participants who were willing to participate in the study completed 8 surveys during the waiting period, which began within 24 hours of completing the bar exam and were administered approximately two weeks apart throughout four months. Once again, we did not have a target sample size, instead recruiting as many

eligible participants as we could in the six weeks prior to the bar exam. The study was reviewed and approved by the authors' Institutional Review Board.

Measures. As in Study 1, key measures for our investigation include time perception and various indicators of distress. Measures of time perception (M = 3.48, SD = .77, rs < -.39), worry (M = 2.86, SD = .89, αs > .81), state anxiety (M = 2.79, SD = .65, αs > .89), negative emotion (M = 1.96, SD = .66, αs > .90), and positive emotion (M = 2.91, SD = .64, αs > .85) were identical to Study 1 except the wording focused on the bar exam rather than a midterm exam. Full measures are available on the Open Science Framework (https://osf.io/d35ap/).

Self-reported sleep and health. Self-reported sleep was measured with eight items (three items taken from the Pittsburg Sleep Hygiene Index; Mastin et al., 2006; five items adapted from the Pittsburg Sleep Quality Index; Buysse et al., 1989). All items were reverse coded so that higher numbers indicated greater sleep disruption (items were z-scored and then averaged to create a single sleep measure; M = .01, SD = .53, αs > .73). Self-reported health was assessed with a single face-valid item from the SF-36 (Ware Jr & Sherbourne, 1992; "Would you say your health has been..."; 1 = *excellent,* 5 = *poor*; M = 2.86, SD = .76).

Subjective coping. Subjective coping (the sense that one is coping well with a stressor, all things considered; see Sweeny & Howell, 2017) was measured with a single item ("How well do you feel like you're coping with the wait for your bar exam result?"; 1 = *not at all,* 5 = *very well*; M = 3.58,

SD = .82).

Results

Time perception predicts distress. Looking at Table 1, results again reveal robust between-persons associations between time perception and distress when time perception predicted distress in the models. People who perceived time to be moving more slowly on average also reported greater worry, state anxiety, negative emotion, and sleep disruption, poorer subjective health (marginally) and subjective coping, and less positive emotion. One within-person effect emerged, such that when time seemed to pass most slowly during the waiting period, participants reported the greatest sleep disruption.

Distress predicts time perception. Turning to Table 2, associations between time perception and distress were similarly robust (perhaps even more so) when distress predicted time perception in the models. People who worried more, experienced greater state anxiety, negative emotion, and sleep disruption, reported poorer subjective health and subjective coping, and experienced less positive emotion on average also reported time moving more slowly on average (i.e., between-persons effects). In addition, at times when people worried the most, experienced the greatest sleep disruption (marginally), and reported the poorest subjective coping, they simultaneously reported time passing more slowly (i.e., within-person effects).

Controlling for covariates. The substantive findings remained the

same with the addition of covariates (the same covariates used in Study 1), with a few exceptions. In models linking negative emotion, sleep disruption, and subjective health with time perception, the between-subject effects were rendered non-significant with the addition of covariates. In contrast, the non-significant within-subject links between subjective health and time perception became marginally significant with the addition of covariates to both models.

Study 3

The findings from Studies 1 and 2 provide support for our hypothesis that time perception is associated with distress during prolonged waiting periods, such that people reported more distress when time seemed to be moving slower, and people perceived time to be moving slower when they were more distressed. In Study 2, participants also reported the greatest sleep disruption when time seemed to move most slowly, and vice versa. In addition, participants perceived time to move particularly slowly at times when they felt most worried and felt that they were coping most poorly. Given the novelty of our endeavor, we sought to replicate these findings in a second sample of law graduates taking the bar exam, in a different year and using slightly different measures of distress. We also included additional health-related measures of distress, namely sleep duration and health-related functioning.

Method

Participants and procedure. Law graduates (N = 125; 61% female;

M_{age} = 27.74; 61% Caucasian, 19% Asian or Pacific Islander, 7% Hispanic/Latino(a), 2% African-American, 11% other/multiple) waiting for their 2016 California bar exam results participated in this study for Amazon gift cards. As in Study 2, we recruited the largest sample we could prior to the bar exam. The study was reviewed and approved by the authors' Institutional Review Board.

This study used a planned missingness design during the waiting period. We randomly assigned participants to one of five arbitrary groups. All five groups completed the first waiting survey within three days of completing the bar exam. Over the next 15 weeks until the release of bar exam results, three surveys were administered to each group in a staggered method. For example, Group 1 completed the second survey during week one, the third survey during week six, and the fourth survey during week 11; Group 2 completed the second survey during week two, the third survey during week seven, and the fourth survey during week 12; and so forth. The fifth and final waiting survey was completed by all groups 24 hours prior to gaining access to their bar exam result.

Measures. Measures of time perception (M = 4.97, SD = 1.20, rs < -.37), worry (M = 4.42, SD = 1.24, αs > .77), and subjective coping (M = 5.22, SD = 1.14) were identical to Study 2, aside from the measurement scale (1 = *strongly disagree*, 7 = *strongly agree*). Full measures are available on the Open Science Framework (https://osf.io/mpnqt/).

State anxiety. State anxiety was assessed with two items (Patient

Health Questionnaire; Kroenke et al., 2010; “How often in the past two weeks have you been bothered by [feeling nervous, anxious, or on edge / not being able to stop or control worrying]?” 1 = *not at all,* 4 = *nearly every day; M* = 2.12, *SD* = .80, *r*s between items > .77).

Emotions. Positive emotions experienced over the previous week were assessed with four items, adapted from the Affect Adjective Scale (Diener & Emmons, 1984; happy, pleased, joyful, enjoyment/fun; 1 = *strongly disagree,* 7 = *strongly agree*; *M* = 5.36, *SD* = .90, *α*s > .87). Negative emotions experienced over the previous week were assessed with four items from the same adapted scale (angry/hostile, frustrated, depressed/blue, unhappy; 1 = *strongly disagree,* 7 = *strongly agree*; *M* = 3.84, *SD* = 1.20, *α*s > .84).

Self-reported sleep and health. Self-reported sleep disruption was measured with thirteen items from the Pittsburg Sleep Hygiene Index (Mastin et al., 2006). For our purposes, and given high internal reliability at each time point, we simply averaged responses across times (5-point scales; *M* = 2.08, *SD* = .55, *α*s > .80). We also assessed self-reported sleep duration in hours (*M* = 7.14, *SD* = .92).

Self-reported health was assessed with five items assessing the extent to which health has interfered with regular activities, taken from the SF-36 (Ware Jr & Sherbourne, 1992; e.g., “During the past week, have you accomplished less than you would like as a result of your physical health?”; 1 = *not at all,* 5 = *very much/extremely*; *M* = 1.80, *SD* = .73, *α*s > .90). As in

Study 1, self-reported health was additionally assessed with a single face-valid item from the SF-36 (Ware Jr & Sherbourne, 1992; “Would you say your health has been...”; 1 = *excellent,* 5 = *poor*; *M* = 2.98, *SD* = .68).

Results

Time perception predicts distress. Starting with Table 1, results were largely consistent with Studies 1 and 2: robust between-persons associations between time perception and distress, such that people who perceived time to be moving more slowly on average also reported greater worry, state anxiety, negative emotion, and sleep disruption (marginally), and poorer subjective coping. Once again, fewer within-person effects emerged. Here, when participants reported that time seemed to pass most slowly, they experienced the greatest worry and state anxiety.

Distress predicts time perception. As shown in Table 2, between-persons associations between time perception and distress were similarly robust when distress predicted time perception in the models. People who worried more, experienced greater state anxiety, negative emotion, and sleep disruption, and reported poorer subjective coping on average also reported that time seemed to be moving more slowly on average. At the within-person level, people worried the most and experienced the most state anxiety at times when time seemed to pass most slowly.

Controlling for covariates. We once again reran the multilevel models controlling for relevant trait-like individual differences as in Studies 1 and 2 (neuroticism was measured with the subscale of the TIPI; Gosling,

Rentfrow, & Swann, 2003). Tables 3 and 4 present the key results of these models. In both models (predicting distress from time perception and predicting time perception from distress), all between-persons and within-person effects that were significant in the simpler models remained significant after controlling for covariates, with one exception (the between-subjects effect of sleep disruption on time perception became marginally significant in the model predicting time perception from distress).

General Discussion

The aim of the current endeavor was to examine time perception in the context of lengthy and stressful waiting periods, ranging from nearly a week to several months. This investigation was grounded in a literature on the links between emotions and subjective perceptions of the passage of time, which reveals that people tend to perceive time as passing more slowly when in an unpleasant emotional state. We extended that literature in four significant ways. First, we investigated these time distortions of longer periods of time, days and months rather than mere seconds or minutes. Second, participants reported their perceptions of the passage of time during a relevant stressful experience rather than estimating its length in retrospect. Third, we brought the study of time perception into periods of stressful uncertainty that have real consequences for participants rather than contrived lab activities, typical daily life, or moments that are not commonly experienced in daily life. Fourth, we extended our investigation from simple emotions to a broad set of distress and health indicators that

might be bidirectionally associated with the passage of time.

Consistent with the previous literature, subjective time perceptions in these contexts were robustly associated with various indicators of distress, most notably worry, anxiety, and poor subjective coping. Furthermore, our data are consistent with a bidirectional relationship between time perception and distress. That is, participants in our studies felt more distressed to the extent that they perceived time to be moving slowly—and to nearly the same degree, participants perceived time to be moving more slowly to the extent that they felt distressed. Although experimental evidence is necessary to definitively test the bidirectional nature of these relationships, our findings point to the possibility that people may experience a “downward spiral” at particularly challenging moments in a waiting period. Perhaps an external cue raises anxiety (e.g., someone brings up the bar exam in conversation), which makes time seem to move more slowly. In turn, anxiety increases even further due to this unpleasant perception of time moving slowly.

Our findings also revealed associations at both the between- and within-person levels. Addressing the between-person level first, participants in our studies who had a general tendency to perceive time as moving slowly also tended to report distress across the waiting period (particularly worry, anxiety, negative emotion, and poor subjective coping), and vice versa. This type of association is fraught with the potential for third-variable explanations; however, the findings largely held even after controlling for individual characteristics of particular relevance to periods of acute

uncertainty (i.e., dispositional optimism, defensive pessimism, intolerance of uncertainty, and neuroticism). It may be that trait-like tendencies in time perception and distress are linked, or perhaps a trait-like tendency to perceive time as moving slowly prompts situational distress, and a trait-like tendency toward distress prompts shifts in situational time perception. In either case, our findings suggest that the tendency to perceive time as moving slowly is related to undesirable psychological outcomes during uncertain waiting periods.

Within-person effects were less consistent across studies, but all studies showed some association between time perception and distress across time. That is, when people experienced particularly high distress relative to their typical level, they also perceived time as moving particularly slowly, and vice versa. These effects were most consistent for worry and anxiety, with less consistent effects emerging with positive emotion, sleep disruption, subjective health, and subjective coping. Taken together, these findings provide compelling evidence for links between moment-to-moment time perception and distress during the stressful waiting periods of interest in our investigation.

Finally, as noted above, our findings were most robust for uncertainty-relevant emotional experiences (worry and anxiety) and subjective perceptions of coping, sleep, and health. The more objective measures of health and sleep included in Study 3 (sleep duration and functional limitation due to physical health) were unassociated with time perception. We suspect

that the dynamic relationship between time perception and subjective experiences of distress can get “under the skin” when distress is sufficiently intense; however, our studies were insufficiently powered to detect these types of distal, indirect effects. Alternatively, it may be that people expressed their feelings of worry or anxiety via our measure of time perception. That is, perhaps when people enthusiastically agreed with a statement like “It feels like it’s taking forever to get my midterm result back,” they were conveying frustration with their worried state rather than evaluating their perception of time per se. Bivariate correlations between well-being indicators and time perception (included on each study’s Open Science Framework page) are robust and positive, but not so strong as to point toward a unitary construct that combines worry and our measures of time perception. Nonetheless, future research can tackle questions about the sources on which people draw to report subjective time perceptions in this context.

Although our studies had a number of strengths, they were also limited in several notable ways. First, as noted earlier, our studies were correlational and thus ill-suited to test causal relationships between subjective time perceptions and psychological distress. Second, our measure of time perception was quite different than measures used in studies that address shorter time periods, by necessity. That is, when measuring perception of time over a few minutes in the lab, it is feasible and sensible to simply ask participants how much time seems to have passed, and then compare that

with the objective passage of time. In our studies, however, the time periods of interest were considerably longer, and participants were likely well-aware of the number of days, weeks, or months that had passed since they took the relevant exam. Thus, our measures took an indirect approach to assessing time perceptions, with reference to participants' perceptions of the time remaining until the point of feedback. Although our findings were consistent with hypotheses, and broadly consistent with previous research, future studies should test the generalizability of our findings with various different measures of time perception to ensure that the findings are robust. Third, the wait for exam results is often more structured and personally relevant compared to a variety of other waiting periods people endure. For example, people are often unaware of when news will come (e.g., the wait for a loan approval or a call back following a job interview), and the news at the end of the wait is often less personally consequential (e.g., the outcome of a political election). Examining less structured waiting periods and outcomes with varying levels of personal importance can reveal nuances in how and the extent to which time perception is related to distress and health during uncertain waiting periods.

In sum, our findings suggest that the emotional time distortions previously observed in brief, controlled lab experiences and relatively brief experience sampling studies assessing experiences in everyday life extend to relatively lengthy and personally consequential life experiences. Most people find waiting for uncertain news to be unpleasant, and the studies

presented here suggest that this unpleasantness is heightened when the wait seems especially interminable. Worse, waiting will seem to drag on longer when people are particularly worried about the news they will receive at the end of the wait.

Alternatively, interventions can also target how waiting periods are structured to more objectively alter perceptions of time during these periods. For example, many medical waiting periods are open-ended, such that patients do not know when they will end (e.g., “We’ll call you when the results are in”). Recent research suggests that many patients would prefer to know when their wait will be over, even if it means waiting longer (Dooley, Burreal, & Sweeny, 2017)—perhaps in part because giving structure to the wait allows people to manage their perception of the passage of time more effectively. Furthermore, it may be possible to derail this downward spiral by reappraising waiting periods as fleeting rather than seemingly endless, perhaps by taking a longer time perspective (“these four months will seem like nothing ten years from now”). Similarly, people may be able to speed up their perception of a waiting period’s duration by effectively managing their distress through mindfulness meditation (Sweeny & Howell, 2017) or pleasantly engaging activities (Rankin, Walsh, & Sweeny, 2018). Therapeutic techniques have successfully minimized distress during stressful moments (e.g., cognitive behavioral therapy, Tatrow & Montgomery, 2006), and several interventions have specifically targeted distress during stressful waiting periods (Bennett et al., 2007; Lancastle & Boivin, 2008; Phelps et al.,

2013). If such interventions can successfully minimize distress while waiting for important news, the downstream consequences of shifting an individual's perception of time can conceivably further reduce the distress experienced.

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Table 1

Results from Multilevel Models Predicting Distress from Time Perception

	Study 1 *b* (*se*)	Study 2 *b* (*se*)	Study 3 *b* (*se*)
Worry			
Within-person	.01 (.07)	.01 (.04)	.22 (.07)**
Between-persons	.58 (.10)**	.52 (.07)**	.50 (.09)**
State anxiety			
Within-person	.16 (.08)*	-.03 (.04)	.15 (.06)*
Between-persons	.33 (.09)**	.27 (.06)**	.14 (.06)*
Negative emotion			
Within-person	.01 (.07)	-.02 (.04)	.04 (.09)
Between-persons	.29 (.08)**	.15 (.06)*	.26 (.10)**
Positive emotion			
Within-person	-.15 (.07)*	-.03 (.04)	.04 (.07)
Between-persons	-.12 (.10)	-.19 (.06)**	-.04 (.07)
Sleep disruption			
Within-person	N/A	.06 (.03)*	-.03 (.03)
Between-persons	N/A	.12 (.05)*	.07 (.04)$^{+}$
Sleep duration			
Within-person	N/A	N/A	-.08 (.08)
Between-persons	N/A	N/A	.03 (.08)
Poor subjective health			
Within-person	N/A	.08 (.05)	.09 (.07)
Between-persons	N/A	.12 (.07)$^{+}$	.10 (.06)
Poor health functioning			
Within-person	N/A	N/A	-.02 (.06)
Between-persons	N/A	N/A	.09 (.05)
Subjective coping			
Within-person	N/A	-.07 (.04)	-.06 (.08)
Between-persons	N/A	-.45 (.07)**	-.43 (.09)**

Note: $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. All analyses controlled for linear and quadratic time and its interaction with time perception.

Table 2

Results from Multilevel Models Predicting Time Perception from Distress

	Study 1 *b* (*se*)	Study 2 *b* (*se*)	Study 3 *b* (*se*)
Worry			
Within-person	.07 (.09)	.12 (.04)**	.36 (.10)**
Between-persons	.34 (.07)**	.38 (.06)**	.32 (.09)**
State anxiety			
Within-person	.15 (.07)*	.04 (.04)	.32 (.14)*
Between-persons	.43 (.09)**	.49 (.08)**	.32 (.15)*
Negative emotion			
Within-person	-.04 (.08)	.05 (.05)	.13 (.09)
Between-persons	.40 (.10)**	.21 (.08)**	.21 (.10)*
Positive emotion			
Within-person	-.17 (.08)*	-.04 (.04)	.08 (.12)
Between-persons	-.15 (.09)+	-.39 (.08)**	-.20 (.13)
Sleep disruption			
Within-person	N/A	.10 (.06)+	-.13 (.30)
Between-persons	N/A	.24 (.10)*	44 (.21)*
Sleep duration			
Within-person	N/A	N/A	-.06 (.11)
Between-persons	N/A	N/A	-.16 (.13)
Poor subjective health			
Within-person	N/A	.05 (.03)	.14 (.13)
Between-persons	N/A	.17 (.07)*	.19 (.17)
Poor health functioning			
Within-person	N/A	N/A	-.03 (.14)
Between-persons	N/A	N/A	.19 (.17)
Subjective coping			
Within-person	N/A	-.12 (.04)**	-.15 (.10)
Between-persons	N/A	-.42 (.06)**	-.38 (.10)**

Note: $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. All analyses controlled for linear and quadratic time and its interaction with distress.

Table 3

Results from Multilevel Models Predicting Distress from Time Perception, Controlling for Individual Differences

	Study 1 *b* (*se*)	Study 2 *b* (*se*)	Study 3 *b* (*se*)
Worry			
Within-person	.01 (.07)	.004 (.04)	.21 (.07)**
Between-persons	.53 (.10)**	.45 (.07)**	.49 (.09)**
State anxiety			
Within-person	.14 (.08)+	-.05 (.04)	.16 (.06)**
Between-persons	.29 (.08)**	.22 (.06)**	.13 (.06)*
Negative emotion			
Within-person	-.01 (.07)	-.02 (.04)	.04 (.09)
Between-persons	.25 (.08)**	.06 (.06)	.25 (.09)**
Positive emotion			
Within-person	-.14 (.08)+	-.03 (.04)	.03 (.07)
Between-persons	-.08 (.10)	-.14 (.06)*	-.02 (.07)
Sleep disruption			
Within-person	N/A	.05 (.03)+	-.03 (.03)
Between-persons	N/A	.07 (.05)	.07 (.04)+
Sleep duration			
Within-person	N/A	N/A	-.08 (.08)
Between-persons	N/A	N/A	.03 (.08)
Poor subjective health			
Within-person	N/A	.10 (.05)+	.09 (.07)
Between-persons	N/A	.08 (.07)	.09 (.06)
Poor health functioning			
Within-person	N/A	N/A	-.02 (.06)
Between-persons	N/A	N/A	.09 (.05)
Subjective coping			
Within-person	N/A	-.05 (.04)	-.06 (.08)
Between-persons	N/A	-.40 (.07)**	-.41 (.08)**

Note: $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. All analyses controlled for linear and quadratic time and its interaction with time perception.

Table 4

Results from Multilevel Models Predicting Time Perception from Distress, Controlling for Individual Differences

	Study 1 *b* (*se*)	Study 2 *b* (*se*)	Study 3 *b* (*se*)
Worry			
Within-person	.06 (.09)	.12 (.04)**	.36 (.10)**
Between-persons	.34 (.07)*	.38 (.06)**	.35 (.09)**
State anxiety			
Within-person	.14 (.07)*	.03 (.04)	.32 (.14)*
Between-persons	.46 (.10)**	.47 (.09)**	.34 (.16)*
Negative emotion			
Within-person	-.04 (.08)	.06 (.05)	.14 (.09)
Between-persons	.43 (.11)**	.12 (.09)	.22 (.10)*
Positive emotion			
Within-person	-.16 (.09)+	-.05 (.04)	.07 (.12)
Between-persons	-.14 (.10)	-.34 (.09)**	-.18 (.14)
Sleep disruption			
Within-person	N/A	.11 (.06)+	-.13 (.30)
Between-persons	N/A	.14 (.11)	.46 (.23)+
Sleep duration			
Within-person	N/A	N/A	-.06 (.11)
Between-persons	N/A	N/A	-.16 (.13)
Poor subjective health			
Within-person	N/A	.06 (.03)+	.14 (.13)
Between-persons	N/A	.13 (.07)	.19 (.19)
Poor health functioning			
Within-person	N/A	N/A	-.02 (.14)
Between-persons	N/A	N/A	.19 (.18)
Subjective coping			
Within-person	N/A	-.11 (.04)*	-.15 (.10)
Between-persons	N/A	-.42 (.07)**	-.43 (.10)**

Note: $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$. All analyses controlled for linear and quadratic time and its interaction with distress.