Acta Psychologica 134 (2010) 130–141

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Aging and the speed of time

William J. Friedman [a,*], Steve M.J. Janssen [b,c]

[a] Department of Psychology, 228B Severance Laboratory, Oberlin College, Oberlin, OH-44074, United States
[b] Department of Psychology and Neuroscience, Duke University, 9 Flowers Dr - Soc/Psych Bldg - Box 90086, Durham, NC-27708, United States
[c] Department of Psychology, University of Amsterdam, Roetersstraat 15, 1018 WB, Amsterdam, the Netherlands

ARTICLE INFO

Article history:
Received 9 August 2009
Received in revised form 16 January 2010
Accepted 18 January 2010
Available online 16 February 2010

PsycINFO classification:
2840

Keywords:
Time perception
Subjective speed of time
Aging
Time pressure

ABSTRACT

Correlational and experimental methods provide evidence relevant to seven theories of humans' general impressions of the speed of time, including theories of the purported subjective acceleration of time with aging. A total of 1865 adults from two countries, ranging in age from 16 to 80, reported how fast time appears to pass over different spans of time. Other measures tapped the experience of life changes and time pressure, and experimental manipulations were used to test two models based on forward telescoping and difficulty of recall. Respondents of all ages reported that time seems to pass quickly. In contrast to widely held beliefs, age differences in reports of the subjective speed of time were very small, except for the question about how fast the last 10 years had passed. Findings support a theory based on the experience of time pressure.

1. Introduction

For more than a century, philosophers and psychologists interested in humans' experience of time have reported, and attempted to explain, the illusion that time appears to pass more rapidly in later adulthood than when one was younger (e.g., Guyau, 1890; James, 1890). Despite this long history and the variety of theories that have been advanced to explain the illusion, our understanding of the underlying mechanisms – and even whether impressions of the speed of time's passage actually change during adulthood – is quite limited. In this article we describe the main theories that previous authors have proposed to explain the subjective acceleration of time; describe new theories of why, at any age, time would seem to pass quickly; and review past evidence (see Block, Zakay, & Hancock, 1998; Craik & Hay, 1999; Draaisma, 2004). We found little evidence relevant to most of the theories, so our final purpose is to present findings that can be used to evaluate many of the theories and test the veracity of the phenomenon that many were devised to explain: older adults experience time passing more quickly than younger adults.

2. Theories

2.1. Theories of subjective acceleration

2.1.1. Age changes in numbers of memorable events

James (1890), Guyau (1890), and Fraisse (1963), Fraisse (1984) have all attributed age increases in the apparent speed of time's passage to a decline during adulthood in the number of memorable events that are experienced. For example, Fraisse (1984, p. 29) wrote that in older people there are "fewer novel events in life that are worthy of being stored", and James (p. 625) maintained that in childhood experiences are varied and distinct but in adulthood "each passing year converts some of this experience into automatic routine which we hardly note at all, the days and weeks smooth themselves out in recollection, and the years grow hollow and collapse". Underlying these explanations is the assumption that humans gauge the magnitude of past intervals of time (e.g., the last year) according to how many events can be recalled from that period. This assumption is shared with another theory, considered in the next section, on why time might seem to pass quickly in both young and older adults.

2.1.2. Ratio theories

Another explanation of age changes is that impressions of a given interval of time are based on an implicit comparison of that interval with the total amount of time one has lived. Janet (1877, cited in Fraisse (1963)) suggested a ratio model, in which the past

* Corresponding author. Tel.: +1 440 775 8365; fax: +1 440 775 8356.
E-mail address: friedman@oberlin.edu (W.J. Friedman).

0001-6918/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.actpsy.2010.01.004

year was subjectively 1/20 for a 20-year-old but 1/60 for a 60-year-old. For Lemlich (1975, p. 235), "the subjective duration of an interval of real time varies inversely with the square-root of the total real time (age)". In both cases the illusion is attributed to smaller ratios in older adults, and one can make quantitative predictions about the magnitude of subjective acceleration. For example, in Lemlich's model the past year will seem .59 as long for a 60-year-old as for a 20-year-old, whereas the value is .33 for the ratio model.

2.1.3. Biological clock theories

In a third explanation, a slowing in the rate of biological processes accounts for an acceleration of experienced time with aging (Craik & Hay, 1999; Draaisma, 2004; Whitrow, 1972). This account assumes that external time, as measured by clocks and calendars, is compared to some internal pacemaker. If the rate of that pacemaker slows down, external time will appear to pass more quickly.

2.1.4. Attentional explanations

Craik and Hay (1999) and Gruber, Wagner, and Block (2004) have suggested that another age-related change might contribute to subjective acceleration with aging: declines in attentional resources. In some theories of time perception (Block & Zakay, 2001; Zakay, 1989), the perceived duration of an interval is influenced by how attention is allocated during that interval, at least when people know in advance that they will be judging an interval (called the *prospective* method). For prospective time judgments, the more attention that is focused on a non-temporal task, the less attention will be left over to notice the passage of time. As a result tasks that demand considerable attentional resources are perceived as briefer than tasks that are undemanding. In the case of aging effects, "If older adults have fewer attentional resources, their prospective duration experience may shorten, especially in situations characterized by more difficult information-processing demands..." (Gruber et al., 2004, p. 194).

2.2. General explanations of the impression that time is passing quickly

Although the view that time appears to pass faster in older than younger adults is probably predominant both among researchers and among the general population, we will see that some findings indicate that age differences are small and that both young and older adults experience time as passing quickly. We consider three new theories that might explain why, throughout adulthood, time appears to be passing quickly.

2.2.1. Forward telescoping

The first explanation of why time seems to pass quickly comes from the research literature on memory for the times of past events (for reviews see Friedman (1993), Friedman (2004) and Thompson, Skowronski, Larsen, & Betz (1996)). The premise of the theory is that when people repeatedly experience a phenomenon called *forward telescoping*, they will have the impression that time is passing quickly. Forward telescoping refers to the tendency in studies of memory for the time of news and personal events to underestimate how long ago particular events occurred (Bradburn, Rips, & Shevell, 1987; Huttenlocher, Hedges, & Bradburn, 1990; Huttenlocher, Hedges, & Prohaska, 1988; Janssen, Chessa, & Murre, 2006; Kemp, 1988; Kemp, 1996; Rubin & Baddeley, 1989). When people learn that they have underestimated the age of an event, they may feel that time is passing at a rapid pace. For example, if an event that seems as if it happened one or two years ago actually turns out to have been four years ago, one might get the impression that four years have passed unexpectedly quickly – the four years seem like just one or two. (See Crawley and Pring (2000) and Draaisma (2004) for discussions of how age differences in forward telescoping might also explain age changes in the subjective speed of time.)

2.2.2. Difficulty of recall

The normal difficulty of accessing many of the events that happened in a past interval of time could also make that span of time appear to have passed quickly. When people think about an interval of time (e.g., things that have happened since this time last year), it will be difficult to activate most events; some events are no longer accessible, and additional, non-temporal recall cues (and time to carry out the search) would usually be needed to access many of the things that could be retrieved. Laboratory studies of time perception using the *retrospective* method (where participants do not know in advance that they will be judging an interval of time) have shown that durations seem shorter if fewer events are recalled (e.g., Block, 1989; Ornstein, 1969; Poynter, 1989). Perhaps the normal difficulty of recalling many events from an interval of time, such as the past year, leads to the impression that the interval is briefer than people expect and consequently that time is passing quickly.

2.2.3. Time pressure

People may be especially likely to think about the apparent speed of time when it is difficult to complete all that they want to accomplish in the time that is available. The experiences associated with being busy or rushing or finding that there is insufficient time to get things done may be reinterpreted as the feeling that time is passing quickly. Repeated experiences of the insufficiency of intervals of time may lead to the general impression that time passes quickly. One might assume that this relation would lead to substantial age declines in the subjective speed of time during adulthood because of greater time-based demands in young adulthood. However, even if time-based demands decrease with age, diminishing energy or cognitive resources could result in older adults often feeling similarly challenged to accomplish all that they want to accomplish in a day or week. Declines in cognitive resources, of course, underlie attentional explanations, but the time–pressure theory differs in predicting that time will seem to pass quickly throughout adulthood.

3. Past studies

There have been no studies in which the authors have attempted to test explanations of why time might seem to be passing quickly for adults in general. However, two sorts of findings have been used to try to demonstrate the existence of subjective acceleration and, in a few studies, to test theories. The first kind of finding comes from measuring the participants' current experience of time and making comparisons between the participants of different ages. The second kind of evidence involves asking the participants to compare the present speed of time's passage to its speed at earlier ages.

3.1. Between-age comparisons of the experience of time

The largest body of research on age differences in adulthood in the experience of the speed of time is a set of studies of judgments of intervals in the range of seconds to minutes.[1] Although the time

[1] There is also a set of studies, including many summarized by Lustig (2003), on age differences in performance on interval-comparison tasks. For example, the participants are sometimes asked to learn the duration of a target interval (e.g., 500 ms) and then judge whether a series of test stimuli match it. There is another group of studies on age differences using the method of reproduction, in which the participants are asked to reproduce the duration of a test stimulus. These studies are excluded from the present review because, if the target interval and the test or reproduced interval is measured by the same psychological processes, it is not clear why between-age comparisons should reflect age changes in the subjective speed of time. In addition, like the other laboratory studies, they are of questionable relevance to age changes in general impressions of the speed of time.

scales in these studies are brief, the findings have been used to try to draw conclusions about age changes in impressions of the speed of time in general (e.g., Block et al., 1998; Lustig, 2003). Block et al. conducted a meta-analysis of 16 experiments in which multiple age groups of adults made judgments of brief durations. None of the studies required the participants to perform a concurrent non-temporal task. The meta-analysis revealed that older adults gave longer verbal estimates of the duration of intervals and shorter productions than young adults. For both estimation and production, the results suggest that a given interval of time passes more *slowly* for older than younger adults.

Different age effects emerged in a group of studies in which non-temporal attentional demands were made during the stimulus interval (Bherer, Desjardins, & Fortin, 2007; Craik & Hay, 1999; Perbal, Droit-Volet, Isingrini, & Pouthas, 2002; Vanneste & Pouthas, 1995). In these studies older adults made longer productions or gave shorter estimates than young adults (as if time passed more *quickly* for older adults). A number of authors (Craik & Hay, 1999; Gruber et al., 2004; Lustig, 2003) have used attention theories of subjective acceleration to account for the differences between these findings and those of the studies reviewed by Block et al. (1998). Attention models of subjective acceleration correctly predict that older adults' prospective time judgments will be disproportionately affected by demanding concurrent tasks, and they may not imply age differences where no such demands are made. However, the models do not explain why time seemed to pass more quickly in the Vanneste and Pouthas experiment, which used retrospective judgments – only in prospective tasks are greater attentional demands predicted to be negatively related to duration estimates.

These findings do not provide a clear answer to the question of whether older adults perceive time to pass more quickly than young adults. In addition, it is possible to question whether estimates of durations on the order of seconds to a few minutes are relevant to general impressions of the speed of time. It seems likely that different processes contribute to impressions of the speed of time on such different scales.[2]

In contrast to the substantial number of cross-sectional studies of the perception of brief intervals, there is only one cross-sectional study in which age differences in general impressions of the speed of time were assessed. In Wittmann and Lehnhoff's (2005) study, trained researchers conducted at-home interviews with 499 German and Austrian participants ranging in age from 14 to 94 years. The participants were queried about how fast time usually passes, how fast the next hour is expected to pass, and how fast the previous week, month, year, and 10 years passed. Surprisingly, the cross-sectional comparisons showed very weak age differences on most measures: For the questions concerning how fast time usually passes, the next hour, and the previous week, month, and year, age accounted for only about 1% or less of the variance. Only one item, "How fast did the previous 10 years pass for you?", showed more than trivial age differences, with an increase from the teens through the 50s accounting for 9% of the variance. Wittmann and Lehnhoff's findings provide little evidence for age differences in adulthood in how fast time appears to be passing and they show that at all ages time seems to pass quickly for most people. Because this is the only study of age differences in general impressions of the speed of time, it is important that other researchers attempt to replicate these findings.

[2] An unpublished study of young (mean age of 18.9) and older (77.8) adults by the first author (2006) failed to show significant correlations between prospective and retrospective judgments of the durations of 20 s intervals and general impressions of the speed of time.

3.2. Retrospective comparisons of the experience of time

In a number of studies, respondents were asked to compare the speed of time at their present age with its speed at earlier ages (Baum, Boxley, & Sokolowski, 1984; Gallant, Fidler, & Dawson, 1991; Joubert, 1983; Joubert, 1984; Joubert, 1990; Lemlich, 1975; Tuckman, 1965; Walker, 1977; Wittmann & Lehnhoff, 2005). These studies reveal that most older adults believe that the speed of time has accelerated during adulthood. They also show a similar view among undergraduates comparing their present age with when they were half their age.

The subset of studies involving quantitative comparisons between one's present age and an earlier age fails to support either Janet's (1877, cited in Fraisse (1963)) or Lemlich's (1975) model. Averaging across studies, the mean rated ratios between one's current age and an earlier age are about 1.58 for one-quarter one's present age and 1.46 for half one's age. For example, if a participant is presently 60 years old, then he or she reports that the current subjective speed of time is on average 1.58 times faster than it was when he or she was 15 years old and 1.46 times faster than it was when he or she was 30 years old. (The predictions are 4.0 and 2.0, respectively, for the ratio model and 2.0 and 1.4 for the square-root model.) It should also be noted that few developmental psychologists would trust people's ability to remember with accuracy their experiences from so long ago. Perhaps the clearest conclusion that can be drawn from these and the other retrospective studies is that both young and older adults report that time seems to pass more quickly now than at earlier ages.

4. Goals of the new studies

This review shows that there is very little evidence available bearing on the question of whether older adults' general impressions of the speed of time differ from those of young adults and even less that makes it possible to evaluate the influences on these impressions that are proposed in different theories. The following two studies were intended to test some of the theories of subjective acceleration and of the impression that time passes quickly in adults in general. In both studies experimental manipulations were used to test new theories based on forward telescoping (Experiment 1) and difficulty of recall (Experiment 2). In addition, correlational designs were used to evaluate theories for which it would be difficult to manipulate the relevant variables. In Experiment 1 we provide correlational evidence relevant to the theory that the subjective speed of time is influenced by the perception of the amount of recent change in one's life, and in Experiment 2 we provide evidence regarding the new time–pressure explanation of the impression that time is passing quickly. Some of the results of the studies also shed light on other theories of subjective acceleration, including ratio models and those relying on age changes in an internal pacemaker. Where differences predicted by a theory were not found, we used effect sizes and confidence intervals to limit the problems associated with accepting the null hypothesis. Finally, age comparisons in both studies make it possible to test the phenomenon that the four theories of subjective acceleration were designed to explain.

5. Experiment 1

Experiment 1 was conducted to provide evidence relevant to several of the theories and to test for age differences in general impressions of the speed of time. An experimental manipulation was used to evaluate the theory that the experience of forward telescoping affects the subjective speed of time. The participants estimated the ages of a set of news events and then received false

Table 1
News events used in Experiment 1 and their dates.

Event	Date
Following public outcry after a child was mauled by a dog, the Government revealed a raft of law changes to tighten dog controls on New Zealand's 400,000 dogs, including requiring all newly registered dogs to be microchipped	April 15, 2003
Parliament passed the Prostitution Reform Bill by 60 votes to 59, legalizing prostitution in New Zealand	June 26, 2003
The body of missing Featherston schoolgirl Coral-Ellen Burrows was recovered from the rugged south Wairarapa coast, concluding a 10-day search. Shortly after her body was found, her stepfather appeared in court charged with her murder	September 19, 2003
Don Brash replaced Bill English as leader of the National Party as a result of a vote by the party's MPs at a caucus meeting	October 28, 2003
US troops captured former Iraqi leader Saddam Hussein near his home town of Tikrit. He was dug out by troops from a narrow hiding hole during a raid on a farm	December 13, 2003
Shrek, the extra-woolly sheep who had not been shorn in many years, was discovered during a Central Otago high-country muster and gained media stardom	April 15, 2004
Lana Coc-Kroft was admitted to Auckland hospital battling a mystery fever after she suddenly became delirious and collapsed during the filming of Celebrity Treasure Island in Fiji	April 29, 2004
Former US President Ronald Reagan died from complications of Alzheimer's Disease at his home in LA	June 5, 2004
PM Helen Clark's motorcade, including marked and unmarked police cars, traveled above the speed limit between Waimate and Christchurch in order for her to catch a flight to Wellington	July 17, 2004
Former All Black Jonah Lomu had a kidney transplant at Auckland City Hospital. (The kidney donor was later revealed to be radio presenter Grant Kereama)	July 27, 2004
Paul Holmes called the United Nations Secretary General Kofi Annan a "cheeky darkie"	September 24, 2004
Iraena Ascher went missing after calling the police for help. The police response had been to send her a taxi, which went to the wrong address	October 10, 2004

feedback about the events' true ages. This manipulation was designed to accentuate or minimize the experience of forward telescoping. In addition, the participants were asked to respond to items tapping the experience of life changes, and this scale was correlated with one measuring impressions of the speed of time.

5.1. Method

5.1.1. Participants

The participants were 49 undergraduates from the University of Otago and the Otago Polytechnic and 50 older adults from Dunedin, New Zealand, and the surrounding area. (It was learned after the experiment was complete that one of the original 50 undergraduate testings was of someone participating a second time.) The younger group had a mean age of 21.36 (SE = 0.03, range 19.83–29.75) and included 23 males and 26 females. They were recruited through a university employment service and paid approximately NZ$11.00 for their participation. The older group had a mean age of 68.15 (SE = 0.10, range 60.17–79.58) and included 24 males and 26 females. Their self-reported health rating, on a 1-to-7 scale from poor to excellent, was 5.32 (SE = 0.02). The older participants were recruited through a research laboratory database, newspaper advertisements, and personal contacts. As compensation for their participation, they were offered a $10 petrol or book voucher. Twenty of the older adults had educations including at least some university study or professional training.

5.1.2. Stimuli and procedure

Testing took place between March 23 and May 25, 2007. All the participants were tested individually in a quiet room, either in their homes or on a university campus. They were recruited to take part in a study of memory for events; the information sheet distributed at the start of testing informed them that there was also a separate study about the experience of time. After signing a consent form, the participants filled out a cover sheet that requested age and gender and, for older participants, education and health information.

5.1.2.1. Judgments of news events. The following two pages listed a random ordering of the twelve news events presented in Table 1. The participants were asked to rate how well they remembered each event on a scale ranging from "don't remember at all" (1) to "remember very well" (7). The next sheets listed the same 12 news events, with spaces below each for estimates of how long ago the events occurred in years and months. The tester selected the six best-recognized events from the previous sheets, choosing randomly in the case of ties, and crossed out the others. After participants wrote in all six of their estimates of how long ago the events had occurred in years and months, the tester wrote next to each a supposedly correct distance. Half of the participants in each age group were randomly assigned to receive feedback distances that were one-third longer ago or a shorter time ago than their estimates, with several exceptions to help disguise the deception.[3] After the tester gave the participants the feedback, she told them, "It looks like a lot of these were *longer ago/more recent* than you thought", the version appropriate for their condition.

5.1.2.2. Questions about the experience of time. Next, the participants were asked to complete a questionnaire titled, "Study of the Experience of Time". Among the questions were six items from Wittmann and Lehnhoff's (2005) questionnaire (Appendix, Items 1–6), all using their five-point rating scale (very slowly [−2], slowly [−1], neither fast nor slow [0], fast [1], and very fast [2]). The time-experience scale also included four new items designed to tap the experience of recent life changes (7–10), and three new items (11–13) designed to measure the experience that one often underestimates the ages of events (forward telescoping). The new statements were all rated on seven-point scales, with the left end labeled "strongly disagree" and the right end labeled "strongly agree". The six Wittmann and Lehnhoff items were the speed-of-time scale, Cronbach's alpha = .72. The alphas were .69 for the life-changes scale and .53 for the forward-telescoping scale.

5.2. Results

5.2.1. News events

5.2.1.1. Recognition ratings. The participants in both age groups reported good memory for the twelve news events, although the older participants produced higher memory ratings. For the young adults, the mean on the seven-point scale for all 12 news events was 5.15 (SE = 0.12), and for the older group the mean was 5.90

[3] First, one event was randomly selected to be designated accurate, and the feedback distance was only 1 month different from the participants' estimate. Second, the maximum forward displacement was 6 months prior to testing, and any more recent estimates were designated to be accurate. Third, if two or more estimates were the same, all but one of them received feedback that was displaced forward or backward by 1 month from the one-third distance.

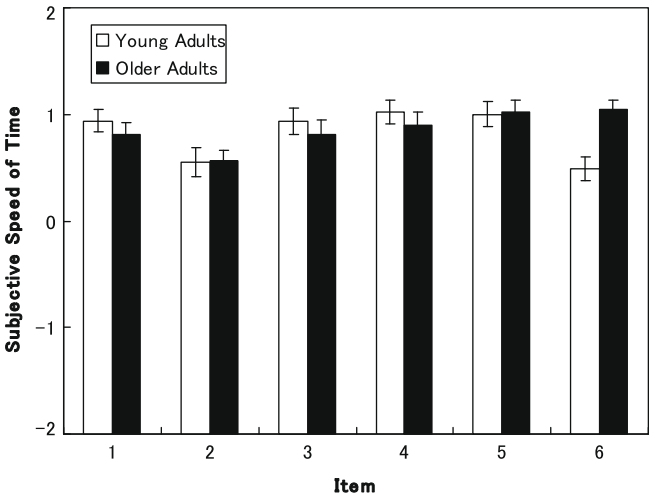

Fig. 1. Mean ratings (and 95% CIs) of the young and older adults in Experiment 1 on Items 1–6 of the speed-of-time scale (Appendix). The values represent time passing: very slowly [−2], slowly [−1], neither fast nor slow [0], fast [1], and very fast [2].

(*SE* = 0.12), $t(97) = 4.42$, $p < .01$, $d = 0.89$ (95% CI 0.47–1.30).[4] For the six items selected for temporal-distance judgments, the mean recognition ratings were 6.38 (*SE* = 0.09) and 6.62 (*SE* = 0.08) for the two groups, $t(95) = 1.84$, $p = .07$.

5.2.1.2. Distance estimates. Estimates of how long ago the six best-remembered events had occurred were first examined as deviations from the true date, whether positive or negative. The mean absolute error was 15.41 (*SE* = 1.06) months for the younger group and 14.81 (*SE* = 0.93) months for the older group. The group difference was not significant. When signed errors are considered, the younger group underestimated the ages of events by an average of 5.59 (*SE* = 1.67) months, a value that differed reliably from zero, $t(46) = 3.34$, $p < .01$. The older groups' mean was less than 1 month from the correct distance. The age groups differed significantly, $t(95) = 2.66$, $p < .01$, $d = 0.54$ (0.43–0.94), in the direction found in a study by Crawley and Pring (2000), in which older adults were sometimes less likely to underestimate the ages of news events (i.e., less prone to forward telescoping). Correlations between the actual distances of the 12 events in the past and groups' mean distance estimates produced *r*s of .08 and .15 for the two groups, indicating a lack of differentiation by true time within the relatively narrow span of about 20 months over which events were distributed.

5.2.2. General impressions of the speed of time

A main question of this study is whether young and older adults differ in their general impressions of the speed of time. The age groups did not differ reliably on the speed-of-time scale, $t(96) = 0.32$, $p = .75$, $d = 0.06$ (−0.33 to 0.46). The means for the younger and older groups were 0.82 (*SE* = 0.07) and 0.86 (*SE* = 0.08). Fig. 1 shows the ratings for individual items. Only one item differed significantly between groups, and this was the only one that had shown a substantial age effect in Wittmann and Lehnhoff's (2005) study: "How fast did the last 10 years pass for you?", $t(93.21) = 3.85$, $p < .01$, $d = 0.77$ (0.36–1.18). (The degrees of freedom of this test are adjusted for unequal variance.)

As Fig. 1 shows most younger and older adults reported time to be passing quickly. In both age groups, *t*-tests showed that the means for each of the items fell above the midpoint of the scale, *p*s < .01.

5.2.3. Recent life changes

On the items measuring perceived life changes, high values correspond to few life changes and new experiences in recent years. The younger group ($M = 2.83$, $SE = 0.15$) rejected these statements more strongly than the older group ($M = 3.46$, $SE = 0.20$), $t(89.87) = 2.57$, $p < .05$, $d = 0.52$ (0.11–0.92), but both means fall towards the "disagree" end of the continuum. In the older group, men reported fewer life changes than women, $t(48) = 2.05$, $p < .05$, $d = 0.58$ (−0.16 to 0.97).

5.2.4. Effects of the experimental manipulation

To test the forward-telescoping theory, the participants were randomly assigned to receive "correct" answers that were either one-third more time ago or one-third less time ago than their distance estimates. A preliminary question is whether the manipulation affected the experience that one often underestimates the ages of events. The participants who were told that their estimates were too long ago and received individual distance estimates consistent with this information had a mean of 3.71 (*SE* = 0.17) on the forward-telescoping items, whereas those given feedback that their estimates were too recent had a mean of 5.25 (*SE* = 0.14). An ANOVA revealed significant effects of feedback condition, $F(1, 95) = 49.62$, $p < .01$, partial eta squared (η_p^2) = .34, and age group, $F(1, 95) = 4.06$, $p < .05$, $\eta_p^2 = .04$. The interaction approached significance ($p = .06$), reflecting a slightly greater feedback effect in the younger group. Further evidence of the efficacy of the manipulation was that the participants sometimes mentioned the feedback as evidence that they tend to date events one way or another.

Despite the substantial effect of the manipulation on forward-telescoping scores, there was no support for the theory that the experience of underestimating the ages of events contributes to the impression that time is passing quickly. An ANOVA performed on the means of the speed-of-time scale produced trivially weak (η_p^2s < .01), non-significant effects of condition, group, and their interaction.

5.2.5. Correlations between scales

Another key question in this study is whether the perception of life changes influences the subjective speed of time. There was no support for this theory either. Despite the fact that the two scales showed acceptable reliability, the scale measuring recent life changes was not significantly correlated with the speed-of-time scale, with *r*s close to zero for each age group. The correlation between the life-change scale and the 10-year subjective-speed item (the only one that showed age differences) was also close to zero. In addition, the forward-telescoping theory failed to receive support from two relevant correlations: There were no significant correlations between the forward-telescoping scale and the scale measuring general impressions of the speed of time, *r*s < .17, and the correlation between actual dating judgments and the speed of time was also very small, $r(N = 96) = .10$ (−0.10 to 0.29).

5.3. Discussion

The results replicate Wittmann and Lehnhoff's (2005) findings that age differences between early adulthood and later adulthood in the subjective speed of time are trivially small, except when people are queried about very long intervals of time. Age differences were small and non-significant on all but one of the items,

[4] Here and later in this and the following experiment, analyses of sex differences in measures of the experience of time and related measures are reported only if they are significant. In addition, where differences are tested for any variable, we report Cohen's *d* and the associated confidence interval rather than retrospective power statistics, following the recommendation of Howell (2007). Because our sample size in Experiment 2 is very large, we also report effect sizes (explained variance or partial eta squared) throughout the manuscript, because even very weak effects can attain significance in such large samples.

the question about the last 10 years. The results for this and most other items taken from Wittmann and Lehnhoff's study indicate that the findings that they obtained with German and Austrian adults generalize well to New Zealand samples. The results also repeat Wittmann and Lehnhoff's in showing that both young and older adults report time to be passing quickly.

The fact that both the present experiment and Wittmann and Lehnhoff's (2005) study showed substantial age differences for the 10-year item but not questions about how fast time usually passes, is expected to pass in the next hour, or how fast it passed in the last week, last month, and last year (Fig. 1) indicates that different processes contribute to the 10-year question and the others, at least for the young adults. Why do older adults believe that the past 10 years passed more quickly than young adults do, even though age differences are not found on the shorter time scales? One possibility is that older adults are influenced by a general belief that time appears to pass more quickly as people grow older. The 10-year question involves considerable retrospection and may tap the same beliefs as the questions used in past studies that ask the participants to compare the present speed of time with its speed at earlier ages. These earlier studies clearly show that most older adults (although apparently not young adults; see Tuckman, 1965) believe that time appears to accelerate as one grows older in adulthood. According to this explanation, the data for the 10-year question reflect a kind of folk theory about aging and time perception, whereas the other questions involve considering one's actual experience.

A second possibility is that younger people looking back over a decade of working towards major life goals perceive it to have passed more slowly than older people, who are less likely to have been striving to attain major life goals in the past decade. Probably most people know that time appears to pass more slowly while waiting for something important, and this may lead younger adults to conclude that the past 10 years have passed more slowly than older adults.

Third, as the life-change models of subjective acceleration assume (e.g., James, 1890), and laboratory studies of retrospective duration judgments show (e.g., Block, 1989; Ornstein, 1969; Poynter, 1989), an interval of time seems longer in retrospect if people remember a greater number of events that occurred during that interval. Someone in their early 20s looking back over the previous decade may retrieve more notable events than a 70-year-old, even in the brief time spent on a single item of a questionnaire. And apart from enumerating events, which must be quite limited in responding to a single item, adults in their early 20s know that their lives have changed tremendously since they were pre-adolescents. It is important to bear in mind, however, that the explanation of age differences in scores on the 10-year item should not be specific to young adults, because scores appear to increase continuously with age through the 50s in Wittmann and Lehnhoff's (2005) study, a finding that is replicated in Experiment 2 of the present study.

Assessments of life changes over a period of many years may contribute to age differences in how rapidly the past 10 years appeared to pass, but it is notable that no age differences are found when the participants consider intervals up to a year in the past. Despite significant differences between the two age groups in their ratings of numbers of life changes in recent years, the groups did not differ significantly on measures of the subjective speed of the last year. Furthermore, the life-change scale and the speed-of-time scale were not correlated: Individuals within an age group who perceived fewer life changes did not report that time passes more quickly, even on the 10-year item. These results indicate that theories based on age changes in the number of memorable life events are, at best, quite limited in their ability to explain general impressions of the speed of time.

This experiment was also designed to test the hypothesis that learning that one has underestimated the ages of events causes one to believe that time is passing rapidly. The experimental manipulation had a substantial effect, in the intended direction, on reports of the experience of forward telescoping, but it had no effect on the critical dependent variable, general impressions of how fast time passes. In addition, ratings on the scales measuring forward telescoping and those measuring the subjective speed of time were not significantly correlated. Both these findings run counter to the expectations of the theory that learning that they have underestimated the ages of events causes people to feel that time is passing quickly. It seems reasonable to abandon forward telescoping as an explanation of people's general impressions that time is passing quickly.

6. Experiment 2

A second experiment was designed to test the other new theories of the impression that time is passing quickly, explanations based on the difficulty of recalling events and time pressure. It also provided an opportunity to collect the data relevant to the question of whether there are age differences in the experience of the speed of time in a very large sample and in another nation, The Netherlands. The hypothesis based on difficulty of recall was tested experimentally by randomly assigning the participants to judge the speed of time either before or after answering questions about 30 news events, 80% of which had occurred within the past year (Meeter, Murre, & Janssen, 2005; Meeter, Ochtman, Janssen, & Murre, 2010). If the theory is correct, pre-exposing the participants to many events from the past year in the "after" condition might counter the normal difficulty of recalling events from this time period and diminish the feeling that the year had passed quickly. The other new theory was evaluated by examining the correlation between impressions of the speed of time and reports of time pressure. The study also provides new information about whether the experience of time pressure differs between adults of different ages.

We chose to conduct the study using the Internet. There are many benefits of using the Internet (Reips, 2000; Reips, 2002), such as the absence of time and organisational constraints. Moreover, easy access for the participants can lead to potentially very large and diverse populations, which makes it easy to achieve sufficient statistical power. Experiment 2 included participants from 16 to 80 years. Age groups between 30 and 60 years are often overlooked, but they can provide critical information about how the subjective experience of time develops across the life span.

Besides these advantages, there are also limitations to psychological research on the Internet (Reips, 2000; Reips, 2002). The first problem of Internet-based research is multiple submissions. We minimized these by supplying passwords and allowing the participants to take the test more than once. Double entries were later filtered out. The second problem is self-selection, which can be controlled by the multiple site entry technique. We promoted the website on which the study was presented through other websites, search engines, traditional media (magazines, newspapers, etc.), and word of mouth. The third possible problem is the absence of a physical experimenter, which could lead to problems during the experiment if the instructions are unclear. Pre-testing the experiment in a usability test (see Meeter et al., 2005, 2010) and providing the possibility for feedback help to improve the clarity of the instructions. The fourth problem is the variance between computers, browsers, and networks, which could lead to reliability problems. We randomly distributed the participants to the experimental conditions so that we could counter these reliability issues. The final problem is the dropout rate, which we reduced by giving information about the duration of the experiment, feedback about progress during the study, and immediate feedback about performance.

6.1. Method

6.1.1. Participants

The experiment was administered via the Internet at http://memory.uva.nl. The participants could come into contact with the website in at least four ways: (1) through links on other websites; (2) search engines; (3) promotion in traditional media, such as newspapers and magazines; and (4) word of mouth. At the end of the test, the participants could invite others to participate by sending them standardized e-mails. Furthermore, we invited the participants who had taken other tests on the website, such as the Favourites Questionnaire (Janssen, Chessa, & Murre, 2007) or the Yearly News Memory Test (Janssen, Murre, & Meeter, 2008). The participants were not financially or otherwise compensated for their participation.

A total of 1766 Dutch participants between the ages of 16 and 80 (see Table 2) took part in the study. The group consisted of 635 men and 1131 women. The majority of the participants had a university degree or its equivalent (58.5%). About half of them watched the news on television every day (50.0%), about half read a newspaper every day (49.0%), and about a third watched the news on television and read a newspaper on a daily basis (32.2%).

According to the Dutch Central Bureau of Statistics (cbs.nl), Internet access is high throughout the age range sampled in this study. Approximately 88% of the Dutch population had household access to the Internet in 2007. This proportion is the highest (98%) for people between ages 15 and 25, and decreases with older cohorts: 93% (25–35 years), 93% (35–45 years), 92% (45–55 years), 79% (55–65 years) and 54% (65–75 years).

Half of the participants were randomly assigned to receive the speed-of-time questionnaire before they were given the news events ($N = 886$), and the rest were presented the questionnaire after the news events ($N = 880$). These two groups did not differ on age ($p = .22$), gender ($p = .45$), level of education ($p = .70$), newspaper reading ($p = .50$), or watching the news on television ($p = .76$).

6.1.2. Materials

The questionnaire about recent news events consisted of 10 open-ended and 20 multiple-choice questions and included the dates of the events (Meeter et al., 2005, 2010). In the open-ended questions, the participants were asked to write the answer in an open text field, whereas they had to choose one of the four alternatives in the multiple-choice questions. Scoring of the answers to the open-ended questions occurred automatically by comparing the participant's answer with a word or a part of a word indicative of the correct answer. Each week three or four new questions were added to the database from which the questions were selected, keeping the items in the questionnaire constantly up-to-date. The participants were given a semi-random selection of questions. Each question had a probability of .30 that it was less than 3 months old and a probability of .50 that it was between three and 12 months old. Questions had a likelihood of .10 of being between 15 and 18 months or between 21 and 24 months old.

The speed-of-time questionnaire included the six questions from Wittmann and Lehnhoff's (2005) study that were used in our Experiment 1 (Appendix, Items 1–6). Again, the participants were asked to respond on a five-point scale that ranged from 'very slowly' [−2] to 'very fast' [2]. A new scale consisted of four items measuring time pressure and rushing: (1) there is often not enough time to do everything I want or need to do, (2) I frequently have to rush to make sure everything gets done, (3) I usually have plenty of time for all the things I want to accomplish in a day (reverse scored), and (4) these days I am not very busy (reverse scored). For these items the participants were asked to rate how well the statements reflected their experience on a seven-point scale that ranged from 'strongly disagree' [−3] to 'strongly agree' [3]. Cronbach's alphas for the two scales were .80 (speed of time) and .74 (rushing).

Table 2
The number of participants (N), the mean age (mean) and the standard deviation (SD) of age for each of the seven age groups in Experiment 2.

Age group	N	Mean	SD
16–20	87	18.66	1.39
21–30	228	26.03	2.86
31–40	196	36.16	3.04
41–50	358	46.76	2.90
51–60	518	55.67	2.88
61–70	296	64.85	2.74
71–80	83	74.84	2.71
Total	1766	48.49	15.07

6.2. Results

The scores on the questions about recent news events were examined with a linear regression analysis, $F(5, 1747) = 50.01$, $p < .01$. The scores were affected by gender ($\beta = .18$, $p < .01$), education ($\beta = .14$, $p < .01$), newspaper reading ($\beta = .16$, $p < .01$), and news watching ($\beta = .13$, $p < .01$), but not by age ($p = .86$). These findings are similar to the results found by Meeter et al. (2005). Men perform better than women, and highly educated participants performed better than the participants with less educational attainment. Newspaper reading and news watching aided performance. The participants who received the speed-of-time questionnaire before the test had similar scores ($M = 0.43$, $SE = 0.00$) as the participants who received the questionnaire after the test ($M = 0.43$, $SE = 0.00$), $p = .95$.

As in Experiment 1, analysis of the composite speed-of-time score showed that most participants reported time to be passing rapidly ($M = 0.96$, $SE = 0.01$), and the mean fell reliably above the midpoint of the scale, $t(1765) = 79.94$, $p < .01$. Only 336 of the 10,596 (3.2%) responses on the speed-of-time scale were 'very slow' or 'slow,' whereas 78.7% of the questions were answered with 'fast' or 'very fast'. The remaining items were answered with 'neither fast nor slow'. Scores on the composite rushing scale also fell reliably above the midpoint of the scale ($M = 0.58$, $SE = 0.03$), $t(1765) = 19.26$, $p < .01$. More than half of the statements about time pressure were given affirmative responses (54.8%), while only about a quarter received a negative response (26.4%).

Our first main question is whether there are age differences in adulthood in the subjective speed of time. Since an ANOVA of age-group differences in the speed-of-time composite score showed a relatively weak deviation from linearity, $F(6, 1759) = 6.31$, $MSE = 0.25$, $p < .01$, $\eta_p^2 = .02$, a more sensitive, correlational analysis was conducted. The Pearson correlation between age and speed of time was $r(N = 1766) = .12$, $p < .01$ (0.07–0.17), indicating that age accounts for only about 1.4% of variance on the composite scale. Fig. 2 shows the mean ratings for individual items as a function of age group. The correlations between age and the six speed-of-time items (Ns = 1766), respectively, were .11 ($p < .01$, 0.06–0.16), .06 ($p < .01$, 0.02–0.11), .06 ($p < .01$, 0.02–0.11), .02 ($p = .51$, −0.03 to 0.06), .04 ($p = .13$, −0.01 to 0.08), and .21 ($p < .01$, 0.17–0.26). As in Experiment 1, the strongest correlation with age is found for the 10-year item (explaining 4.5% of the variance). The other correlation that was highly significant was between age and Item 1, which asked how fast time usually passes (explaining 1.2% of the variance). The correlations between age and Items 2 and 3 reached significance, but their explained variances were very small (0.4% and 0.4%).

Another goal of this study was evaluating the hypothesis that difficulty of recalling events from a past interval makes it seem

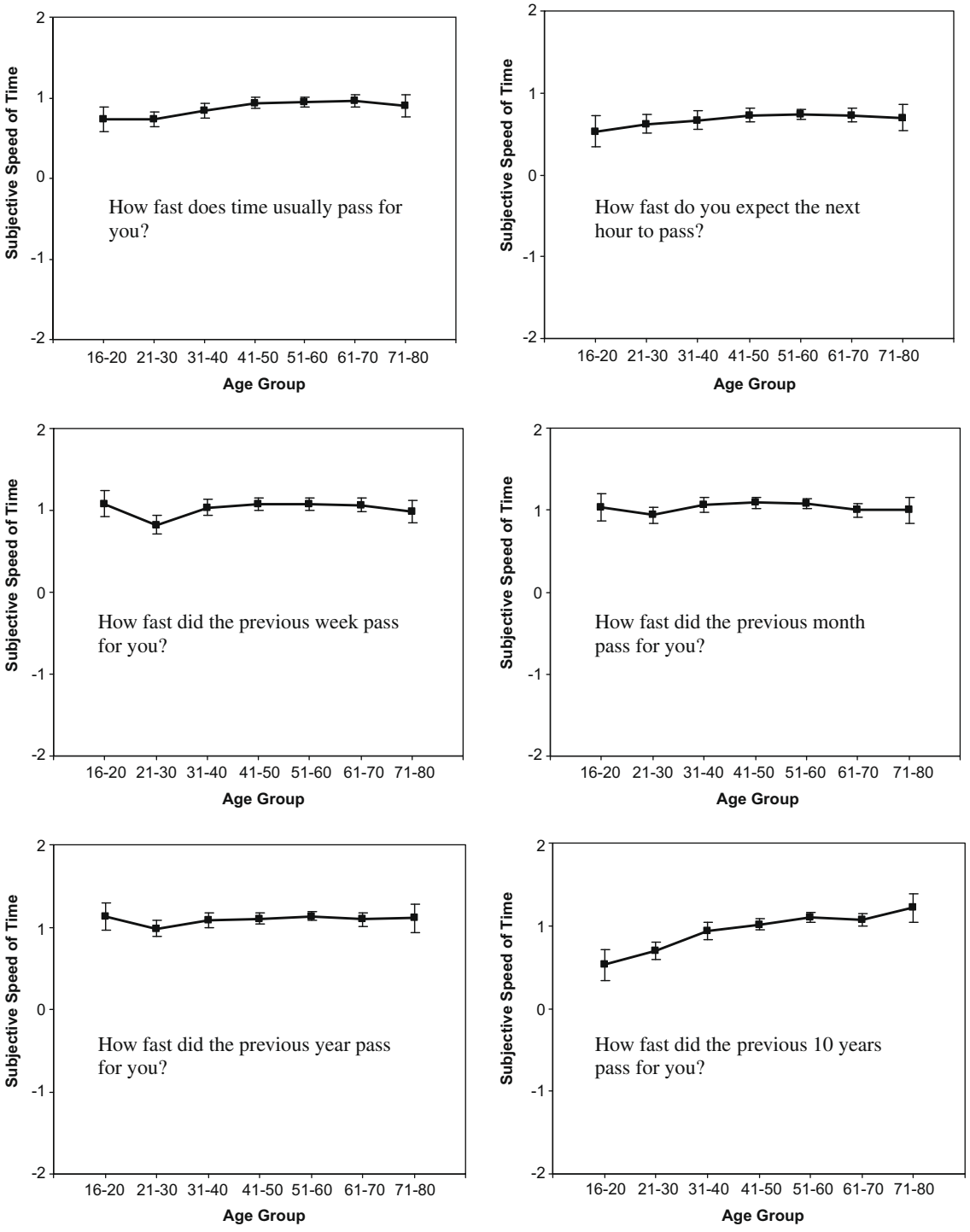

Fig. 2. Mean ratings (and 95% CIs) of the different age groups in Experiment 2 on Items 1–6 of the speed-of-time scale (Appendix). The values represent time passing: very slowly [−2], slowly [−1], neither fast nor slow [0], fast [1], and very fast [2].

unexpectedly brief. This was tested by comparing the participants who rated their experience of the speed of time before and after answering thirty questions about news events from the past two years. The participants who made speed-of-time judgments after answering the news questions ($M = 0.98$, $SE = 0.02$) actually had slightly larger speed-of-time scores than the participants who made the judgments before answering the news questions ($M = 0.94$, $SE = 0.02$). This difference only approached significance, $t(1764) = 1.77$, $p = .08$, $d = 0.07$ (−0.16 to 0.03), and it was very small and in the opposite of the predicted direction. The very large sample sizes allow us to reject a Cohen's d any larger than 0.03 in the predicted direction with 95% confidence. When individual speed-of-time scales were examined, presentation order had a non-significant effect on the 1-month item, $t(1764) = 1.76$, $p = .08$, $d = -0.06$ (−0.13 to 0.01), and a significant effect on 1-year item, $t(1764) = 2.07$, $p < .05$, $d = -0.07$ (−0.14 to 0.00). The participants who made speed-of-time judgments after answering the news questions ($M = 1.13$, $SE = 0.02$) reported that the previous year had passed faster than the participants who made the judgments before answering the news questions ($M = 1.06$, $SE = 0.02$). The effects on the other items were even smaller ($ps > .12$).

The results were also used to test another new theory that the experience of time pressure (being busy or rushing or finding that there is insufficient time to get things done) is responsible for the impression that time is passing quickly. This theory was tested by correlating the composite speed-of-time and rushing scales, $r(N = 1766) = .32$, $p < .01$ (0.28–0.36). The value of this correlation tells us that 10.0% of the variance in the subjective speed of time is associated with the experience of time pressure, an effect more than seven times as strong as that of age. Correlations between time pressure and subjective speed of time were highly significant within each age group ($rs > .27$, $ps < .01$), except the youngest ($r(N = 87) = .17$, $p = .11$, −0.04 to 0.38) and oldest age group ($r(N = 83) = .23$, $p < .05$, 0.01–0.43). All correlations between the composite rushing scale and the individual speed-of-time scales were significant ($ps < .01$), but the correlation between the rushing scale and the 10-year item ($r(N = 1766) = .11$, 0.07–0.16) was lower than the other correlations ($rs > .21$).

This study also provides data on age changes in the experience of time pressure. An ANOVA of age differences in the rushing composite (also see Fig. 3) showed that the overall group difference was reliable, $F(6, 1759) = 6.53$, $MSE = 1.56$, $p < .01$, $\eta_p^2 = .02$. A post-hoc test comparing the two oldest groups ($M = 0.23$, $SE = 0.07$) with the participants who were less than 61 years of age ($M = 0.67$, $SE = 0.03$) revealed a reliable age decrease in rushing, $t(1764) = 6.04$, $p < .01$.

Finally, the scores of women and men on the subjective speed-of-time and rushing composites were compared. Women ($M = 1.01$, $SE = 0.01$) reported higher speed-of-time scores than men ($M = 0.87$, $SE = 0.02$), $t(1764) = 5.39$, $p < .01$, $d = 0.13$ (0.09–0.18). This gender difference was also found on each individual speed-of-time item ($ps < .01$), except on the 10-year item, which only approached significance ($p = .14$). Gender did not interact with age group in a two-way ANOVA ($p = .12$) on the composite speed-of-time score. Women ($M = 0.68$, $SE = 0.04$) also had higher rushing scores than men ($M = 0.40$, $SE = 0.05$), $t(1764) = 4.56$, $p < .01$, $d = 0.28$ (0.16–0.41). Again there was no interaction between age group and gender ($p = .71$).

6.3. Discussion

The results of Experiment 2 replicate some of the main findings of Experiment 1 and provide data relevant to two additional theories. The adults in this study overwhelmingly reported that time seems to pass quickly, a finding that repeats in another nation the results of Experiment 1 and Wittmann and Lehnhoff's (2005) study. In addition, as in these two studies, there was quite limited evidence for age changes in adulthood in the subjective speed of time. In the present experiment, age differences accounted for only about 1% of variance on the composite speed-of-time scale. Four individual items did show significant age increases, but for three of them (Items 1, 2 and 3) the effects were so weak that they are only likely to be reliable in very large samples like this one. A somewhat larger correlation – but still one only accounting for about 4% of the variance – was found between age and responses to the question about how fast the previous 10 years had seemed to pass (Item 6). This item showed the strongest age differences in both Wittmann and Lehnhoff's study and Experiment 1, and possible reasons for its exceptional status are presented in the discussion of Experiment 1. Given the convergent evidence from three studies conducted in four nations, we can conclude that when adults report on their general impressions of the speed of time, age differences are very small. Somewhat larger age differences, but still weak ones, appear when adults reflect on the past 10 years.

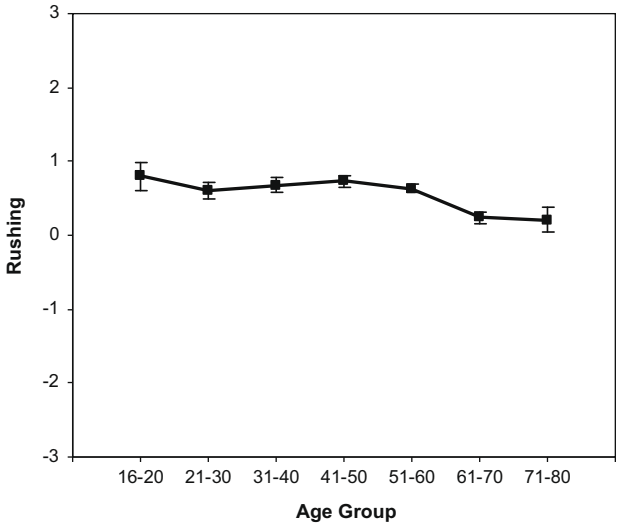

Fig. 3. Mean ratings (and 95% CIs) of the different age groups in Experiment 2 on the composite rushing scale.

The first of the new theories tested in this experiment is that the difficulty of accessing events from a past interval of time makes it appear that the interval has passed quickly. This memory-based explanation was tested through an experimental manipulation, and it received no support. The participants who gave their impressions of the speed of time after being reminded of a substantial number of news events from the last two years actually tended to report time as passing more rapidly than those who had not yet been reminded of the events. It is possible that our manipulation had a weak effect on the perceived difficulty of remembering events, but our large sample sizes made it possible to reject effects with even a Cohen's d as small as 0.03.

Another possible limitation to the inferences that can be drawn from the null effect of the manipulation in this study follows from the fact that we directed attention to public events rather than events from the participants' own lives. Zauberman, Levav, Diehl, and Bhargave (2010) have shown that the subjective impression of how recent an event appears to be depends specifically on the number of intervening events activated that are related to the target event. We queried the participants about intervals rather than target events, but they may have thought about events in their own lives to define the start of an interval. If this were the case, manipulating the numbers of personal events that are activated, rather than news events, might affect the speed with which an interval appears to pass. It should be noted, however, that in Experiment 1 there was no relation between the subjective speed of time and the perceived number of recent life events.

In contrast to the failure to find support for the memory hypothesis, the results are consistent with another new theory, that the experiences of being busy, rushing, and finding that there is not enough time to get things done are associated with the impression that time is passing quickly. The rushing scale predicted 10% of the variance in the speed-of-time composite, and the two scales were reliably related within each age group, except for the 16-to-20-year-old group. Rushing correlated with all individual speed-of-time scales, but the correlation with the 10-year item (Item 6) was lower than the correlations with the other items, which referred to shorter time intervals.

Of course, these findings cannot be taken as direct support for the time–pressure explanation of general impressions of the speed of time, because causality cannot be inferred from correlations. However, it is worth reflecting on the fact that, at least over long intervals, humans cannot have direct experiences of the amount of time a given interval occupied. People cannot have such impres-

sions while sleeping, nor are they likely to notice the rate of time's passage while attending to many other things that engage them when they are awake. But people do have direct experiences of rushing to get things done or failing to complete them in the expected amount of time. Adults in modern societies believe that objective time passes at a constant rate, one that is uninfluenced by the contents of an interval (Piaget, 1969). However, in daily encounters with clocks and calendars, people may have experiences akin to a musician having difficulty keeping up with the pace of a metronome. People know that time is not altered by their activities, but it *seems* to be passing too quickly.

Age affected the results on the 10-year item, but failed to make an impact on the items that asked about impressions of smaller time intervals, whereas rushing correlated with those items more than it did with the 10-year item. These results suggest that the scores on the 10-year item and the other items are influenced by different factors. Finding where, between the past year and the past 10 years, the changes occur might shed light on the reasons for this pattern. Adding an intermediate item, asking how quickly time has passed in the last 3 or 5 years, would be helpful in determining the location of this shift.

This study is only the second one to provide data about age differences in adulthood in the experience of time pressure. Wittmann and Lehnhoff (2005) included a five-item time–pressure scale in their study, and their items were similar to those on the time–pressure scale in the present study (e.g., "I haven't enough time to complete my tasks" p. 925). Like Wittmann and Lehnhoff, we found that the experience of time pressure is common throughout adulthood. Our findings also partially replicated the age pattern in their study. Wittmann and Lehnhoff found that the participants younger than 20 years and older than 60 years reported less time pressure than those between these ages. In the present study, we found a significant decline in time–pressure scores after 60 years, but we did not find less reported time pressure in our teenage participants. Age declines in time pressure after age 60, of course, may reflect changes accompanying retirement, but we do not have data that allow us to confirm this. Because the sizes of the effects between age and subjective speed of time and between age and rushing were very small, the estimates of the speed of time did not decrease along with the small decrease in the rushing scores at later ages, even though they were moderately correlated. Finally, rushing seems to predict the variance within age groups that are reflected by Items 1–5 better than it predicts the variance between age groups, which is reflected best by Item 6.

Women in this study showed significantly higher scores on both the speed-of-time and rushing scales, a finding that provides further support for the linkage between the two kinds of experience. Neither of these gender differences interacted reliably with age, suggesting that throughout adulthood women feel greater time pressure and experience a faster pace of time than men. Competition between the demands of a greater number of roles for women may be responsible.

Given that the proportion of households with Internet access declines from 98% in the youngest group to 54% in the oldest group, there might be a concern about a possible sampling bias in the results of Experiment 2, despite its large sample size ($N = 1766$). The number of participants, however, did not decrease with age. In fact, the largest age group was between 51 and 60 years old. It is nevertheless possible that there might be a difference between the older adults with and without Internet access and that this difference could somehow have influenced the effects of rushing examined in this study. However, it is not clear why, under the different theories predicting change, such bias would have attenuated the direct correlation between age and the subjective speed of time as suggested by most explanations. In addition, the samples in Experiment 1 and Wittmann and Lehnhoff's (2005) study had no such selection bias but produced similar age patterns in general impressions of the speed of time. Furthermore, the correlation between the speed of time and rushing was found within age groups, and here age differences in Internet access are not an issue.

7. General discussion

This study was designed to evaluate a variety of explanations of adults' general impressions of the speed of time. Four of the theories are intended to account for a purported increase in the subjective speed of time during adulthood, so it is appropriate to begin with the question of whether older adults experience time passing more quickly than young adults. The results for the scale tapping the general experience of the speed of time showed very small age differences, with $d = .06$ in Experiment 1 and age accounting for only 1% of the variance in Experiment 2. Somewhat stronger effects were found on an individual item in both experiments: older adults rated the past 10 years as passing more quickly than did younger adults. On the other speed-of-time items, most older *and* young adults reported that time had passed quickly. This pattern of results replicates Wittmann and Lehnhoff's (2005) findings and may indicate that impressions of the speed of time now and over the past week, month and year do not change from early to late adulthood. Only when reflecting on very long intervals of time does the speed of time's passage seem to increase during adulthood.

Of course, as for any cross-sectional study, cohort differences could obscure the true developmental pattern. For example, societal changes could cause the subjective speed of time to be greater for contemporary young adults than it was for the older adults when they were young. There do not seem to be data on the speed of time at one's current age for earlier generations, although young adults in the 1970s clearly believed that the subjective speed of time had increased since they were one-half and one-quarter their present age (Lemlich, 1975; Walker, 1977). If the undergraduates in those studies were poor at remembering how fast time passed at earlier ages – as seems likely – and were really expressing the view that time is passing rapidly now, Lemlich's and Walker's data may suggest that time seemed to pass quickly for young adults in the 1970s too.

Just as there may be cohort differences in the experience of time (and in the developmental pattern) in a particular culture, it is very likely that there are present-day cultural differences. Taken together with Wittmann and Lehnhoff's (2005) data, there is considerable consistency in the developmental findings among samples tested in Austria and Germany, New Zealand, and The Netherlands. But these are similar nations in a number of important respects, and it would be risky to generalize the findings to other cultures.

The answer to the first question, then, is that in industrialized Western nations contemporary young and older adults' general experience of the speed of the time does not differ, except when reflecting on very long past intervals. This finding diminishes the appeal of the four theories designed to explain subjective acceleration, theories based on age changes in numbers of notable life events, the ratio of a recent interval of time to the total time one has lived, the speed of biological clocks, and attentional resources.

Of course, some of these mechanisms do contribute to judgments of brief intervals of time. Past research has shown that attentional factors have a potent influence on prospective time judgments (e.g., Block, 1992; Brown, 1985; Lustig, 2003; Zakay, 1989): The greater the cognitive demands of a task, the shorter its duration is perceived to be. Similarly, as noted earlier, laboratory studies have shown that the more events or changes that are remembered from an interval, the greater the retrospective estimates of its duration. But it is difficult to see how attention or change models or models based on differences in the speed of

internal clocks would explain the developmental pattern seen in the present study. For example, why would age-related changes in a biological clock or in attentional capacity influence how one reflects on the speed of time over the past 10 years, but not the pace of time in one's everyday experience or how fast the past year has passed?

The ratio model is probably not useful in explaining humans' experience of the speed of time. In the introduction it was seen that collectively the studies designed to test ratio and square-root models do not produce results that fit their mathematical predictions. In addition, these models cannot explain the absence of age differences in the present study on most items tapping one's experience of the speed of time. For example, there was no reliable difference in Experiment 1 on the 1-year item between young adults who, under these models, would be comparing the past year to about 20 years and older adults, who would be comparing the last year to about 70 years. Even the age difference on the 10-year item in Experiment 1 (about 0.5 on a five-point scale) seems small if younger participants are comparing 10 years to about 20 years and older participants are comparing the past decade to about 70 years.

In contrast to the very limited evidence for age differences, there was clear evidence that most adults experience time as passing quickly, and we considered several theories that could explain this phenomenon. One of the theories received support: the scale consisting of items tapping rushing, being busy, and finding that there is insufficient time to get things done was correlated with impressions of the speed of time. This rushing scale yielded a weaker correlation with the 10-year item than with judgments of shorter time intervals. Additional research will be necessary to test the mechanisms underlying this theory and to explain the developmental pattern. Furthermore, the fact that this was not a strong correlation may mean that other factors contribute to the experience of time passing quickly. Perhaps new attentional models, such as ones based on the repeated experience of time passing unexpectedly rapidly when people are engrossed, can be devised to explain the finding that time appears to pass quickly throughout adulthood. Two memory-based theories do not appear to be good candidates for supplemental explanations, however. Predictions of the forward-telescoping and recall-difficulty models were not confirmed in the relevant experiments.

The general impression that time is passing quickly is widespread among adults, at least in the Austrian, Dutch, German, and New Zealand populations that have been studied, and this phenomenon deserves further study. Additional work is needed to explain the determinants of this important aspect of adults' experience of time, work that might include experimental manipulations and theoretically motivated comparisons of subgroups within a population. Another significant question is why age differences in the subjective speed of time are found when adults are asked to consider the last 10 years but not present or very weak when they report on the last year or more recent intervals. The answers to these questions may shed additional light on a topic that has engaged philosophers and psychologists for more than 100 years.

Acknowledgements

We would like to thank Christine Bastin for her comments on an earlier version of the manuscript and Fiona Jack for her extensive contributions to the first experiment. We also wish to thank Jaap Murre and Martijn Meeter, founders of the website used to conduct Experiment 2.

This material is based upon the work supported by the National Science Foundation under Grant No. 0241558. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. A William Evans Fellowship from the University of Otago and the award of Research Status from Oberlin College to the first author also helped to make this work possible. The conduct of Experiment 2 was supported by a Rubicon grant from the Netherlands Organisation for Scientific Research (NWO) to the second author.

Appendix

1. How fast does time usually pass for you?
2. How fast do you expect the next hour to pass?
3. How fast did the previous week pass for you?
4. How fast did the previous month pass for you?
5. How fast did the previous year pass for you?
6. How fast did the previous 10 years pass for you?
7. The past two years have been a time filled with many new experiences (reverse scored).
8. In the past several years, my life has been quite routine.
9. When I think back over the past two years, few notable events come to mind.
10. There have been few notable changes in my life in the past year.
11. When I try to remember the date of some event, I often come up with a time that is not as long ago as the true time.
12. When I think that something was just a few years ago, it often turns out that it happened long before that.
13. I often find that things actually occurred much longer ago than I thought (reverse scored).

References

Baum, S. K., Boxley, R. L., & Sokolowski, M. (1984). Time perception and psychological well-being in the elderly. *Psychiatric Quarterly, 56*, 54–61.

Bherer, L., Desjardins, S., & Fortin, C. (2007). Age-related differences in timing with breaks. *Psychology and Aging, 22*, 398–403.

Block, R. A. (1989). Experience and remembering time: Affordances, context and cognition. In I. Levin & D. Zakay (Eds.), *Time and human cognition: A lifespan perspective* (pp. 333–363). Amsterdam: North Holland.

Block, R. A. (1992). Prospective and retrospective duration judgment: The role of information processing and memory. In F. Macar, V. Pouthas, & W. J. Friedman (Eds.), *Time, action and cognition: Towards bridging the gap*. Dordrecht, The Netherlands: Kluwer.

Block, R. A., & Zakay, D. (2001). Retrospective and prospective timing: Memory, attention, and consciousness. In C. Hoerl & T. McCormack (Eds.), *Time and memory: Issues in philosophy and psychology* (pp. 59–76). Oxford: Oxford University Press.

Block, R. A., Zakay, D., & Hancock, P. A. (1998). Human aging and duration judgments: A meta-analytic review. *Psychology and Aging, 13*, 584–596.

Bradburn, N. M., Rips, L. J., & Shevell, S. K. (1987). Answering autobiographical questions: The impact of memory and inference on surveys. *Science, 236*, 157–161.

Brown, S. W. (1985). Time perception and attention: The effects of prospective and retrospective paradigms and task demands on perceived duration. *Perception and Psychophysics, 38*, 115–124.

Craik, F. I. M., & Hay, J. F. (1999). Aging and judgments of duration: Effects of task complexity and method of estimation. *Perception and Psychophysics, 61*, 549–560.

Crawley, S. E., & Pring, L. (2000). When did Mrs. Thatcher resign? The effects of ageing on the dating of public events. *Memory, 8*, 111–121.

Draaisma, D. (2004). *Why life speeds up as you grow older: How memory shapes our past*. Cambridge: Cambridge University Press.

Fraisse, P. (1963). *The psychology of time*. New York: Harper and Row.

Fraisse, P. (1984). Perception and estimation of time. *Annual Review of Psychology, 35*, 1–36.

Friedman, W. J. (1993). Memory for the time of past events. *Psychological Bulletin, 113*, 44–66.

Friedman, W. J. (2004). Time in autobiographical memory. *Social Cognition, 22*, 605–621.

Gallant, R., Fidler, T., & Dawson, K. A. (1991). Subjective time estimation and age. *Perceptual and Motor Skills, 72*, 1275–1280.

Gruber, R. P., Wagner, L. F., & Block, R. A. (2004). Relationships between subjective time and information processed (reduction of uncertainty). In P. A. Harris & M. Crawford (Eds.), *Time and uncertainty* (pp. 188–203). Boston: Brill.

Guyau, J.-M. (1890). *La genese de l'idee de temps [the origin of the idea of time]*. Paris: Alcan.

Howell, D. C. (2007). *Statistical methods for psychology* (6th ed.). Belmont, CA: Wadsworth.

Huttenlocher, J., Hedges, L. V., & Bradburn, N. M. (1990). Reports of elapsed time: Bounding and rounding processes in estimation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 196–213.

Huttenlocher, J., Hedges, L. V., & Prohaska, V. (1988). Hierarchical organization in ordered domains: Estimating the dates of events. *Psychological Review, 95*, 471–484.

James, W. (1890). *The principles of psychology* (Vol. 1). New York: Henry Holt and Co..

Janssen, S. M. J., Chessa, A. G., & Murre, J. M. J. (2006). Memory for time: How people date events. *Memory and Cognition, 34*, 138–147.

Janssen, S. M. J., Chessa, A. G., & Murre, J. M. J. (2007). Temporal distribution of favourite books, movies and records: Differential encoding and re-sampling. *Memory, 15*, 755–767.

Janssen, S. M. J., Murre, J. M. J., & Meeter, M. (2008). Reminiscence bump in memory for public events. *European Journal of Cognitive Psychology, 20*, 738–764.

Joubert, C. E. (1983). Subjective acceleration of time: Death anxiety and sex differences. *Perceptual and Motor Skills, 57*, 49–50.

Joubert, C. E. (1984). Structured time and subjective acceleration of time. *Perceptual and Motor Skills, 59*, 335–336.

Joubert, C. E. (1990). Subjective expectations of the acceleration of time with aging. *Perceptual and Motor Skills, 70*, 334.

Kemp, S. (1988). Dating recent and historical events. *Applied Cognitive Psychology, 2*, 181–188.

Kemp, S. (1996). Association as a cause of dating bias. *Memory, 4*, 131–143.

Lemlich, R. (1975). Subjective acceleration of time with aging. *Perceptual and Motor Skills, 41*, 235–238.

Lustig, C. (2003). Grandfather's clock: Attention and interval timing in older adults. In W. H. Meck (Ed.), *Functional and neural mechanisms of interval timing* (pp. 261–293). Boca Raton, FL: CRC Press.

Meeter, M., Murre, J. M. J., & Janssen, S. M. J. (2005). Remembering the news: Modeling retention data from a study with 14,000 participants. *Memory and Cognition, 33*, 793–810.

Meeter, M., Ochtman, D. J. C., Janssen, S. M. J., & Murre, J. M. J. (2010). Of sports and politics: Predicting category-specific retention of news events from demographic variables. *European Journal of Cognitive Psychology, 22*, 117–129.

Ornstein, R. E. (1969). *On the experience of time*. Middlesex, UK: Penguin.

Perbal, S., Droit-Volet, S., Isingrini, M., & Pouthas, V. (2002). Relationship between age-related changes in time estimation and age-related changes in processing speed, attention, and memory. *Aging, Neuropsychology and Cognition, 9*, 201–216.

Piaget, J. (1969). *The child's conception of time*. London: Routledge and Kegan Paul.

Poynter, D. (1989). Judging the duration of time intervals: A process of remembering segments of experience. In I. Levin & D. Zakay (Eds.), *Time and human cognition: A lifespan perspective* (pp. 305–331). Amsterdam: North Holland.

Reips, U.-D. (2000). The Web experiment method: Advantages, disadvantages, and solutions. In M. H. Birnbaum (Ed.), *Psychological experiments on the Internet* (pp. 89–114). San Diego, CA: Academic Press.

Reips, U.-D. (2002). Standards for internet-based experimenting. *Experimental Psychology, 49*, 243–256.

Rubin, D. C., & Baddeley, A. D. (1989). Telescoping is not time compression: A model of the dating of autobiographical events. *Memory and Cognition, 17*, 653–661.

Thompson, C. P., Skowronski, J. J., Larsen, S. F., & Betz, A. (1996). *Autobiographical memory: Remembering what and remembering when*. Mahwah, NJ: Erlbaum.

Tuckman, J. (1965). Older persons' judgments of the passage of time over the life-span. *Geriatrics, 20*, 136–140.

Vanneste, S., & Pouthas, V. (1995). Estimation temporelle prospective et retrospective chez la personne âgée: Comparison avec le jeune adulte [prospective and retrospective temporal estimation in the older person: Comparison with the young adult]. *Bulletin de Psychologie, 48*, 539–543.

Walker, J. L. (1977). Time estimation and total subjective time. *Perceptual and Motor Skills, 44*, 527–532.

Whitrow, G. J. (1972). *The nature of time*. New York: Rinehart and Winston.

Wittmann, M., & Lehnhoff, S. (2005). Age effects in perception of time. *Psychological Reports, 97*, 921–935.

Zakay, D. (1989). Subjective time and attentional resource allocation: An integrated model of time estimation. In I. Levin & D. Zakay (Eds.), *Time and human cognition: A lifespan perspective* (pp. 365–397). Amsterdam: North Holland.

Zauberman, G., Levav, J., Diehl, K., & Bhargave, R. (2010). 1995 feels so close yet so far: The effect of event markers on the subjective feelings of elapsed time. *Psychological Science, 21*, 133–139.