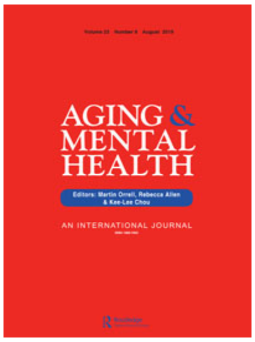

Aging & Mental Health

ISSN: 1360-7863 (Print) 1364-6915 (Online) Journal homepage: https://www.tandfonline.com/loi/camh20

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To cite this article: Avner Caspi, Merav Daniel & Gitit Kavé (2019) Technology makes older adults feel older, Aging & Mental Health, 23:8, 1025-1030, DOI: 10.1080/13607863.2018.1479834

To link to this article: https://doi.org/10.1080/13607863.2018.1479834

Published online: 26 Nov 2018.

AGING & MENTAL HEALTH
2019, VOL. 23, NO. 8, 1025–1030
https://doi.org/10.1080/13607863.2018.1479834

Technology makes older adults feel older

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ABSTRACT
The current study aims to examine the effect of technology use on the assessment of subjective age across the adult lifespan, with the assumption that using technology might make older people feel older. One-hundred and fifty-one participants (ages 18–83) assessed their subjective age before and after using familiar and unfamiliar applications on a touchscreen tablet. Subjective age was assessed either by line marking or by numerical response. The oldest participants felt older after the manipulation relative to their pre-manipulation baseline, unlike the youngest participants in the sample. This effect was stronger for the unfamiliar application than for the familiar application. We suggest that using technology evokes stereotype threat. Although this threat does not impair performance, it still changes self perception. These findings could have far-reaching implications for the well-being of older adults in an ever more technological world.

ARTICLE HISTORY
Received 24 December 2017
Accepted 14 May 2018

KEYWORDS
Attitudes; self-evaluation; mobile Application; stereotype Threat; subjective Age

Introduction

When asked about their subjective age, older adults often report that they feel younger than their chronological age (Barak, 2009; Choi, DiNitto & Kim, 2014; Cleaver & Muller, 2002; Hubley & Hultsch, 1994; Hughes, Geraci, & De Forrest, 2013; Kastenbaum, Derbin, Sabatini, & Artt, 1972; Kotter-Grühn, Kornadt, & Stephan, 2015; Montepare, 2009; Montepare & Lachman, 1989). Feeling younger than one's actual age is associated with better health outcomes and with greater psychological well-being (e.g., Boehmer, 2007; Hughes et al., 2013; Kotter-Grühn, Kleinspehn-Ammerlahn, Gerstorf, & Smith, 2009; Stephan, Caudroit, & Chalabaev, 2011; Stephan, Chalabaev, Kotter-Grühn, & Jaconelli, 2013). Such a discrepant report might reflect a self-protective strategy that allows individuals to distance themselves from old age and to counteract negative images of aging (Weiss & Lang, 2012).

It has been shown that experimental manipulations can affect subjective age. For example, Hughes et al. (2013) found that taking a short memory test increased subjective age perception among older but not among younger participants. In fact, the mere expectation that memory would be tested made older participants report older subjective age. In another study, taking neuropsychological tests made older adults feel older, even when receiving positive feedback (Geraci, De Forrest, Hughes, Saenz, & Tirso, 2017). These findings presumably reflect fear of age-associated memory decline, which was aroused by the experimental manipulation. Likewise, older participants who were asked to learn emoticons used by teenagers for digital communication reported older subjective age (Eibach, Mock, & Courtney, 2010). In addition, listening to sad music and reading a sad story increased subjective age perception in individuals aged 40–80 (Dutt & Wahl, 2017). Experiencing age discrimination, in the form of less respectful treatment or worse service, has also increased subjective age perception (Stephan, Sutin, & Terracciano, 2015).

Thus, there is a contextual-situational effect on subjective age. This effect might be based on the more general phenomenon of Stereotype Threat. A stereotype threat is defined as a decrement in performance or in self perception in individuals who are targeted by negative stereotypes (Lamont, Swift, & Abrams, 2015; Schmader, Johns, & Forbes, 2008; Spencer, Logel, & Davies, 2016). Memory deterioration, the experience of discriminating behavior, or simply being sad might stereotypically link to aging. Chasteen, Bhattacharyya, Horhota, Tam, and Hasher (2005) compared recall on a task framed as a memorization task to recall on the same task when framed as an impression formation task. Older participants performed more poorly when assuming that the task examined memory. That is, stereotype threat affected their performance.

The current study tests the effect of technology use on subjective age, with the assumption that using technology might evoke age-related stereotype threat. Over the years, the emergence of new tools and applications has accelerated exponentially (Kurzweil, 2004). As such, technology is inherently perceived as novel and advanced. We suggest that these characteristics make people believe that technology is for the young. This notion has received some support in a discourse analysis of discussions by older adults who participated in computer classes (Turner, Turner, & Van de Walle, 2007). Older people felt alienated from technology and made statements such as 'I'm too old to learn how to use and control these technologies.' Indeed, some non-internet users cited 'too old to learn' as their reason for being offline (Zickuhr, 2013).

If technology is intuitively associated with younger age, technology use might elicit an age-related stereotype that favors the young. Thus, the current study aims at uncovering the impact of age-related stereotype threat that may

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Table 1. Correlations between chronological age and subjective age, as measured by line marking and numeric response before and after the manipulation.

	Chronological Age	Line marking (Pre)	Numeric response (Pre)	Line marking (Post)
Line marking (Pre)	.571**			
Numeric response (Pre)	.851**	.523**		
Line marking (Post)	.859**	.589**	.779**	
Numeric response (Post)	.912**	.535**	.941**	.855**

Note. **$p < .001$.

operate implicitly and on a daily basis. Two hypotheses are tested. First, we hypothesize that using technological applications will increase older people's reported subjective age. Second, we predict that less familiar technology will have greater influence on subjective age than more familiar technology. By manipulating application familiarity we may also distinguish between the effects of technology per se and the impact of novelty on subjective age.

Method

Participants

We used GPower™ to determine sample size. Given a medium effect size (0.30, following Hughes et al., 2013), a sample of at least 135 participants was required. We recruited 151 community-dwelling adults (age range: 18–83, 56% women) with no history of learning disorders, psychiatric disturbances, neurological disease, tremor, significant eyesight difficulties, or head trauma, as verified by self-report. Older individuals (age >60) scored within the normal range (27–30) on the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975). The average number of years of education of the entire sample was 14.11 ($SD = 3.11$), and there was no correlation between age and education ($r = -.08$, ns).

Tools and procedure

Background information

Participants completed pre- and post-manipulation questionnaires. In the pre-manipulation questionnaire they reported year of birth, education, subjective health, and life satisfaction. To mask the main purpose of the study, other questions resembling the questions about subjective age in form and content were added to the questionnaire. These questions addressed leisure activities, as well as life satisfaction (single item) and subjective health (single item). Participants were asked to answer questions by providing a numeric response (e.g., 'The number of books that I read every month is ____', or 'I spend ____ number of hours on leisure activities every day'). They were also asked to tick mark their response on a line (e.g., 'Please mark on the line how satisfied you are with your life'. The ends of the line said 'highly satisfied' and 'highly dissatisfied'), and scores were calculated as the distance in mm between the leftmost endpoint and the tick mark. In addition, participants were asked to rate their response on a Lickert scale (e.g., How would you rate your health on a scale of 1 = 'not good at all' to 5 = 'very good).

The post-manipulation questionnaire was administered immediately after the manipulation. As part of this questionnaire, participants were asked to tick mark their attitudes toward technology concerning three items (e.g., 'To what extent do you feel updated regarding new technologies', Cronbach's alpha = .77); to report their self-perception of success in completing the task on a line whose ends were 'not at all' and 'very much'; to answer 11 yes-no questions about technology use (e.g., 'Do you use a Tablet?', 'Do you download applications?'); and to assess their cognitive ability through eight questions (based on Pearlin, Mullan, Semple, & Skaff, 1990). This set of questions was presented at the end of the study, so as not to affect participants' perception of subjective age.

Dependent variables

Participants reported their subjective age both before and after the manipulation. We used two methods to examine subjective age – an implicit measure (line marking) and an explicit measure (numeric response). The implicit measure was selected to make sure that participants would be unable to repeat their report of subjective age following the manipulation through remembering their first report. Line marking was presented before numeric response, both before and after the manipulation.

Line marking

Participants indicated how old they felt by tick marking a 66-mm-long line whose endpoints were labeled 'birth' and 'death'. We measured the distance in mm between the leftmost endpoint and the tick mark. To allow a comparison to the actual age (as well as to the explicit measure obtained by numeric response), we multiplied each response by 1.82. In this way we scaled the measure to the range of 0–120 years (following Hughes et al., 2013).

Numeric response

Participants were asked five questions about their subjective age, such as 'Most of the time I feel as though my age is ____' (based on Kastenbaum et al., 1972, as well as on Moschis & Mathur, 2006, Cronbach's alpha = .97). The five questions were highly correlated ($.77 < r < .96$). We used the mean age across the five questions as a measure of numeric subjective age.

The two subjective age scores, as measured by line marking and numeric response, were positively and significantly correlated (see Table 1).

Manipulation

Participants were asked to perform a short task on a touchscreen Tablet PC (Samsung Galaxy Tab 10), and were randomly assigned to a familiar condition, involving a navigation application (WAZE), or to a less familiar condition involving a travel reservation application (BOOKING). According to SimilarWeb (www.similarweb.com), which tracks application downloads around the world, WAZE

Table 2. Hierarchical linear regressions predicting subjective age pre-post difference by manipulation type and chronological age.

Subjective age		Coefficient	SE	t	p	95% CI		ΔR^2
Line marking	$R^2 = .32$, $F(3, 147) = 23.21$, $p < .001$							
	Constant	−1.30	1.70	−0.77	.444	−4.56	2.04	
	Application (1 = BOOKING)	0.80	3.39	0.24	.812	−5.89	7.51	
	Chronological age	0.67	0.09	7.69	.001	0.50	0.84	.28
	Interaction	0.50	0.17	2.85	.005	0.15	0.84	.04
Numeric responses	$R^2 = .25$, $F(3, 147) = 16.49$, $p < .001$							
	Constant	2.09	0.52	3.99	.001	1.06	3.13	
	Application (1 = BOOKING)	0.83	10.5	0.79	.428	−1.24	2.91	
	Chronological age	0.16	0.03	6.00	.001	0.11	0.22	.19
	Interaction	0.18	0.05	3.24	.002	0.07	0.28	.05

ranked among the top 10 popular application in Israel, whereas BOOKING did not appear among the top 50. The manipulation involved a short search with the same number of steps: finding a specific route through WAZE or finding a specific hotel through BOOKING. After the task, participants reported prior familiarity with the relevant application: 70.1% of participants reported having used WAZE before, and 43.2% reported having used BOOKING before. The difference was significant, $t(149) = 3.44$, $p < .001$, Cohen's $d = 0.56$, mean difference = 26.9, 95% CI = 11.4–42.3. In addition, there were negative correlations between age and prior familiarity with applications: WAZE, $r = -.29$, $p = .01$; BOOKING, $r = -.48$, $p < .001$. However, the difference between the two correlations was not significant, $Z = 1.36$, $p = .17$.

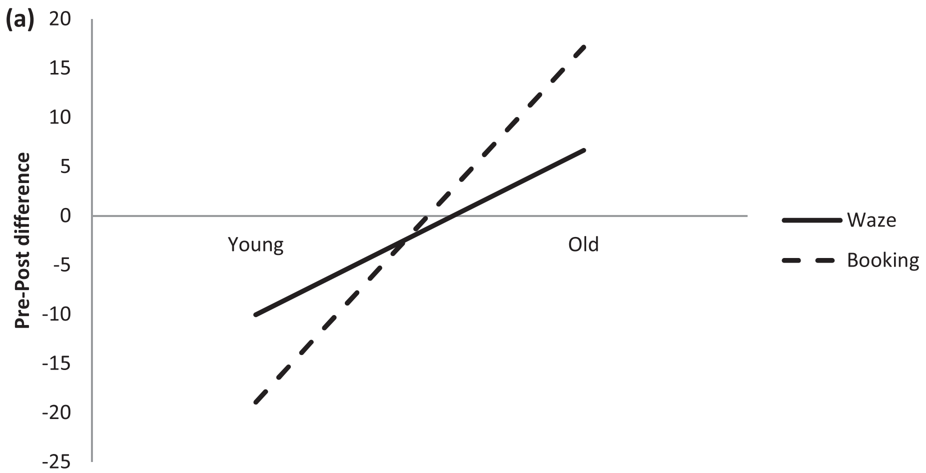
Results

An analysis of participants' report of task success showed moderate satisfaction with performance, which was similar across tasks, WAZE: mean = 65.47, $SD = 24.09$; BOOKING: mean = 59.66, $SD = 21.82$, $t(149) = 1.55$, $p = .12$. The older the participant was, the less was the overall feeling of success, $r = -.56$, $p < .001$. However, there was no significant difference between these correlations as computed for each application, $Z = -0.72$, $p = .47$. In addition, the older the participant was, the longer it took to complete the task, $r = .54$, $p < .001$. This correlation was similar across both applications, $Z = -0.24$, $p = .81$.

To examine our first hypothesis that using technological applications will increase older people's reported subjective age, we compared subjective age to chronological age and looked at the differences between subjective age before and after the manipulation. The average chronological age was 46.04 ($SD = 19.49$). At baseline, there was no significant difference between chronological age and subjective age as measured by line marking (mean = 48.74, $SD = 22.42$), $t(150) = 1.70$, $p = .09$, Cohen's $d = 0.11$, mean difference = 2.70, 95% CI = −5.85 to 0.45. In contrast, when asked to give numeric responses, participants reported younger subjective age at baseline (mean = 39.72, $SD = 20.39$) relative to their chronological age, $t(150) = 6.38$, $p < .001$, Cohen's $d = 0.21$, mean difference = 6.32, 95% CI = 4.36–12.18. To better understand these trends, we also looked at the 50 youngest participants in the sample (mean age = 24.96, $SD = 4.24$) and the 50 oldest participants in the sample (mean age = 70.18, $SD = 6.42$). These analyses showed that at baseline, the youngest adults reported older subjective age than their actual age, as examined by line marking (mean = 34.11, $SD = 17.56$), $t(49) = 3.78$, $p < .001$, Cohen's $d = 0.54$, mean difference = 9.15, 95% CI = 4.28–14.01. However, their numeric responses for subjective age (mean = 23.27, $SD = 8.38$) did not differ significantly from their chronological age, $t(49) = 1.72$, $p = .09$, Cohen's $d = 0.25$, mean difference = 1.69, 95% CI = −0.29 to 3.68. In contrast, at baseline, the 50 oldest participants felt younger than their chronological age regardless of assessment method: line marking (mean = 65.48, $SD = 16.31$), $t(49) = 2.09$, $p = .04$, Cohen's $d = 0.30$, mean difference = 4.70, 95% CI = 0.19–9.21; numeric responses (mean = 62.27, $SD = 12.64$), $t(49) = 4.00$, $p < .001$, Cohen's $d = 0.57$, mean difference = 7.91, 95% CI = 3.95–11.87.

To examine our second hypothesis that that less familiar technology will have greater influence on subjective age than the more familiar application, we looked at the effect of chronological age together with the effect of application type by running two separate hierarchical linear regressions, one for line marking and one for numeric responses. In each regression we first entered the application condition (a dummy variable) as a predictor, then entered chronological age (a continuous variable), and then entered their interaction. The difference between subjective age before and after the manipulation was the dependent variable. These analyses showed that there was no significant main effect of application. The older the chronological age of the participant was, the greater was the difference between subjective age before and after the manipulation (see Table 2). Predicting subjective age as reported by line marking, chronological age accounted for 28% of the variance. Predicting subjective age as reported with numeric response, chronological age explained 19% of the variance. There was also a significant interaction between manipulation type and chronological age, so that the pre-post difference was larger for the less familiar application only for the oldest participants (see Figure 1). The interaction added 4% to the explained variance in predicting subjective age as measured by line marking, F_{change} (1, 147) = 8.11, $p = .005$, and 5% in predicting subjective age as measured by numeric response, F_{change} (1, 147) = 10.49, $p = .001$.

We used the Johnson-Neyman technique (Johnson & Neyman, 1936) to detect the objective age in which the effect of application familiarity on subjective age became significant. For line marking we found that the interaction became significant below age 24 and above age 61. For numeric responses the interaction became significant below age 23 and above age 54. Thus, the difference between the applications was most noticeable in the youngest and the oldest participants, although the direction of the difference was opposite in each age bracket.



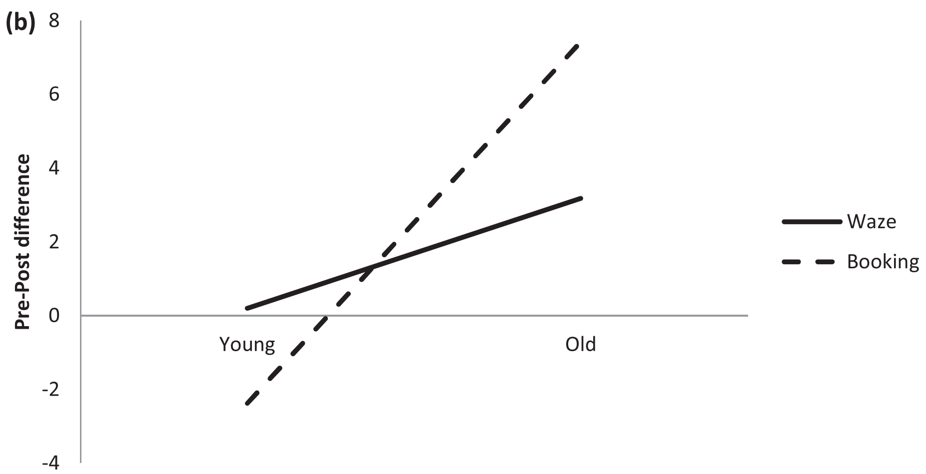


Figure 1. Interaction between manipulation type and chronological age. Panel A – Line marking, Panel B – Numeric response. Young = mean age −1 *SD*; Old = mean age +1 *SD*. The Y-axis presents differences in years between pre-manipulation and post-manipulation reports of subjective age.

Table 3. Means (and *SD*) of subjective age for the 50 youngest and 50 oldest participants, by method of report and manipulation type.

		50 Youngest participants		50 Oldest participants	
		WAZE (*N* = 24)	BOOKING (*N* = 26)	WAZE (*N* = 25)	BOOKING (*N* = 25)
Chronological age		23.91 (4.63)	25.92 (3.69)	69.40 (5.10)	70.96 (7.54)
Pre manipulation subjective age	Line Marking	31.40 (16.07)	36.61 (18.79)	67.99 (14.63)	62.97 (17.76)
	Numeric response	20.31 (7.27)	26.00 (8.53)	63.53 (9.37)	61.01 (15.33)
Post manipulation subjective age	Line Marking	23.13 (10.23)	21.14 (11.32)	80.52 (12.85)	87.80 (13.28)
	Numeric response	20.88 (6.95)	24.11 (8.60)	67.52 (5.60)	70.16 (12.42)

We note that using the implicit line marking, the oldest participants felt on average older not only relative to their pre-manipulation subjective age reports, but also relative to their chronological age. When asked to report explicit numeric measures, the reported age after the manipulation was higher than the reported age prior to the manipulation but it did not differ significantly from chronological age. The youngest participants felt slightly but significantly younger than their chronological age after the manipulations, regardless of assessment method (see Table 3).

Last, we ran the same regressions reported above with subjective health, life satisfaction, self-assessment of cognitive ability, technology use, prior application use, and attitude toward technology as covariates. All variables correlated significantly with chronological age as well as with the pre-post-manipulation difference in subjective age (see Table 4). Adding the covariates did not change the results reported above. Controlling for time to complete the task did not change the results as well.

Discussion

Our study shows that older people who used technology, especially unfamiliar technology, felt older than they did before using the technology. This effect remained significant after controlling for subjective health, life satisfaction, perception of cognitive ability, degree of technology use, attitudes toward technology, or time to complete the task. Previous studies of subjective age in older individuals show that maintaining a youthful age identity is beneficial to psychological as well as to physical health (Kotter-Grühn et al., 2015), most likely because it reflects a greater sense of mastery (Infurna, Gerstorf, Robertson, Berg, & Zarit, 2010). The current findings reveal the *negative* influence of exposure to technology on subjective age. These results fit

Table 4. Correlations between chronological age, pre-post difference in subjective age, and background measures.

	Chronological age	Δ Line marking	Δ Numeric responses	Subjective health	Life satisfaction	Cognitive ability	Technology use	Attitudes toward technology
Δ Line marking	.533**							
Δ Numeric responses	.442**	.385**						
Subjective health	−.639**	−.417**	−.242**					
Life satisfaction	−.322**	−.152	−.022	.418**				
Cognitive ability	−.332**	−.291**	−.238**	.255**	.305**			
Technology use	−.614**	−.388**	−.232**	.423**	.335**	.172*		
Attitudes toward technology	−.544**	−.283**	−.307**	.384**	.343**	.256**	.423**	
Prior application use	−.385**	−.211*	−.224*	.156*	.276**	−.032	.519**	.189*

Note. $^{*}p < .05$; $^{**}p < .001$.

well with previous non-experimental reports of the effect of exposure to age stereotypes on subjective age (e.g., Hughes & Lachman, 2016; Stephan et al., 2015). Earlier studies have shown that phenomenological cues of aging (e.g., birthday cards, Ellis & Morrison, 2005, or computer emoticons, Eibach et al., 2010) may affect older adults' susceptibility to ageist stereotypes. In the present study we show that exposure to technology, especially new technology, changes older adults' reports of subjective age, possibly by evoking stereotype threat. This threat could reflect participants' belief that there is a generation gap in the approach to technology.

Although the generational digital divide is slowly diminishing, older adults are still more reluctant to adopt new technologies, and they use them far less often than do younger people (Anderson & Perrin, 2017; Friemel, 2016; Yu, Ellison, McCammon, & Langa, 2016). We suggest that associating technology with young age evokes threatening feelings among older adults that make them feel older, most likely due to decreased sense of mastery. It is also possible that older adults embrace stereotypical thinking about their technological ability. Hence, older adults might be reluctant to adopt and use technology not only because they are slow learners (Posthuma & Campion, 2009), but also because technology makes them feel old and incompetent. It is possible that in the future older people who are using technology now will no longer be threatened by it. Yet, it is also possible that there is an inherent link between technology, innovation, novelty, and younger age. If this is indeed the case, the stereotype threat will not vanish in the near future.

A competitive or perhaps a complimentary mechanism that might account for our results is the fact that older participants might have felt more tired after the manipulation than did younger adults, possibly because of the mental workload associated with technology use (e.g., Czaja & Sharit, 1993). We note though that the tasks were short and all participants completed them successfully. In addition, had fatigue led to the report of older subjective age, it would have affected individuals in both conditions equally, unlike the results we got. Another possibility is that instead of technology use per se, it was the fact that older adults took more time to complete the tasks that led to our results. However, each participant completed the experiment alone, with no reference to performance of other participants, and no information regarding the average time required to complete the task. Thus, this alternative explanation is rather unlikely.

We note that the assessments of subjective age differed by way of measurement. The implicit measure (line marking) revealed stronger effects than did the explicit measure (numeric response). However, both show that older people feel older after using technology, especially if that technology is unfamiliar. Implicit measures are less susceptible to methodological biases, such as recalling the pre-manipulation subjective age report. On the other hand, the implicit method might be less clear to participants, given that an ambiguous metric is used. Nevertheless, the results of both measurements provide converging evidence that subjective age is affected by technology use.

Research on subjective age has shown that older adults often feel younger than their actual age, yet once threatened by age-related stereotypes their subjective age might increase (e.g., Hughes et al., 2013). While previous studies of stereotype threat have manipulated well-known age-related difficulties (e.g., memory deterioration, vision acuity), the tasks used in the current study did not explicitly relate to any disadvantages associated with age. We found that even when participants used relatively common technology on an easy-to-use device (a touchscreen tablet with a large virtual keyboard), they still felt older afterward. These results have far-reaching implications for the development and marketing of new technology for the older population. As long as developers market new technologies to the young, it is difficult to see how the stereotype threat will diminish.

Disclosure statement

No potential conflict of interest was reported by the authors.

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