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Age, Time, and Decision Making: From Processing Speed to Global Time Horizons

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Abstract

Time and time perceptions are integral to decision making because any meaningful choice is embedded in a temporal context and requires the evaluation of future preferences and outcomes. The present review examines the influence of chronological age on time perceptions and horizons and discusses implications for decision making across the life span. Time influences and interacts with decision making in multiple ways. Specifically, this review examines the following topic areas: (1) processing speed and decision time, (2) internal clocks and time estimation, (3) mental representations of future time and intertemporal choice, and (4) global time horizons. For each aspect, patterns of age differences and implications for decision strategies and quality are discussed. The conclusion proposes frameworks to integrate different lines of research and identifies promising avenues for future inquiry.

Time and perceptions of time are integral to decision making because any meaningful choice is embedded in a temporal context and requires the evaluation of future preferences and outcomes. Construals of temporal horizons inform not only mundane choices (such as those at the lunch counter) where decision outcomes are realized within minutes, but also complex interpersonal and career decisions that will influence life-trajectories for decades to come. Importantly, time is linked with decision making at multiple levels ranging from processing time and timing of the decision task itself (e.g., time pressure), to time as a characteristic of decision options (e.g., differences in duration or delay), and global time horizons on the part of the decision-maker^{1,2}.

In general, people are well-prepared to appreciate and navigate temporal aspects of decision making. In fact, it has been argued that the ability to monitor time and simulate future events are part of what makes us uniquely human^{3,4}. Nevertheless, most people show systematic biases in time perceptions that may put them at risk for suboptimal decisions^{5,6}. Further, although the awareness of time and its passing is a human universal⁷, time horizons and construals show considerable interindividual variability. Thus, some decision makers may be at greater risk for temporal fallacies than others.

Based on these considerations, the present chapter reviews the influence of chronological age on time perceptions and horizons and discusses implications for decision making across the life span. As mentioned above, time influences and interacts with decision making in multiple ways and a complete coverage of age differences would go beyond the scope of the present chapter. Instead, I focus on select topics that have attracted sufficient life-span developmental research to allow for broader conclusions about the direction of age

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trajectories. Moving from short-term to long-term intervals and from time as a characteristic of the decision task to time perspectives of the decision-maker, I will discuss the following specific topics: (1) processing speed and decision time, (2) internal clocks and time estimation, (3) mental representations of future time intervals and events, and (4) global time horizons. I conclude the chapter by proposing strategies to integrate different lines of research and by identifying promising avenues for future inquiry.

Processing Speed and Decision Time

Making a decision takes time. While some choices require split-second responses, others evolve over hours, days, or – in the case of important life choices - months and years. Within a given choice setting, individuals may vary widely in decision time and while some settle quickly on a favored option, others take extended time to make a choice ^{8,9}.

At first glance, the literature on age differences in decision time appears to present a paradox: On the one hand, older adults take longer than younger adults to review individual pieces of information and to make simple decisions ¹⁰⁻¹². On the other hand, age is often associated with faster choices in complex decision scenarios ¹³⁻¹⁵. A closer examination of the relative age trajectories of basic cognitive operations as compared to higher-order decision strategies explains this apparent contradiction.

At the level of basic cognitive processing, there is consistent evidence for substantial age-related slowing ^{16,17}. Across task types, processing time is estimated to be about 1.5 times longer for older adults in their 70s as compared to younger adults in their 20s¹⁸. Age-related slowing extends to the basic building blocks of complex decision making including information acquisition, categorization, and comparisons across options ¹⁰. As a result, older decision makers may face limits in the total amount of information that can be processed in a given time frame ^{17,19}. Moreover, early stages of processing may become so time intensive that higher order stages are curtailed or information decays before it can be subjected to advanced processing ¹⁷.

Although the time to review and process a given piece of information increases with age, this does not necessarily translate into longer decision times. For one, older decision-makers tend to review less information than their younger counterparts ¹⁹⁻²². In addition, advanced age is associated with a preference for simpler, rule-based strategies ^{13,23} and a reliance on experiential knowledge ^{15,24} which both contribute to shorter decision times. It is important to note that age-related preference for heuristic and affect-rich strategies may not only reflect limitations in processing resources but also correspond to age-related shifts in motivational priorities ²⁵ – a point to which I will return below (see also the contribution by Strough in this volume).

Nevertheless, the observed age differences in information search and decision strategies raise concerns about possible decrements in choice quality. Indeed, age-related limitations in information seeking may put older adults at risk for objectively worse decisions ²⁶. However, negative consequences are not inevitable. In a recent simulation study, reduced information seeking had only minor effects on decision quality ²². Also, in applied settings, older adults appear to be able to maintain high decision quality in spite of reduced information seeking and simplified strategies^{13,14}. In summary, although older adults are slower to review and process decision-related information, effects on overall decision time and decision quality appear to be relatively minor.

Internal Clocks and Time Estimation

While all decisions unfold over time, some hinge directly upon the correct estimation of time intervals. This includes deciding whether a gap in traffic is sufficient to make a turn or when to flip the pancake for a perfect crust. Over short-term intervals, ranging from milliseconds to minutes, humans are thought to keep track of time with the help of a clock-like internal mechanism. According to scalar timing theory²⁷, this internal pacemaker generates pulses at a regular rate which are then recorded by an accumulator. To estimate time, information from the accumulator is accessed by working memory and compared to reference values stored in long term memory²⁷.

Research suggests that the setting of people's internal clocks is affected by age. To estimate the speed of the internal pacemaker, respondents are typically asked to produce regular fingertaps (keeping their arm immobile) at the fastest possible rate or at a rate that is perceived as subjectively comfortable (the latter measure is also known as “spontaneous motor tempo”²⁸). Across studies, advanced age was found to be associated with slower tapping for both fastest and spontaneous rates²⁸⁻³¹ (note that although tapping rates are linked to processing speed, the two concepts are not identical and have unique correlates²⁸).

People's internal clocks not only run more slowly with age, they also become somewhat less accurate. Compared to younger adults, older adults have particular difficulties with temporal sequencing, that is, the ability to produce complex rhythms involving intervals of varying length³². Moreover, older adults are worse at estimating and reproducing the length of reference stimuli³¹, especially for tasks placing simultaneous load on working memory³³.

Not surprisingly, age differences in the pace and accuracy of the internal clock may lead to problems for fast-paced decisions such as navigating busy traffic or operating complex machinery³⁴. Difficulties with time estimation may also affect laboratory assessments of risk taking that involve a timing component. Mather and colleagues³⁵, for example, examined age differences in a “driving” game where participants could gain points by pressing an “accelerator” key during a yellow light phase, but risked losing all if the light switched to red while the accelerator was pressed. While there were few age differences in a control condition, older adults made more frequent starts and stops and earned fewer points than younger adults after an experimental stress induction. Conceivably, stress may have interfered with older adults’ already limited time estimation skills. In any case, age differences in risk taking measures that involve a timing component need to be interpreted with caution since performance among younger adults may primarily reflect actual risk taking propensity while performance among older adults may also depend on age-related changes in time estimation skills.

In general, although age differences in internal timing mechanisms may be problematic in certain contexts, expertise and training appear to largely offset any age decrements^{24,36}. Thus, age differences in internal clock settings are presumably more salient in novel decision scenarios and likely to dissipate with practice.

Mental Representations of Time and Temporal Discounting

Age differences in the pace of our internal clocks are intriguing, but their relevance is limited to decisions involving very short time frames up to a few minutes in length. Construals of longer time intervals appear to be governed by a different set of mechanisms³⁷. A likely cause for this disconnect is that decisions about short-term intervals involve the perception and estimation of *actual time* whereas decisions about longer-term intervals draw on *mental representations of time*.

Age differences in mental construals of time have been observed with regard to the subjective speed of time, the mapping of subjective to objective time, and the affective and phenomenological characteristics of future representations. In this section, I first review age differences in these aspects of temporal representations and then discuss implications for decision making with particular emphasis on *intertemporal choice*, that is, decisions involving trade-offs between proximal and distal outcomes³⁸.

The subjective speed of time

For millennia, people have been acutely aware of the ceaseless flow of time and many have joined the Roman poet Virgil in mourning its irretrievable passing: *Tempus fugit* – time flees³⁹. Particularly intriguing is the illusion that time seems to pass more quickly as we age. Several explanations for this phenomenon have been discussed³⁷. The most prominent account proposes an age-related decline in the number of novel and memorable events, resulting in mindless routines and increased difficulty in recalling recent events^{40,41}. Moreover, older adults have reduced attentional resources which may limit their ability to monitor the passage of time – especially when engaged in mentally taxing tasks⁴². Alternatively, it has been noted that the ratio of a given time interval relative to years already lived becomes smaller with age^{40,43}. For example, the corresponding ratio for a one-year time interval would be 1/15 for a teenager but 1/100 for a centenarian which might make the same future time interval appear shorter for older adults.

Although there are plenty of anecdotal reports and literary references to age-related accelerations in time perception, systematic empirical evidence is surprisingly scarce and mostly limited to short-term intervals ranging from seconds to minutes³¹. A review of the literature identified only a couple of studies examining age differences in the subjective speed of time over years and decades. One study⁴⁴ asked an adult life-span sample to rate the pace of time in reference to past and future time intervals of various lengths. Evidence for an age-related acceleration was limited to retroactive ratings of the speed of time over the past decade. A second study³⁷ reported similar effects across two diverse samples. Again, age differences in self-reported speed of time were limited to ratings of decade-long intervals with little evidence of age effects in shorter time increments. In summary, although people generally report that time is passing fairly quickly³⁷, empirical evidence for an age-related acceleration is fairly limited and implications for decision making have not been examined.

Mapping objective to subjective time

People's mental representations of time differ not only in subjective speed, but also in the mapping between objective and subjective time. Research in psychophysics indicates that, as in other sensory modalities (e.g., loudness or brightness), perceptions of *actual* time intervals follow the Weber-Fechner law⁴⁵ with a logarithmic relationship between objective and subjective time^{46,47}. Recent evidence suggests that the association between objective time and *anticipated* future time is also nonlinear in nature. In a series of studies, Zauberman and colleagues^{48,49} asked participants to rate the relative length of future time intervals (ranging from months to years) on an analog scale from “very short” to “very long”. Across several undergraduate samples, they found that as temporal distance increases, time perceptions become subjectively condensed. For instance, relative to a 3-month time interval, the subjective length of a 36-month time interval was estimated at barely 6 months⁴⁸. Thus, people's mental construals of the future tend to place a disproportionate emphasis on the window of time surrounding the immediate present and show diminishing sensitivity for more distant time horizons. So far, age differences in the mapping of subjective to objective time have not been systematically examined. However, preliminary data collected in my laboratory (Rutt & Löckenhoff, in preparation) suggest that the subjective compression of

time may be even more pronounced among older adults, which would be consistent with reports that time appears to pass more quickly as we age.

Construing the future

Temporal distance also influences the phenomenological characteristics of future representations. For example, when asked to write a lengthy chapter that is due in several months, a scientist may readily accept the offer because she construes it as a welcome opportunity to share her scientific insights. However, as the deadline approaches, she becomes increasingly aware of specific details (being hunched in front of a computer in the middle of spring) and contextual factors (such as her teething infant) that limit her enthusiasm for completing the task at hand. According to construal level theory^{5,50}, such preference reversals are due to a tendency to represent distant events as higher-level construals that emphasize abstract features and general goals (i.e., the “why” aspects of an event) and to represent proximal events as low-level construals that include contextual and incidental details (i.e., the “how” aspects of the event).

While there is broad empirical support for construal level theory in younger adults⁵, little is known about age-related shifts in construal levels. Some recent evidence suggests that in advanced age, representations of future events show less episodic details and more generalized, semantic content. Addis and colleagues^{51,52} asked participants of different ages to imagine concrete and plausible future events in free association to experimental cues. They found that compared to younger adults, older adults reported significantly fewer details related to the central event they were describing. While Addis et al. attribute this pattern to an age-related deficit in the episodic memory system, it could also reflect an age-related shift towards higher-level construals. Additional research is needed to tease apart these possibilities.

Affective forecasting

In addition to episodic details, temporal distance also influences affective vividness and emotional complexity of mental representations⁵³. As a result, people's ability to predict future emotions, also known as *affective forecasting*, is somewhat limited^{3,54}. Granted, people are not bad at predicting the general valence of their future emotional responses. For instance, they know that they will feel good about winning and bad about losing⁵⁵. Even predictions about specific types of future emotions (e.g., disgust in response to a filthy bathroom or fear in response to a snake) are fairly accurate⁵⁶. In contrast, people routinely misestimate the duration and intensity of their future emotional responses⁵⁴.

Several recent studies suggest that affective forecasting shows age-related stability or improvement. For affective responses to sadness eliciting photographs⁵⁷ and satisfaction with choices among everyday products⁵⁸ no age differences in forecasting accuracy were found. In a laboratory task involving monetary gains and losses⁵⁹, older adults were as accurate as younger adults at predicting the valence of their emotional responses and more accurate at predicting arousal. The pattern of age-related improvements in affective forecasting extends to real-life contexts. Older adults in the MIDUS longitudinal survey were better than middle-aged and younger adults in predicting levels of life satisfaction over an 8-10 year interval⁶⁰. Further, when adults of different ages were asked to forecast their affective responses to the 2008 presidential election, predictive accuracy was positively associated with age – especially among supporters of the winning candidate⁶¹.

Importantly, errors in affective forecasting are not distributed at random. Instead, people appear to falsely assume that their affective responses to an event will be less intense the farther it occurs in the future. This tendency towards “future anhedonia” is well-documented

in younger samples⁶² (see also Ersner-Hershfield's discussion of future self-continuity in this volume), but emerging evidence suggests that older adults may be less susceptible to this bias. In a recent study, my colleagues and I⁶³ asked an adult life-span sample to rate their emotional responses to monetary gains and losses occurring at various delays in the future. Consistent with future anhedonia, younger adults' arousal and valence ratings were less intense with increasing delays. However, this effect was diminished in the middle-aged sample and completely absent among older adults. We have since replicated this pattern for age differences in anticipated responses to emotion eliciting photographs⁶⁴. In combination, these findings suggest that with advanced age comes the awareness that events will likely feel exactly the same, regardless of whether they occur in the immediate present or at some delay in the future.

Implications for intertemporal choice

From a decision-making perspective, age differences in mental representations of time and its passing have important implications for choices among events or outcomes that occur at different points in time. In such *intertemporal choices*⁶⁵, decision-makers typically show a relative disregard for distant gains and losses relative to more immediate ones. This tendency to devalue delayed events is also referred to as *temporal discounting* (for a review see^{38,65}). For instance, when people are asked to choose between a smaller monetary reward available sooner and a larger reward available later, they show a disproportionate preference for the sooner award - often with staggering discount rates of over 200%⁶⁶.

Theoretically, age differences in time and time perceptions may influence temporal discounting along several pathways. First, as a result of age-related changes in the subjective speed and compression of time, a given future event may appear subjectively closer to older as compared to younger adults. In younger adults, perceiving future events as closer has been linked to reduced temporal discounting⁴⁹. Thus, one would expect to see a lower tendency to devalue future consequences in advanced age.

Second, well-preserved affective forecasting skills and reduced future anhedonia may lead older adults to imagine future events more vividly than younger adults and thus reduce future discounting. Both of these considerations are consistent with empirical evidence suggesting that the tendency to discount future monetary gains wanes with age^{63,67-69} (although see^{70,71}).

At this point, additional research is needed to clarify the underlying mechanisms and examine a wider range of outcomes. Consistent with an affective explanation, my co-authors and I⁶³ found that age differences in discounting rates for monetary gains were linked to age differences in mental health and future anhedonia. However, this pattern does not extend to monetary losses⁶³ or emotional events⁶⁴. Further, recent evidence suggests that age patterns in temporal discounting differ across primary and secondary rewards⁷² highlighting the need for a closer examination of the role of decision domains. Moreover, most studies examining age differences in discounting used relatively short time intervals of months to years. At longer intervals spanning a decade or more, age differences in mental representations of time may be overshadowed by the impact of global perceptions of time left in life. In the following section, I discuss the role of such global time horizons in more detail.

Global Time Horizons

Anniversaries, birthdays, graduations, and funerals are all salient markers that serve as reminders of passing lifetime. Although such events are encountered throughout life, their

meaning is likely to shift over the life span with younger adults focusing on time since birth whereas older adults are increasingly reminded that the end of their life span is approaching.

When given a horizontal line with “birth” and “death” marked at the endpoints, most adults mark their current position between these anchors with very little hesitation indicating that one's location on the life span is a readily accessible construct. Not surprisingly, subjective distance from birth (or closeness to death) is strongly associated with chronological age (although advanced age is associated with a slight tendency to underestimate one's current life location ⁷³). Tapping into a related concept, questionnaire measures of perceived time left in life (e.g., “my future seems infinite to me” ⁷⁴) consistently show negative associations with chronological age suggesting that, as we age, our future horizons are shrinking ^{63,75,76}.

Since the mid 1990's, socioemotional selectivity theory (SST) ^{77,78}, a life-span theory of motivation, has inspired a broad body of research that examines the implications of age-associated limitations in time perspective for people's thoughts, feelings, and interpersonal relations. According to SST, age-related changes in future time perspective and increasing awareness of the finite nature of life systematically affect goal priorities. Younger adults, who perceive their future as open ended, are likely to pursue goals aimed at optimizing the future, whereas older adults are thought to pursue goals aimed at optimizing the present moment ^{77,78}. In concrete terms, future oriented goals may involve information acquisition or the creation of new social contacts whereas present-oriented goals target current emotional well-being.

To appreciate the implications of SST for decisions across the life span, some conceptual clarifications are necessary. First, the proposed shifts in goal priorities do not occur suddenly at the onset of old age. Instead, changes are thought to be gradual as cues for time limitations increase in saliency from young to middle adulthood and into late life ⁷⁷. Second, the manifestations of age-related motivational shifts may differ across contexts. While many situations allow for the simultaneous pursuit of present and future-oriented goals, the predictions of SST are most relevant when there are explicit trade-offs between present and future ^{77,78}. Further, the implications of SST are not limited to differences between age groups. Regardless of age, life events (such as geographical moves or graduations ⁷⁶) or health conditions (such as HIV/AIDS ⁷⁹) may affect time horizons and lead to corresponding shifts in goal priorities. Finally, motivational adjustments in response to shifting future horizons are conceptually distinct from reactions to loss and diminishing control over the environment (as proposed by the lifespan theory of control ⁸⁰), and mortality salience (as proposed by terror management theory ⁸¹), and can be empirically disentangled from either of these concepts ^{82,83}.

In concrete decision contexts, motivational shifts in response to limited time horizons may manifest themselves at multiple levels. First, they may direct people's preferences towards certain types of choice outcomes; second, they may affect responses to instructional and contextual framing; and third, they may influence information-processing and decision-making strategies. In the following sections, I discuss each of these mechanisms in more detail

Choice preferences

As outlined above, SST argues that age-related limitations in time horizons lead to a prioritization of immediate emotional well-being over efforts to prepare for an extended future ⁷⁷. In many choice domains, potential outcomes differ in the extent to which they map – explicitly or implicitly – onto these sets of goal priorities. As a result, preferences for choice alternatives and attributes may shift as a function of chronological age and temporal horizons.

In the interpersonal domain, for instance, some social encounters offer immediate social gratification (present-oriented goals) whereas others offer opportunities to learn new information or expand one's social network (future-oriented goals). Compared to younger adults, older adults were found to show a stronger preference for close social partners who are likely to offer gratifying social interactions, and a reduced preference for encounters with novel social partners offering the potential for future contact or new learning⁷⁶. This finding has been replicated across a variety of contexts and cultural settings^{82,83}. Moreover, limitations of future time horizons due to experimental manipulations or societal events yield a comparable pattern of social preference shifts as advanced age, suggesting that future time perspective, not chronological age, is driving the effects^{76,82,83}.

Convergent age differences are found in employment and volunteering contexts. Several recent meta-analyses suggest that compared to younger workers, workers of advanced age prioritize intrinsic and social motives that can be realized in the present moment over extrinsic and growth motives aimed at future payoffs⁸⁴⁻⁸⁶. In concrete terms, higher pay and training options were found to appeal more to younger employees whereas organizational citizenship and social commitment carry more leverage for older workers⁸⁷.

The findings discussed so far indicate that advanced age and limited future time perspective influence choice preferences when choosing among objectively different outcomes. As illustrated in the following section, age-associated shifts in time perspective may also affect preferences when the very same options are presented in different contextual frames.

Responses to instructional framing

Extant research in psychology and behavioral economics has demonstrated that subtle changes in instructional framing can dramatically shift choice preferences among options that are otherwise equivalent⁸⁸. While early research focused on framing effects at the group level, more recent work has explored interindividual differences in susceptibility to framing^{89,90}. With regard to age effects, emerging evidence suggests that older adults prefer instructional frames that match their subjective time horizons and motivational priorities.

Fung and Carstensen⁹¹, for example, created advertisements for consumer goods that were paired with slogans emphasizing either emotional meaning in the present moment or expanding horizons and future success. A camera, for instance, was said to capture either “the unexplored world” (future-oriented/knowledge acquisition framing) or “those special moments” (present-focused/emotional framing,⁹¹ page 178). When asked to indicate their preference among these ads, older adults preferred the present-focused over the future-oriented appeal whereas younger adults did not show this preference. Moreover, age difference in advertisement preferences were no longer significant when older adults' time perspective was expanded by asking them to imagine a medical breakthrough adding years to their life⁹¹. This suggests that it is indeed time perspective, not chronological age, which is driving the effects.

While Fung and Carstensen examined complex instructional frames that mapped onto specific motivational priorities, other studies employed simpler, affective frames that merely cast the same material in a positive or negative light. According to SST, limited time horizons and the resulting activation of emotional goals should make older adults more sensitive to such affective frames⁹². Support for this claim comes from the health domain (see also the contribution by Notthoff and Carstensen in this volume). For example, when asked to evaluate health pamphlets, older adults rated health messages more favorably and remembered them better when they were described in positive versus negative terms whereas younger adults did not show any framing effects⁹³. Similarly, older adults were more likely to request information about their susceptibility to health and environmental

threats if instructional frames emphasized protection versus risk whereas younger adults did not respond to affective framing ⁹².

For financial decisions, age effects in response to affective frames are less clear cut. While some studies found that advanced age is linked to stronger responses to affective framing ^{90,94,95}, others did not report this pattern of effects ^{63,96,97}. Further, although age-related increments in sensitivity to affective frames are consistent with SST, the proposed role of future time perspective as a causal factor has not been systematically examined. Apart from age-related shifts in time horizons, cohort effects ⁹⁶ or cognitive decrements may play a role as well. Future studies should experimentally manipulate time perspective or at least assess self-reported time horizons as a covariate.

Information-processing and decision-making strategies

In addition to choice preferences and framing, age-associated changes in global time horizons may also affect basic-information processing and decision-making strategies. Specifically, older adults are thought to engage in cognitive strategies that optimize emotional well-being in the present moment – even if this entails a cost in terms of reduced accuracy and thoroughness ²⁵.

One such strategy involves the selective prioritization of positive over negative information, also known as the “age-related positivity effect” ^{25,98}. The positivity effect is well-documented for attention and memory tasks (for a review see ⁹⁹) and information processing in decision scenarios is affected as well. In a series of studies ^{92,100,101} older and younger adults were asked to make healthcare choices that were presented as tabular arrays on a computer screen. The amount and valence of reviewed information was tracked automatically and revealed that compared to younger adults, older adults reviewed a disproportionate amount of positive (versus negative) material. Similarly, when asked to evaluate various options during consumer choices, older adults listed a greater proportion of positive (versus negative) attributes than their younger counterparts ⁵⁸. Given older adults’ focus on positive material in the pre-choice phase, it is not surprising that they also recall their choices more positively than their younger counterparts ^{58,100-102}.

Importantly, SST conceptualizes the positivity effect as a proactive selection process in response to limited time horizons. Consistent with this view, positivity effects in pre-choice information acquisition were found to be associated with limited future time horizons ¹⁰⁰. Moreover, age differences in positivity were found to be absent when instructional manipulations elicited information acquisition goals ¹⁰⁰ or when older adults were asked to choose for a considerably younger person who presumably had a more expansive time horizon ¹⁰¹.

In addition to a specific emphasis on positive material, limited time horizons and the chronic activation of emotion-regulatory goals may also increase the general salience of emotional content and promote affective/experiential as opposed to deliberative modes of processing ^{92,99}. In the realm of judgment and decision making, support for this claim is not as strong as for the age-related positivity effect, although empirical evidence is generally supportive.

In everyday problem solving, for instance, older adults focus more on emotional aspects of problems than their younger counterparts ¹⁰³ (see also the contribution by Mienaltowski in this volume). Compared to younger adults, older adults are also more susceptible to incidental affect and mood congruency effects ¹⁰⁴. Moreover, older adults perform better on cognitive tasks that draw on affective as compared to deliberative modes of processing ¹⁰⁵⁻¹⁰⁷, although it is not clear whether this effect is driven by a deliberative

prioritization of affect-rich processing styles (as predicted by SST) or an automatic compensatory response to decrements in executive functioning¹⁰⁸.

As a first step towards examining this question, my colleagues and I¹⁰⁹ used instructional manipulations to elicit emotion- versus information-focused processing styles in healthcare choices. Consistent with prior findings, older adults performed better under emotion- as compared to information-focused instructions whereas older adults showed the opposite pattern. More importantly, older adults in the control condition appeared to default to an emotion-focused processing style. Although this suggests, that older adults can adjust decision-making strategies in response to contextual factors, clear evidence for an influence of future time perspective on age differences in affective versus deliberative strategies is still outstanding.

To sum up, age-related shifts in global time horizons appear to affect cognitive processing and decision making at multiple levels including choice preferences, responses to framing, and strategy selection. Future research should aim to provide clearer evidence of the proposed causal role of future time perspective and the pathways by which global time horizons and mediating process variables (attentional biases, coping strategies, etc.) translate into concrete decision outcomes.

Summary and Conclusions

Taken together, the different lines of research reviewed in this chapter illustrate that a better understanding of time and time perceptions can provide important insights into the specific mechanisms that underlie age differences in decision making. As we have seen, time and choice intersect at multiple levels and each level reveals unique patterns of age effects that suggest promising avenues for future research. For instance, with respect to decision time, the apparent paradox of age-related increments in processing speed but decrements in decision time highlights the role of higher-order decision-making strategies. Age-related limitations in the pace and accuracy of internal clocks, in turn, suggest that age differences in fast-paced decision settings may not only depend on minimum reaction times but also on the ability to correctly estimate time intervals. Further, a better understanding of life-span changes in mental representations of time may lead to insights about age differences in intertemporal choice, and age shifts in global time horizons have implications for choice preferences, framing effects, and processing strategies.

To date, much of this research is organized in tight clusters and studies on age differences in any given aspect of time and time perception show little connection to alternative conceptualizations of time horizons. Forging such connections is an important target for future research. Age differences in the use of heuristic decision strategies, for example, might be a compensatory response to limitations in processing speed but could also result from shifts in global time perspective that promote an affect-rich processing style. Similarly, age effects in affective forecasting and future anhedonia (which have important implications for intertemporal choice) could result from a subjective compression of time perceptions, differences in the subjective speed of time, or deeper insights into one's emotional functioning in the face of limited future time horizons.

A first step towards integrating disparate lines of research is the development of overarching conceptual frameworks and an appropriate taxonomy to disambiguate multiple aspects of time and time horizons. At a broader level, this could involve an explicit differentiation between perceptions of actual time as opposed to mental representations of time. At a more specific level, several related concepts need to be teased apart. For example, a better differentiation is needed between processing time and spontaneous motor tempo and among different views of global time horizons^{73,78,110}.

As part of this process, researchers also need to reconsider the abundance of timing and time perspective measures that are currently in use. From fingertapping²⁸ to visual analog scales^{48,73}, questionnaire-based measures^{74,110}, and the construction of hypothetical future events¹¹¹ – measures of time and time perceptions use a wide range of methodological approaches and little is known about their inter-relations and associations with individual difference variables. Ideally, representative examples for each type of measure should be administered to a life span sample to gain a better understanding of convergent and divergent age trajectories in various aspects of time horizons.

Unfortunately, the research reviewed in this chapter shares many of the methodological limitations that are commonly seen in research on aging. Some of these are particularly problematic when studying age differences in time horizons. One example is the common practice of considering student samples as representative of “younger adults” and comparing them to community dwelling older adults. Students share distinct demographic and personal characteristics that are far from representative for younger adults in general. It also appears that certain aspects of student life, most notably one's upcoming graduation, but also leaving home or moving dormitories, may serve as markers of limited time horizons and result in social preferences shifts and emotional experiences that resemble those seen in advanced age^{112,113}. Further, most of the studies reviewed above rely on comparisons between extreme age groups. Thus, little is known about time horizons in midlife or the shape (linear or curvilinear) of age effects. Moreover, existing research is largely cross-sectional and confounds age with cohort effects. The time horizons of a given cohort are likely shaped by historical changes in the pace of life, demographic shifts in life expectancy, and societal markers of endings and hardships (such as the great depression, World Wars I and II, and the 9/11 attacks¹¹⁴). Conceivably, such cohort effects could either mask or exacerbate genuine age effects.

In spite of these limitations and although research at the intersection of aging, time, and decision making is still in its infancy, this line of inquiry carries much potential. In contrast to chronological age, time perceptions and horizons can be modified by training³⁶, life experience¹¹⁵, societal events⁷⁶, or contextual manipulations^{76,101}. This opens up promising avenues for interventions targeted at optimizing decision making across the life span.

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