It's about Time: Let's Do More to Support the Process of Aging (vs. the State of Being "Old")

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ABSTRACT

Focus on aging as a process vs. (old) age as a state of life. How do needs for supporting information and information tools change through the years of a person's adult life? Of special interest in the context of successful aging are innovations that are better for all adults but work even better for people as they age. To identify innovations that "age well", begin by routinely sampling across a spectrum of adult ages, both in studies of current tool use (e.g., observations, interviews, surveys) and design alternatives. As a further step, cross age with other factors. Less formal methods involving forms of group deliberation can also elucidate age-related changes in the landscape of information need. A focus on the process of aging (vs. "old age") is inclusive of people across the decades of their adult lives.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **HCI theory, concepts, and models**;

KEYWORDS

Personal information management (PIM), successful aging

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1 INTRODUCTION

Tick-tock. Another minute of your life gone even as you read the title of this article, then scan the abstract and arrive, perhaps dubiously, at the introduction you now read. Time passes. A minute. Perhaps two by now. And you are now a minute… or two… older.

This article is about time. And aging. The article explores a good news message that there may be much more we might do about each, as individuals and as members of the computer-human interaction (CHI) research community. No, we can't stop time nor the processes of aging. But, through our practices of *personal information management* (PIM)[22] and the support of our information tools we may be able to do much more both to reduce the inevitable declines of aging even as we take full advantage of the improvements that come with aging.

This article is in three **sections**, each with a *key message* for our CHI community.

- **We are all getting older** (of course) and, as we age as adults, we are all in gradual cognitive decline with respect to some measures of cognitive ability (e.g., measures of working memory capacity) even as measures continue to improve throughout adulthood in other areas (e.g., general world knowledge, vocabulary).
- **Can our information tools keep up?** Considerable research suggests that, as we age, we may all have increasing difficulty making optimal use of our information tools (at least as measured in many laboratory tasks). Let's turn things around. A few studies suggest that some information tool innovations, while providing general, cross-age benefit, may also reduce or even eliminate observed age-related decrements in performance. Develop information tools that exploit the improvements that come with age while decreasing dependence upon facilities, such as working memory, that are shown to decline with age.
- **Time for a broader sampling… and a broader perspective.** Time and, with time, aging, should be factored routinely into investigations of information tool use and design alternatives. If nothing else (i.e., if age isn't its own condition in a crossed design), sample widely across the spectrum of adult ages. Doing so provides some basis for correlational explorations into potential interactions between age and alternatives, whether in information tool design or methods of PIM. Some alternatives, while of general, cross-age benefit, may also reduce or even eliminate performance deficits related to the cognitive declines of normal aging. In other cases, study participants of a more advanced age may help to bring to light differences that are masked in younger participants operating with a youthful abundance of raw information processing ability. A broader perspective with an emphasis

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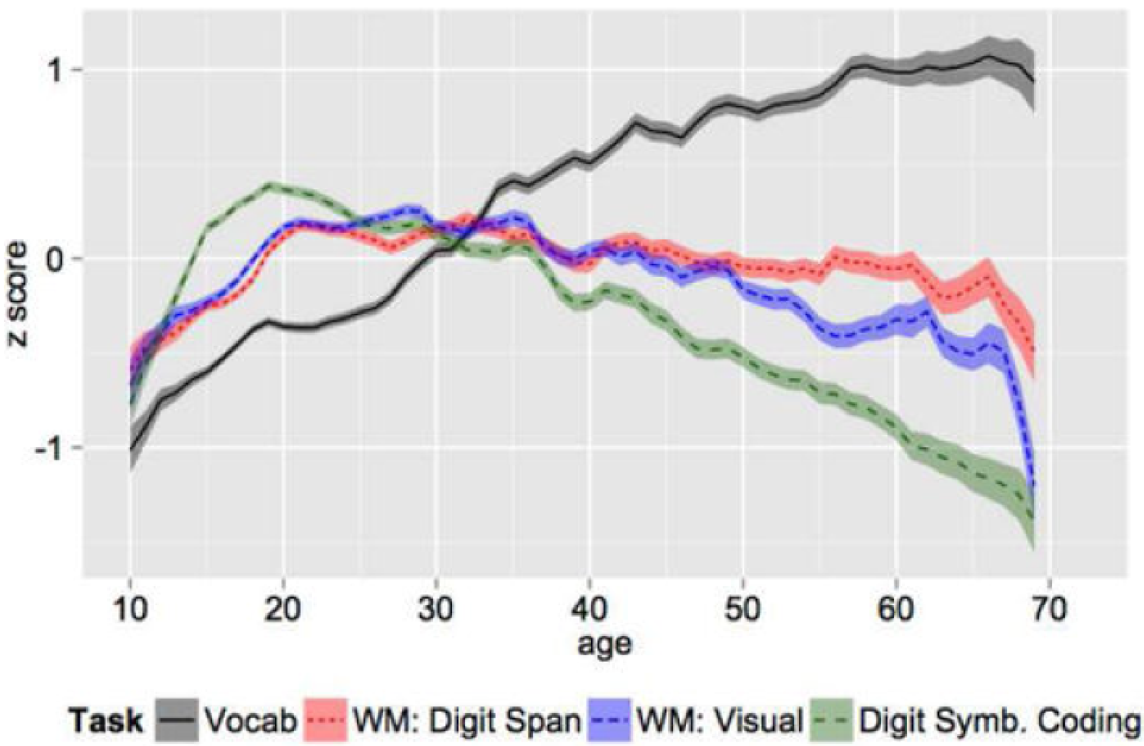

Figure 1: Performance on some cognitive tasks, e.g., the digit symbol coding task (colored green) begins to decline early in adulthood even as performance on other measures, e.g., the vocabulary (colored grey) continues to increase as people age into their 60's.

on the process of aging and on the use of our information tools over time may also promote the development of tools and tool constellations that "age well" as we age.

2 WE ARE ALL GETTING OLDER

In an impressive analysis involving data from nearly 50 thousand web participants and including also normative data from standardized IQ and memory tests, Hartshorne and Germine [18] found that when in their lives people reach a peak of performance varies greatly for different measures of cognitive ability. For some abilities, people peak and then begin to decline just around the age of twenty. For other abilities, people reach a stable plateau in early adulthood that may persist for several decades. And then for some abilities, people don't reach a peak of performance until 60 or older.

In a selected depicture of measures in Figure 1 (taken with permission from [18:15] [1]), performance on one cognitive measure, a digital symbol coding task[2], begins to decline before age 20 while performance on a vocabulary task (given a word, provide its definition) continues to improve through a person's 60's i.e., throughout the range of ages included in the study.

Age-related discrepancies in performance across tests of intelligence and cognitive ability have given rise to a proposed distinction between *fluid* and *crystallized intelligence* [6]. Horn notes that fluid intelligence is "relatively independent of education and experience; and it can 'flow' into a wide variety of intellectual activities" whereas crystallized intelligence is "a precipitate out of experience. It results when fluid intelligence is 'mixed' with what can be called the 'intelligence of the culture.' Crystallized intelligence increases with a person's experience, and with the education that provides new methods and perspectives for dealing with that experience."[20:54].

Crystallized intelligence is represented by measures of cognitive function that continue to increase well into later adulthood. In Hartshorne and Germine's study, these include measures of *vocabulary* (i.e., provide definitions for words), *information* (answer general knowledge questions) and *comprehension* (explain, for example, why we have parole). Per the quote by Horn above, crystallized intelligence is much more than a simple rote-like accretion of facts. Rather it represents an integration of raw information, acquired through facilities of fluid intelligence, into a more coherent whole – as shaped through prior learning and the experiences of formal education.

Fluid intelligence is represented by measures of cognitive function that decline early in adulthood, including measures of abstract reasoning, the ability to reason in novel situations, spatial memory, visual search and, most especially, working memory.

[1]Figure reprinted through permission #1326359 (https://marketplace.copyright.com/rs-ui-web/mp/license/f57bed82-99c4-4de4-8a28-288bc0111e30/c485b695-0eaa-4ccf-adcb-e14dcc8e548a)

[2]"Digits 1–3 are each paired with a symbol. Given list of symbols, write down corresponding digit as fast as possible" [18:15].

Working memory (WM) is characterized as the ability to keep a problem representation active as we endeavor to solve it [16]. WM is important in, for example, planning an outing with a sequence of stops (in what order?) or in formulating a response during a debate. (What to say? When? Addressing what points?)

3 CAN OUR INFORMATION TOOLS KEEP UP?

Considerable research indicates that, as we age, we may all have increasing difficulty making optimal use of our information tools [4, 8–14, 19, 26, 28, 30]. Implicit in much of the discussion of this research is a thought that people may have trouble "keeping up" i.e., with tool innovations, as they age. Acceptance of this implication is a likely basis for much the ageism reported in our society.[3]

But let's flip this reasoning on its head. What can, should, our tools be doing to "keep up" with us as we age, both towards helping us to compensate for the gradual declines in abilities of fluid intelligence (most notably declines in working memory and spatial ability), even as we continue to take full advantage of improvements in vocabulary, general world knowledge and other abilities of crystallized intelligence that improve with age?

Consider the metaphor of "cognitive eyeglasses". Wearing glasses, by young and old, is now commonplace[4]. Moreover, the prescription for a person's eyeglasses or contacts is routinely updated to adjust for age-related changes in vision.[5] When some 75% or more of us have corrected vision, we hardly think that corrected vision is even a consideration, let alone a disqualification, in decisions of employment.

Might we, through our constellation of information tools and a periodic updating of these (e.g., the better to accommodate age-related changes in a person's constellation of cognitive abilities) reach a point where age-related declines (e.g., in WM) are no more a hinderance, nor a consideration in matters of selection (e.g., for employment), than age-related declines in the ability to focus on nearby objects without reading glasses?

We take inspiration from two examples.

3.1 Back to the future with a full-screen text editor

Many of us may not remember nor ever have experienced a time when full-screen, WYSISWYG ("what you see is what you get") editing was not an everyday reality[6]. But in the early 80's full-screen editing was brand new. The standard of the day was the line-based text editor. Users of a line-based editor such as "ed"[7] would need to formulate commands to effect change in a document even as they endeavored to keep the current state of the document "in mind". The command "3s/two/three/" for example might be used to effect a change in line three of the string "two" to be "three". Not so easy! And putting a lot of burden on a person's WM.

Studies of line-based text editors had reliably demonstrated a negative correlation between increasing age and performance even after influences for other relevant factors (e.g., education level, computing experience) were removed [15].

But in a comparison of results from two different studies, one of performance on a line-based editor (ED) and the other of performance on a full-screen editor (a prototype called TED), Gomez et al. [17] reported a dramatic reduction in the effects of age for the performance measures of learning time, error rate and execution time. (Participants were all female ranging in age from 28 to 62 years, mean 43).

The Text Editor (line-based vs. full-screen) X Age interaction was significant for both execution time and error rate. For execution time in the full-screen editor condition, there was still a slight upward trend as a function of increasing age that was not significant. For first-try errors there was actually a slight, but not significant, benefit for increasing age in the full screen editor condition.

Moreover, performance using the full-screen editor was overall better, by a factor of nearly 2 to 1, vs. using the line-based editor. In other words, the benefits for older people were not purchased at the cost of decrements in performance for younger people. The screen-based editor was better for everyone – only especially better for older people.

How might this be? By one explanation, the full-screen editor functioned like a pair of cognitive eyeglasses with respect to the "acuity" of working memory. Certainly, the contrasting line-based editor was demanding of working memory. With the screen-based editor, commands could be expressed more directly (albeit still awkwardly using function arrows; a mouse was not available). The document and its current state could also be more easily, more completely viewed in the screen-based editor.

Study results point to the possibility that in the right information environment and on at least certain tasks, having more youthful cognitive facilities such as for working memory capacity might be no more relevant to performance than having good *uncorrected* vision is to performance on tasks in today's typical office setting. Alas, the study has not, as best we can determine, ever been replicated.

A somewhat more recent study by Charness et al.[7], focusing on the use of one of the earliest versions of a full-screen editor, Microsoft Word for Windows 1.1a[8] (quite basic by today's standards), still found age effects among novice users with little prior word-processing experience but also found these age effects were markedly reduced or eliminated among users with prior word-processing experience. The authors suggest that remaining effects of age might be further reduced by continuing improvements in training techniques and software interface.

Moving from the ameliorating effects of training and prior experience to tool innovation, consider the gains that have been made since the early 1980's! We now use mice, touchpads, and direct screen touch to manipulate the information of a document. We can use voice-to-text, spell and grammar checking, and autofill. We can use a side navigation pane to stay oriented (the less to keep in our minds). We even have features that help us to re-establish a working context when we re-open a document later (e.g., a "Welcome back!" that offers to take us back to the place in a document where we were last).

[3] https://en.wikipedia.org/wiki/Ageism.
[4] About 3 of 4 adults in the United States wear some form of corrected vision (https://www.statista.com/statistics/732250/adults-wearing-vision-correction-us/).
[5] https://www.allaboutvision.com/eyeglasses/prescription-expiration-date/.
[6] https://en.wikipedia.org/wiki/WYSIWYG.
[7] https://en.wikipedia.org/wiki/Ed_(text_editor).
[8] https://en.wikipedia.org/wiki/History_of_Microsoft_Word.

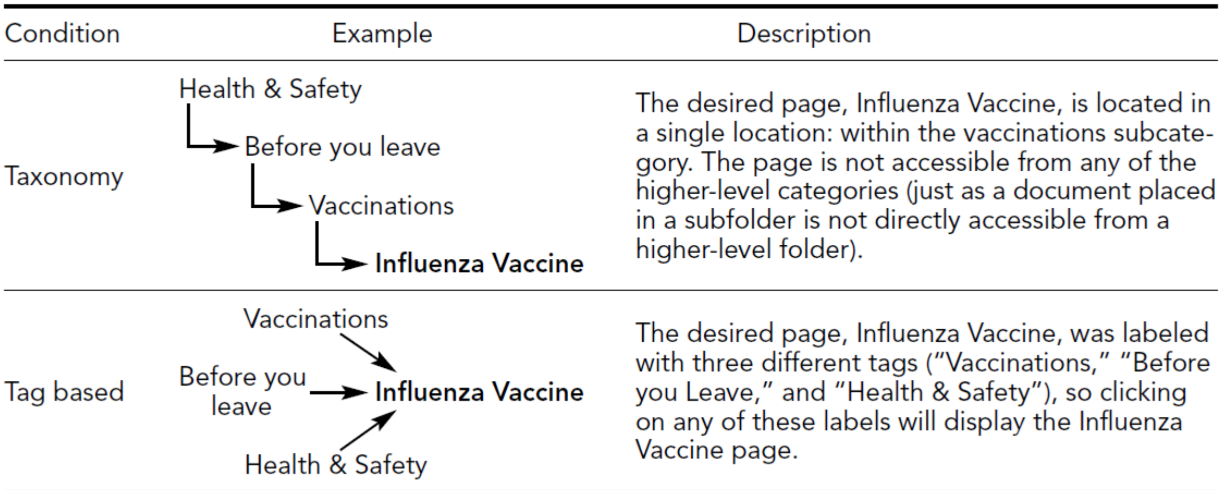

Figure 2: Illustration of taxonomy vs. tag-based conditions for information retrieval. (Table 2 in [27])[9]

Might at least some of these advances be shown to further reduce the performance decrements of age? Or do some of these work in the other direction, i.e., as differentially benefiting younger people? Either way, it is important to know.

3.2 From document processing to finding information on the web

We take a big 25-year jump in time, from 1983 to 2008, in our next case study involving a design alternative and age. The performance of older adults in information retrieval tasks is frequently lower than for younger adults [23]. Pak and Price [27] noted that most of the retrieval tasks under study in the late 90s and early '00s involved some variant of a hierarchical or taxonomic navigation (e.g., web page navigation via hyperlinks or help menu navigation) and that these tasks placed a considerable burden on a participant's spatial abilities to stay oriented. We can suspect that a participant's working memory was also burdened. Both spatial ability and working memory capacity are associated with fluid intelligence.

Pak and Price reasoned from the fluid/crystallized distinction to consider an alternate tag-based information retrieval interface that might better engage a participant's vocabulary for search terms. Vocabulary, an aspect of crystallized intelligence, continues to expand with age.

The difference between the two information retrieval interfaces is represented in Figure 2. Fifty younger adults (23 men, 18 to 23 years in age) and fifty older adults (23 men, 55 to 78 years in age) were randomly assigned to either the taxonomy or tag-based condition. Orientation and instruction in the two conditions were comparable. Guided completion of one task (e.g., "How much luggage can you take on a cruise ship?") was followed by practice solo completion by the participant of a second task. All participants then completed 30 experimental tasks and were measured, per task, for completion time, number of mouse clicks and number of errors.

The essentials of study results:

- Young people performed significantly better than older people overall, resulting in a significant main effect of age on a composite performance measure (averaging completion times, number of errors and number of mouse clicks).
- However, this effect of age was expressed in the taxonomy condition but not in the tag-based condition. Age-group performance differences in the tag-based condition were not significant. For two performance measures (mouse clicks per task and error rate), older participants performed slightly better than younger participants (although these differences were not significant).
- The interaction of condition (taxonomy vs. tag-based search UI) with age group was significant.

As with word processing, so too with information retrieval: A variation – an innovation – in the user interface served to dramatically reduce, even eliminate, the effects of age.

We note that cognitive processes depicted by Pak and Price for the tag-based condition can be regarded as a variation of those we do every day through a search service like Google, i.e., form a goal or intention, convert to a search term, and then, in their experiment, select the appropriate tag. By contrast, of course, we directly type into a search box (or speak) to get results from a service like Google. But increasingly we also see, and accept, suggested completions to the term we begin to specify so that we are essentially selecting a tag suggested by the search service. (A service such as Google has a vast amount of data to work with – from our own past queries and those of billions of other users – to suggest search term completions).

Even as we may continue to navigate through taxonomies in the form of menus in our applications and the hyperlinked pages of a web site, initial access to web information is via search e.g., type in at least the beginning of a search term, possibly accept a suggested completion, click to access a web page represented in the results listing, repeat. Some of us can possibly remember using the Yahoo menus as a fundamentally taxonomic way to access web information. Those days are long gone.

[9]Reprinted by permission of the authors.

Finally, it should be noted that a preference for search as a means of finding public information on the web (and its potential role in reducing the effects of aging) stands in stark contrast to a persistent preference for navigation as the preferred, primary means of access to the files we keep locally on our computer. Here too, Bergman [2] observes an effect for age such that study participants over 50 years of age were four times more likely to use search (vs. navigation) as a means of return to personal files than participants in their 20s. Bergman's analysis indicates that navigation is a faster, more efficient method of return to personal files and that older participants are more likely than younger participants to use search on occasion because they are more likely to have forgotten where the file was initially placed. But it is also possible that older study participants selected search even if they knew how to reach the target file via navigation, e.g., older participants may have determined that for *them* search was the faster method of return.

Returning to retrieval of public information from the web, the past two decades have seen considerable innovation in the support for search via services such as Google, Bing and DuckDuckGo, including, for example, suggesting search term completions, suggesting "related searches" (typically at the bottom of the results page), and even bringing information "forward" into the results page for immediate consumption so that further clicking is often obviated.

Will this lead to even less reliance on navigation as means of access to public information on the web? Even within web sites? Will this, in turn, lead to further reductions in the performance gap between younger and older users? To repeat one of the most popular lines to include in a research paper, "further research is needed".

In cases of information retrieval of public information, the performance gap in favor of youth may disappear or even be reversed. None of us in adulthood are likely as fast as we once were. But possibly we make up for declines in raw speed with greater background knowledge concerning what to look for and what words to use as search terms.

There has not, to our knowledge, been an effort to replicate the results of either this information search study or the word processing study described in the previous subsection. The impetus to do so has faded. Full-screen, WYSIWYG editing is clearly better for everyone than is line-based editing; similarly, direct searching (i.e., with suggested completions as in Google or Bing) is preferred to navigation as a means for finding public information (e.g., on the Web).[10]

But newer questions in information tool design arise continually and explorations into design alternatives are ongoing. Why not more systematically factor age into these studies? As we do so, our focus can shift in a potentially profound way – away from the study of old age as, at least implicitly, a disability and towards a more systematic study of the process of aging as something we are experiencing.

[10] But see Bergman [1, 3] for evidence that people prefer navigation as a primary method of return to personal files.

4 DISCUSSION: TIME FOR BROADER SAMPLING. . . AND A BROADER PERSPECTIVE

This paper argues for more support of aging as a process vs. "old" age as a state and this most especially in the form of better information tools (and constellations of these) that might support us better as we age throughout our adult lives. The argument is directed to our CHI community (and more generally to those involved in human-computer interaction work).

An enormous amount of research on aging is already being done in journals on geriatrics and gerontology.[11] Participants in many of the studies of these journals are, in fact, sampled to represent a range of adult ages.[12] However, a focus on the design and development of information tools is generally missing. There is also, to be sure, considerable good research being done on the needs of older people vis-à-vis information tools, which is well beyond the scope of this short article to review (but see [4, 8–14, 19, 26, 28, 30]). More research is needed.

A melding of the two – the focus on our changing needs in information tool support as we age through our adult lives – represents a shift away from the study of old age as, at least implicitly, a disability and towards a more systematic study of the process of aging as something we are all experiencing. This shift potentially brings several benefits including:

- Delivery of results in tool design of broad applicability to all members of an aging adult population.
- Inclusion of the "old"[13] in a continuum i.e., regard the old not as a special needs category but rather as on a continuum that includes us all, as productive members of our society.

Aging should be factored routinely into investigations of information tool use and design alternatives. If nothing else (i.e., if age isn't its own condition in a crossed design), sample widely across the spectrum of adult ages. Doing so provides some basis for correlational explorations to identify potential interactions between age and alternatives in information tool design. Interesting patterns can be studied further in designs with age as an explicit factor.

And then, perhaps not just "younger" vs. "older" people. Salthouse [29] argues for the inclusion of an intermediate group, which we might call "middle-aged" or the "younger old". Sharit et al. [30] do this in a study of information seeking on the Web involving younger adults (ages 18-39), "younger-old" (ages 60-70) and "older old" (ages 71-85) to derive implications for instructing older adults in web information seeking. What about the "older young"? (e.g., 40 to 59).

What might we expect to observe? In many cases, simply an overall decline in performance with age (e.g., execution times, error rates and learning times are likely to increase with age). As noted previously, the declines in WM and other measures of fluid intelligence are gradual with age from age 20 to 70 or older [18, 25]. The range of gradual decline may extend further still [5].

[11] For a listing of journals see https://www.umb.edu/gerontologyinstitute/publications/journal.
[12] See for example [24].
[13] Wherever this moving goal post of "old" may be placed as people stay active and healthy well into retirement.

But in some cases, we may see an interaction between the factor of age and other conditions of the study (for simplicity's sake we'll refer to these conditions as "A" and "B"). Consider two:

1. An innovation i.e., in condition "B" differentially benefits younger participants. The lines may cross such that older participants are worse in condition B while younger participants perform better. Or it may simply be the case that, while everyone performs better in condition B, improvements are less for older people. Older participants, as the proverbial "canary in the coal mine" may help to reveal important differences otherwise missed. Further study might reveal that design B includes a correctable problem that is made apparent only in older participants and is masked in younger participants, operating as they are with a youthful abundance of raw information processing ability.
2. In a different interaction, age-related performance differences of A are reduced or even eliminated in condition B. In one variation of this interaction, people regardless of age perform better in condition B but the benefits of condition B increase with age.

With both possibilities (#1 and #2) there may be the realization of a digital form of *universal design*[14], the movement to design for accessibility by all regardless of age, physical makeup, etc. As a *curb cut effect*[15] of universal design, innovations designed for one group (e.g., people in wheelchairs) prove useful to other groups as well (e.g., bicyclists, people with shopping carts, people pushing prams). So too with information tools, that innovations addressing problems that are especially apparent in older people prove useful across age groups.

Going a step further, consider the possibly that many of the successful innovations in our information tools, while of general, cross-age benefit, may have actually supported people as they age – even if that outcome was not an explicitly stated intention. We have considered two: 1. The transition from line-based to full-screen editing and, beyond, towards ever increasing external representation of state (of the document we are editing, the current task); 2. the ability to "jump" directly to public information rather than having to navigate through a hierarchy. Neither innovation was motivated (as best the authors can determine) by an original concern to support people as they age. But were we, as a community endeavoring to improve human-computer interaction, to prioritize the goal of supporting people as they age, then perhaps the pace would quicken towards tools that work better for everyone.

We prioritize by sampling, in our study, across all "seasons" and not just the "perpetual spring" of the college campus (demographically restricted in many ways besides age). But there are also less formal, more qualitative ways towards better support as we age. The authors recently participated in a PIM 2022 workshop in association with the annual ASIS&T conference[16] with an explicit objective to understand how our needs for information and information tools change over time and as we age. The workshop itself was an in-person day-long affair. However, in preparation for the workshop, participants, including those who were unable to attend the in-person portion of the workshop, participated in a week-long, on-line asynchronous discussion involving a variation of the Delphi Method.[21]. As people read the responses of others, they frequently added information they might not have otherwise (e.g., "I actually do something similar to what <name> does but . . ."). We might liken to the exchange of "What I did during the big blizzard" stories exchanged at a dinner party.

Four questions were considered. The first question was simply: "*How has your own use of information tools changed over time?"*. Twenty-two people participated, widely distributed in age from mid-20's to 70. All but one participant reported significant changes in their use of information tools over time but were roughly divided in their reasons for these changes between 1. perceived declines in memory, 2. changes in roles and responsibilities (e.g., from college to full-time work), 3. and, interestingly, an overall increased wariness with tools e.g., as possibly transient, more cost than benefit, and increasing overall information fragmentation. (A more detailed report of the workshop including this pre-workshop discussion is the topic of another article).

4.1 Plan for presentation at the conference.

In keeping with the story-telling dynamic of the on-line Delphi Method discussion descried above, priority at the actual presentation of the authors' work at the conference is given to maximize the opportunity for interactivity. Presentation of main points of the paper is limited to the first 3 minutes, followed by exercises to encourage the audience to "time travel", first from the past to the present; and then onward into the future. Through pictures, timeline visualization and a summary table, we'll endeavor to depict the evolution in tools, paper-based and digital, over the decades in support of prospective memory (e.g., calendaring, to-do list management, timeline visualizations) and episodic memory (e.g., notetaking, journaling, digital photos). We will similarly track the time course of tool innovations that likely shifted the reliance on fluid intelligence (e.g., working memory, visual/spatial abilities) and crystalized intelligence (e.g., vocabulary, general world knowledge). During this portion of the presentation (about 7 minutes), people are encouraged, through some open discussion and an on-line survey, to relate to their own experiences. How has their use of tools changed with time?

In the final (5) minutes remaining, the audience and presenters will engage in an open discussion of the future. What would we like to see in tools and especially tools to grow with and adapt to us as we age? What about integrations such that information in support of the future (e.g., task management and project planning) can later support the present (as tasks are completed) and then still later can support our essential remembrances for the past (where these remembrances are, in turn, key to our ability to make future plans). People will have the option to continue the discussion informally later in the day (e.g., during a happy hour).

5 CONCLUSIONS

We are all aging. And, by some measures of cognitive ability, we experience declines as early as when we turn 20 even as other cognitive abilities continue to improve through our 50's and into our 60's (and possibly beyond). The authors argue for a focus on

[14]https://en.wikipedia.org/wiki/Universal_design.
[15]https://en.wikipedia.org/wiki/Curb_cut_effect
[16]http://pimworkshop.org/2022/.

aging as a process vs. (old) age as a state of life. Include people across a broad spectrum of adult life.

We might hope to identify variations in information tool design that are better in general for everyone regardless of age but that especially support people as they age. This might happen through innovations that reduce the demands on cognitive facilities such as working memory, shown to be in decline for all of us as adults. Conversely, this might happen through better exploitation of facilities such as vocabulary or general experience –aspects of crystallized intelligence that are shown to improve with age. Such innovations provide general improvement for everyone, not just for older people.

There is a need and a tremendous opportunity to include, more consistently, more systematically, the effects of aging in studies of information tool design and not just in studies whose primary purpose is to target the needs of older people.

It’s about time.

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