



Print exposure across the reading life span

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Abstract

Leisure reading is a main contributor to print exposure, which is in turn related to individual differences in reading and language skills. The Author Recognition Test (ART) is a brief and objective measure of print exposure that has been used in reading research since the 1990s. Life span studies have reported contradicting results concerning age differences in print exposure, possibly due to the use of ART versions that differed regarding authors' mean publication year. We investigated effects of participant age and authors' mean publication year, literary level, and circulation frequency on author recognition probability between adolescence and old age ($N = 339$; age 13–77 years). An explanatory item response analysis showed that participant age and circulation frequency were positively related to recognition probability. Mean publication year was negatively related to recognition probability, indicating that recent authors who have been widely read for only a few years were less often recognized than classic authors who have been widely read for several decades. The relation between participant age and recognition probability was moderated by author variables. For classic authors, the recognition probability increased between adolescence and old age. By contrast, for recent authors, the recognition probability increased only between adolescence and middle age. Our results suggest that the mean publication year is a key author variable for the detection of print exposure differences between young, middle-aged and older adults. We discuss implications for author selection when updating the ART and for measuring print exposure in age-diverse samples.

Keywords Author Recognition Test · Explanatory item response analysis · Life span · Print exposure · Reading

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Introduction

According to meta-analyses, print exposure is positively related to the language and reading skills of children, adolescents, and young adults (Mol & Bus, 2011). The frequency of leisure reading is an important source of differences in print exposure. To assess relative differences in the amount of leisure reading, print exposure checklists with author names or book titles are often used. Print exposure checklists only take a few minutes to administrate. They contain foil items that control for social desirability in participant responses. Age-specific print exposure checklists have been developed for preschool children (e.g., Grolig, Cohrdes, & Schroeder, 2017), school children (e.g., Schroeder, Segbers, & Schröter, 2016) and college students (e.g., Stanovich & West, 1989). By contrast, little is known about leisure reading between middle adulthood and old age, and how it affects reading development. Moreover, studies have reported heterogeneous results regarding differences in exposure to written texts between young and older adults. The first aim of this study is therefore to investigate how print exposure accumulates across the reading life span.

Most studies investigating print exposure in adults use the Author Recognition Test (ART; Stanovich & West, 1989). In the ART, real authors have to be discriminated from fake authors. The ART has been used in many research fields, including reading and language research (e.g., Mol & Bus, 2011) and social cognition research (e.g., Mumper & Gerrig, 2017). To date, author names have been selected as author items for the ART based on how widely they are read (e.g., bestseller lists; Acheson, Wells, & MacDonald, 2008; Stanovich & West, 1989). In addition to the bestseller criterion, we propose that author item properties can be used for a further standardization of the item selection. Authors differ with regard to their works' mean publication year (i.e., the averaged publication year of the first and last published work of an author), literary level (highbrow vs. popular literature authors), and circulation frequency (e.g., how often they are borrowed from public libraries). The second aim of this study is to investigate how these author variables are related to author recognition probability and whether they moderate age trends in the ART.

Leisure reading across the life span: Cognitive correlates and contradicting evidence

Early engagement in intellectual activities, such as leisure reading, builds long-lasting habits and a densely-knitted neural network, which both protect cognitive functionality in old age (Stern, 2009). In young and older adults, leisure reading is related to crystallized abilities, such as cultural knowledge and vocabulary, but it is not related to fluid abilities, such as reasoning and working memory (Stanovich, West & Harris, 1995). In the course of adulthood, working memory performance peaks between 20 and 30 and begins to decline between 30 and 40, whereas performance in vocabulary peaks much later, between 50 and 70 (Hartshorne & Germine, 2015). Frequent leisure reading serves as a buffer against the negative consequences of working memory declines, facilitating word and sentence processing (Lowder &

Gordon, 2017; Payne, Gao, Noh, Anderson, & Stine-Morrow, 2012), and thus sustaining high levels of reading comprehension in older adults. In addition, higher levels of literacy in late-life are associated with a later decline in cognitive functioning, even after controlling for early-life education (Sisco et al., 2013). Taken together, these studies indicate that leisure reading has positive effects on crystallized abilities and protects cognitive functioning in later life.

The extant evidence is inconclusive regarding the increase of print exposure between adolescence and old age. Two studies reported significant differences in the ART between young and older adults (Choi, Lowder, Ferreira, Swaab, & Henderson, 2017; Liu et al., 2016) and one study with 18- to 81-year-olds reported a large correlation between age and print exposure (Payne et al., 2014). By contrast, another study reported no print exposure differences between young and older adults (Stanovich et al., 1995), and a life span study with 18- to 65-year-olds reported a very small correlation between age and print exposure (West, Stanovich, & Mitchell, 1993). In sum, previous studies investigating print exposure between adolescence and old age have yielded conflicting results. The first aim of this study is therefore to explore differences in print exposure between adolescence and late adulthood.

Age effects in the ART and properties of author items

Diverging age effects are possibly due to the use of varying versions of the ART with different author items. How widely authors are read can change substantially within a few years, which also has consequences for their recognition rate in the ART. For example, changes in the author frequency in print and online media corpora are related to changes in the author item difficulty (Moore & Gordon, 2015). Studies by Stanovich and colleagues from the 1990s used the original ART (Stanovich & West, 1989), whereas more recent studies have used an updated version (Acheson et al., 2008). In the updated version, author items with recognition rates at floor or ceiling were removed and replaced by other author items which were assumed to provide more information on individual differences in print exposure. From the original ART, only 15 authors were retained and 50 authors were added (Acheson et al., 2008). Among these 65 authors, more than half are authors who have been read for several decades (e.g., F. Scott Fitzgerald, T.S. Eliot, and Virginia Woolf). We therefore refer to such authors as ‘classic authors’ as opposed to ‘recent authors’ who have been read for only a few years. This replacement of recent authors from the 1980s by classic authors could have influenced author recognition probability and resulted in the observed differential age effects in the ART.

More specifically, we propose that the author recognition probability varies as a function both of the mean publication year of an author’s books and participant age. First, the longer the works of an author are available to the public, the more likely it is that readers discover the author. The mean publication year of an author’s works reflects the time point when they became available to the public. Second, studies show that the amount of cultural activities and openness to new experiences decreases between middle adulthood and old age (Schwaba, Luhmann, Denissen, Chung, & Bleidorn, 2018), suggesting that older adults seek

less exposure to recent authors than young adults do. Moreover, experiences from adolescence and young adulthood are especially well retained in memory by adults, presumably due to cognitive changes and identity formation during these years (Rubin, Rahhal, & Poon, 1998). For these reasons, the mean publication year effect should be more pronounced in older readers than in younger readers.

In addition to the mean publication year, the literary level and the circulation frequency of authors' works are two variables that could also be differentially related to author recognition probability in age-diverse samples. With respect to literary level, most authors are primarily perceived either as creators of art (called highbrow literature) or as creators of literary entertainment, with less emphasis on the artistic value (called popular literature; see Kidd & Castano, 2017, for a discussion of this differentiation). In a study with young adults, the author recognition rate was similar for highbrow and popular literature authors (Kidd & Castano, 2017). The ART in the present study includes the same number of highbrow and popular literature authors which allows the investigation of the relation between literary level and author recognition probability across the reading life span. Regarding circulation frequency, a study with college students found that the number of author name occurrences in linguistic corpora was related to author recognition probability (Moore & Gordon, 2015). Thus, authors who appeared more often in texts were more likely to be recognized in the ART. To investigate the relation between the dissemination rate of authors' works and author recognition probability across the reading life span, we use loan statistics from the largest public library system in Germany as a measure of circulation frequency. In sum, the second aim of this study is to investigate how author mean publication year, literary level, and circulation frequency are related to author recognition probability, and whether this relation changes between adolescence and old age.

The present study

This study investigates differences in print exposure between adolescence and old age. Our first aim is to clarify the relation between age and print exposure across the reading life span. Our second aim is to investigate how author variables are related to author recognition probability, and whether they moderate the effect of age on author recognition probability. To our knowledge, no previous study has investigated the effect of the author mean publication year on author recognition probability. In addition to the focal author variable mean publication year, we also include the literary level (highbrow vs. popular literature) and the book circulation frequency as potential moderator variables of author recognition probability. Only two studies with undergraduate samples have investigated how item difficulty is related to author frequency in corpora (Moore & Gordon, 2015) and literary level (Kidd & Castano, 2017). The overarching goal of this study is to clarify how print exposure increases between adolescence and old age and whether exposure to specific kinds of literature increases differently across the reading life span.

Method

Participants and procedure

Data were collected in two contexts. We administered the ART in four small-scale, cross-sectional psycholinguistic studies to a total of 108 participants between summer 2016 and spring 2017. Seventy-eight participants were university students (50 female) and 30 participants were senior citizens (15 female). The age of the university students ranged between 18 and 34 years ($M_{\text{age}} = 25$ years, $SD_{\text{age}} = 3.7$ years). The age of the senior citizens ranged between 65 and 74 years ($M_{\text{age}} = 69.3$ years, $SD_{\text{age}} = 3$ years). All senior citizens had at least completed high school (6 high school degree, 3 undergraduate degree, 19 master's degree, and 2 doctoral degree). All participants were native speakers of German, had normal or corrected-to-normal vision, and reported no hearing, reading, or language difficulties. Written consent was obtained from all participants. They received monetary reimbursement for their participation.

In addition, 252 participants completed the ART during the Frankfurt book fair in 2016, which is a large consumer show that is visited by school classes, families, and senior citizens. Participants were asked to test their knowledge by completing a literary quiz. Subjects were eligible to participate in a lottery of ten book vouchers (10€ each). They were informed that they were taking part in a scientific study and that their responses to the literary quiz and their demographic information would be used for analyses. Participants were asked to mark author names that they recognized, and informed that guessing was easily detectable due to the inclusion of made-up author names. Twenty-one participants (8.3%) were excluded because they did not indicate their age or were not yet adolescents. Among the 231 participants (164 female) included in the final sample, age ranged between 13 and 77 years ($M_{\text{age}} = 33.6$ years, $SD_{\text{age}} = 15.8$ years). The sample included 43 adolescents (13 to 17 years old, $M_{\text{age}} = 15.6$ years, $SD_{\text{age}} = 1.3$ years), 92 young adults (18 to 35 years old, $M_{\text{age}} = 24.2$ years, $SD_{\text{age}} = 4.9$ years), 59 middle-aged adults (37 to 50 years old, $M_{\text{age}} = 45.3$ years, $SD_{\text{age}} = 3.9$ years), and 37 older adults (51 to 77 years old, $M_{\text{age}} = 58.1$ years, $SD_{\text{age}} = 7.1$ years).

Average ART scores were not affected by administration context (see Appendix 1). The data from the psycholinguistic studies and the book fair were therefore pooled for all analyses, resulting in a sample size of 339 participants. Overall, participant age ranged from 13 to 77 years (68% female). Table 1 summarizes age and gender characteristics of the sample.

Author Recognition Test

Each of the two parallel test forms of the German ART consists of 50 author items and 25 foil items (see Appendix 1 for test description and equivalence tests between test forms). Appendix 2 summarizes three properties of the author items,

Table 1 Corrected hit rates for groups in the Author Recognition Test (ART)

	Age group				Gender	
	Adolescents	Young adults	Middle-aged adults	Older adults	Female	Male
<i>N</i>	43	170	59	67	229	110
Age range	13–17	18–35	36–50	51–77	13–77	13–74
<i>M</i> years	15.7	24.4	45.3	63.2	34.6	34.7
(<i>SD</i>)	(1.3)	(4.4)	(3.9)	(7.9)	(16.9)	(17.4)
<i>M</i> ART	.24	.42	.65	.59	.49	.43
(<i>SD</i>)	(.15)	(.20)	(.25)	(.20)	(.23)	(.26)

Female and male participants are equally distributed across age groups, $\chi^2(3, N = 339) = 1.00$

which are described in the following (see Appendix 3 for information on foil items).

Mean publication year

We added the publication year of the first and the last work of an author as shown by the Catalogue of the German National Library and divided the result by two. Mean publication years ranged from 1792 to 2013 ($M = 1990$, $SD = 35$).

Literary level

The ART includes 37 popular literature authors (49.3%; e.g. thriller, crime, history, fantasy, romance, entertainment) and 38 highbrow authors (50.7%) as determined in a rating procedure. The first and third author of this study independently rated each author as predominantly highbrow or popular literature author. We calculated the interrater reliability and found a high agreement (97.3%; Cohen's $\kappa = .95$). Discrepancies were resolved by discussion.

Circulation frequency

We calculated how often the works of each author were borrowed from the largest German public library system between the years 2001 and 2015 (M. Seitenbacher on behalf of the Berlin public library, personal communication, December 6, 2015). The circulation frequency varied considerably ($M = 1884$, $SD = 2054$; range 79–12,697).

Statistical analyses

We adopted an explanatory item response analysis approach (De Boeck & Wilson, 2004). We analyzed participants' item responses as a function of age and author variables by using generalized linear mixed-effects models with a binomial distribution (*lme4* package by Bates, Maechler, Bolker, & Walker, 2015; De Boeck et al.,

2011). To reduce nonessential multicollinearity, we centered each continuous predictor variable. Log-transformed circulation frequency data were used in the analyses. To investigate linear and non-linear relations between age and print exposure, we included linear and quadratic effects of age in the model (Cohen, Cohen, West, & Aiken, 2003). As a measure of model fit, we calculated the variance explained by fixed effects (marginal R^2) and the variance explained by fixed and random effects (conditional R^2 ; Nakagawa, Johnson, & Schielzeth, 2017).

Results

Descriptive statistics

On average, participants recognized 24.36 authors ($SD=11.96$; range 0–50). We calculated a corrected hit rate by subtracting the proportion of selected foils from the proportion of selected authors (see Table 1). Appendix 2 summarizes the hit rate for each author. The mean number of selected foils was 0.45 ($SD=1.14$; range 0–12). Appendix 3 summarizes the false alarm rate of each foil item.

Explanatory item response analysis

A generalized linear mixed-effects model with participant age and the author variables of mean publication year, literary level, and circulation frequency as fixed effects was fitted. The model also included interactions between age and author variables as fixed effects. The continuous variables age, mean publication year, and circulation frequency were centered. The categorical variable literary level was effect-coded. The model included random intercepts for participants and items.

Overall effects were tested by using contrast coding and the Anova function of the *car* package (Type 3 model comparison; Fox & Weisberg, 2011). For post hoc comparisons, we applied the *glht* function of the *multcomp* package (Hothorn, Bretz, & Westfall, 2008) by using cell means coding and single *df* contrasts. We chose the age points 15, 25, 45, and 65 for comparisons as these correspond to our samples' mean ages of adolescents, young adults, middle-aged adults, and older adults, respectively (see Table 1). We also included a point of comparison at 75 for the oldest participants in our sample. Table 2 summarizes the effects of the model.

Main effects

The model showed a significant main effect of age, which we investigated by comparing the mean recognition probability between age points (see Fig. 1). Post hoc comparisons showed a significant increase of recognition probability from age 15 to age 25 ($t=8.83$, $p<.001$) and from age 25 to age 45 ($t=11.73$, $p<.001$). The main effect of age on recognition probability did not increase between the ages 45 and 65 ($t=0.53$, $p=.60$), and there was a slight drop between ages 65 and 75, $t=2.50$,

Table 2 Mixed-effects model of author recognition with age, author variables, and their interactions as fixed effects and participants and items as random intercepts

	<i>df</i>	χ^2	<i>p</i>
<i>Fixed effects</i>			
Intercept	1	7.78	< .01
<i>Main effects</i>			
Age	2	152.87	< .001
Mean publication year	1	22.28	< .001
Literary level	1	1.41	.23
Circulation frequency	1	5.29	.02
<i>Interactions</i>			
Age × mean publication year	2	25.32	< .001
Age × literary level	2	81.07	< .001
Age × circulation frequency	2	55.74	< .001
<i>Random effects</i>			
Participants	1	3057.60	< .001
Items	1	3242.20	< .001
Marginal R^2		.25	
Conditional R^2		.66	

Tests are based on Type III sum of squares and χ^2 values with Kenward–Roger *df*

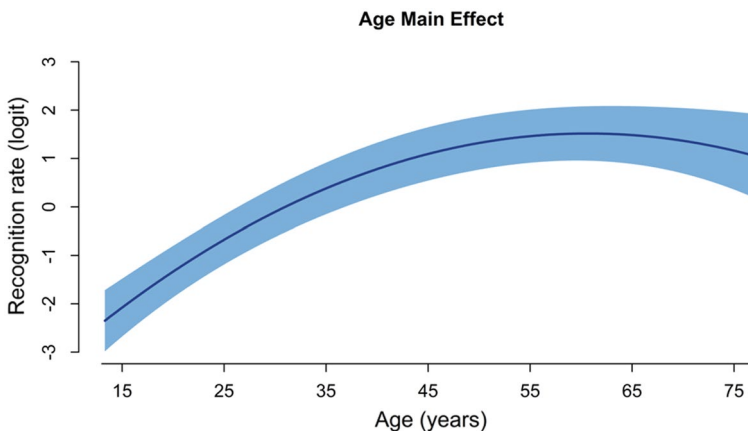


Fig. 1 Mean probability of author recognition as a function of subject age with 95% confidence intervals

$p = .01$. Overall, the recognition probability increased with age until age 45, where it reached a plateau that slightly dropped off after age 65.

There was a significant main effect of mean publication year ($t = -4.61$, $p < .001$), indicating that recognition probability decreased with increasing mean publication year. Additionally, there was a significant main effect of circulation frequency ($t = 2.30$, $p = .02$), indicating that recognition probability increased with increasing circulation frequency. The main effect of literary level was not significant, $t = -1.19$, $p = .23$.

Interactions

There were significant interaction effects between age and mean publication year, age and literary level, and age and circulation frequency (see Figs. 2a–c). To investigate these interactions, we tested the significance of the author variables at each age point (ages 15, 25, 45, 65, and 75). If contrasts indicated that the author variable effect was significant at more than one age point (e.g., at age 15 and at age 25), then we tested whether the author variable effect changed between ascending age points (e.g., author variable effect at age 15 vs. effect at age 25) to compare the progression of the interaction effects.

Age × mean publication year We compared the recognition probabilities for the mean publication years 1965 versus 2015. Post hoc comparisons showed that the recognition probability was different between 1965 and 2015 at ages 15, 25, 45, 65, and 75 all $t_s > 3.03$, all $p_s < .01$. At all age points, classic authors (mean publication year 1965) were more likely to be recognized than recent authors (mean publication year 2015). Further post hoc comparisons showed that this effect did not increase between ages 15 and 25 ($t = 1.60$, $p = .11$), but between ages 25 and 45 ($t = 2.57$, $p = .01$), between ages 45 and 65 ($t = 4.88$, $p < .001$), and between ages 65 and 75, $t = 4.50$, $p < .001$. Inspection of Fig. 2a suggests an overall steeper increase of recognition probability for 1965 versus 2015. Post hoc comparisons confirmed this: The recognition probability for 1965 increased between ages 15 and 25, 25 and 45, and 45 and 65, all $t_s > 2.51$, all $p_s < .05$. The increase between ages 65 and 75, however, was not significant, $t = 0.46$, $p = .65$. For 2015, the recognition probability only increased between ages 15 and 25 ($t = 8.98$, $p < .001$) and ages 25 and 45 ($t = 10.33$, $p < .001$), but not between ages 45 and 65, $t = -1.84$, $p = .07$. Between ages 65 and 75, the recognition probability for 2015 decreased significantly, $t = -4.37$, $p < .001$.

Age × literary level We compared the recognition probabilities for popular versus highbrow literature authors at ages 15, 25, 45, 65, and 75. Post hoc contrasts indicated that the recognition probability of highbrow versus popular literature authors differed at age 15 ($t = 3.00$, $p < .01$) and at age 25 ($t = 2.36$, $p = .02$). In contrast, the difference was not significant at age 45 ($t = 1.11$, $p = .27$), at age 65 ($t = 0.09$, $p = .93$), and at age 75, $t = -0.32$, $p = .75$. The interaction is shown in Fig. 2b. From age 15 to age 25, readers recognize popular literature authors with a higher probability than highbrow literature authors. Between middle age and old age, recognition probability is apparently not related to literary level.

Age × circulation frequency We compared the recognition probabilities of authors with higher circulation frequency (+1 *SD*) versus lower circulation frequency (−1 *SD*) at ages 15, 25, 45, 65, and 75. Post hoc contrasts indicated that the recognition probability differences were not significant at age 15 ($t = 0.51$, $p = .61$) and at age 25, $t = 0.98$, $p = .33$. By contrast, the recognition probability difference was significant at age 45, $t = 2.37$, $p = .02$. Again, the recognition probability difference was not significant at age 65 ($t = 1.67$, $p = .10$) and at age 75, $t = 0.53$, $p = .59$. Thus, there was a significant recognition probability difference only for middle-aged readers, who were more likely to recognize authors with a higher circulation frequency than authors with a lower circulation frequency (see Fig. 2c). In contrast, recognition probability was not related to circulation frequency for adolescents, young adults, and older adults.

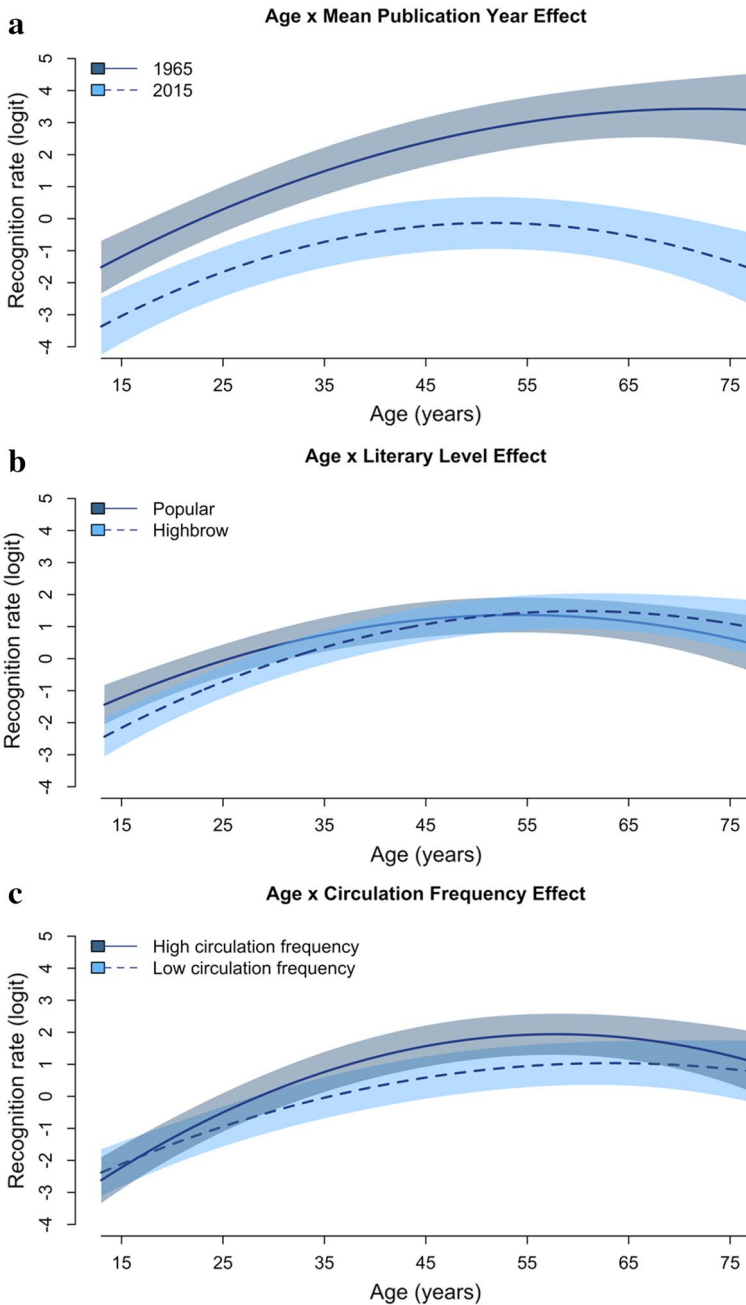


Fig. 2 Mean author recognition rate as a function of mean publication year and subject age (a), as a function of literary level and subject age (b), and as a function of book circulation frequency and subject age (c) with 95% confidence intervals

In sum, our analyses indicate that (a) there is a positive, curvilinear relation between age and print exposure, and that this curve reaches a plateau around age 45 which slightly drops off again after age 65, (b) authors' mean publication year is negatively related to author recognition probability, with classic authors more likely to be recognized than recent authors, and (c) that age moderates the effects of mean publication year, literary level, and circulation frequency. Regarding interaction effects, the effect of mean publication year increased between ages 25 and 75. In contrast, the effect of literary level was only significant at ages 15 and 25, and the effect of circulation frequency was only significant at age 45. Taken together, our results suggest that item effects vary between adolescence and old age. The mean publication year effect is comparatively small for adolescents and young adults but increases significantly between ages 25 and 75.

Discussion

The present study investigated print exposure differences in a sample of 13- to 77-year-old readers. Our study extends previous research investigating age differences in author recognition probability (Stanovich et al., 1995) by analyzing how the relation between age and author recognition probability is moderated by author variables. We found a positive, curvilinear relation between age and print exposure and that the curve plateaus between age 45 and age 65, after which it slightly drops off. In addition, author recognition probability was negatively related to mean publication year and positively related to circulation frequency. Importantly, the relation between age and print exposure was moderated by mean publication year, literary level, and circulation frequency.

Print exposure in life span studies: The key role of authors' mean publication year

Overall, print exposure increased between adolescence and old age, which is in line with the results of three previous studies (Choi et al., 2017; Liu et al., 2016; Payne et al., 2014). This result contrasts with two studies that did not find age differences in print exposure between young and older adults (Stanovich et al., 1995; West et al., 1993). Contrary to the assumption that print exposure accumulates throughout adulthood (Stanovich et al., 1995), we found a slight decline of the recognition probability curve between age 65 and age 75. This drop-off, however, was driven by older adults' lower recognition rates for recent authors (see Fig. 2a). Our results suggest that older adults prefer to read classic authors and are less familiar with recent authors.

More importantly, we did not find an increase of print exposure between middle adulthood and old age (see Fig. 1), which can be explained by the interaction between age and mean publication year. In particular, between adolescence and old age, the recognition probability for classic authors was higher than the recognition probability for recent authors (see Fig. 2a). The likelihood of recognizing classic authors increased between adolescence and old age, but the likelihood of recognizing recent authors only increased between adolescence and middle age. This differential trajectory could be related to decreases in the amount of cultural activities and openness to

new experiences between middle adulthood and old age (Schwaba et al., 2018). In line with this interpretation, a life span study has found that less openness to new experiences is related to a lower reading frequency (Kraaykamp & van Eijck, 2005). Another explanation for this pattern of results is that the years between adolescence and middle adulthood are formative regarding cognitive and cultural identity development, resulting in a heightened memory for experiences from this life phase (Rubin et al., 1998).

The shape of the interaction between mean publication year and age explains why studies from the 1990s did not find print exposure differences between age groups whereas more recent studies consistently report a positive correlation between print exposure and participant age. In the present study, the recognition probability curve for the mean publication year 1965 is based on classic authors. This curve increases between adolescence and old age. Similarly, studies that used an updated ART version with a large proportion of classic authors (Acheson et al., 2008) also reported positive correlations between age and print exposure. By contrast, the recognition probability curve for the mean publication year 2015 is based on recent authors. This curve increases between adolescence and middle adulthood, and then decreases slightly. Similarly, studies that used the original ART with a large proportion of recent authors (Stanovich & West, 1989) did not report print exposure differences between young and older adults.

Implications, limitations, and conclusion

Our results imply, first, that author variables should be used for the item selection in the ART because they are related to author recognition probability even after controlling for age effects. The differential mean publication year effect increased between ages 25 and 75, which explains previous contradicting results regarding the relation between age and print exposure. Revisions of the ART should report author variables and test the equivalence of measurement properties. In the long term, this will lead to a better comparability of ART versions and a better replicability of results across time and cultures.

Second, the interaction between participant age and mean publication year implies that there is a connection between the mean publication year of author items and the reading experience they measure. Selecting more authors with a high mean publication year optimizes the estimation of recent reading experiences between adolescence and middle adulthood. At the same time, such a focus on recent authors could result in an underestimation of older adults' print exposure because they are presumably less likely to read books from recent authors. On the other hand, selecting more authors with a low mean publication year might result in an underestimation of young and middle-aged adults' recent reading experiences. As a solution to this predicament, life span studies could use comprehensive recognition checklists with authors from the last three or four decades. ARTs that are tailored to participants' reading preferences explain additional variance in outcome measures over and above ARTs that are not adapted to their reading preferences (Mar & Rain, 2015; Martin-Chang, Kozak, & Rossi, 2019; Spear-Swerling, Brucker, & Alfano, 2010). An ART version for life span studies could be constructed by selecting and combining author items from previous ART versions (Acheson et al., 2008; Moore & Gordon, 2015; Stanovich & West, 1989). Including the mean publication year as

a continuous variable in moderation analyses would allow an investigation of current versus earlier reading experiences on cognitive outcome measures.

A third implication of our results is that, between middle age and old age, readers are less likely to gain new vocabulary and cultural knowledge from reading recent authors than adolescents and young adults. This should be taken into account when assessing crystallized abilities. For life span studies, vocabulary test items could be selected on the basis of the word frequency in book corpora that comprise the works of ART authors from different decades. This approach would both minimize age biases and allow the investigation of word learning from book reading in different life phases.

Regarding limitations, the authors included in the original ART (Stanovich & West, 1989) were almost exclusively popular literature authors. By contrast, the ART in this study contains about 50% of highbrow literature authors, some of which are commonly read at school and college. Our results, however, show that at ages 15 and 25, readers are more likely to recognize popular literature authors than highbrow literature authors (see Fig. 2b). Popular literature is usually read during leisure time. Therefore, the estimation of students' print exposure in the present study is probably not unduly biased by in-school reading. Moreover, our results are based on cross-sectional data and we therefore cannot differentiate between age and cohort effects. Future studies with cohort-sequential designs that incorporate longitudinal data from different cohorts would be ideal to disentangle these effects. Future studies could also use print exposure scores for different decades to investigate their respective effects on reading and language skills, which would shed further light on how individual differences in these skills develop across the reading life span.

In conclusion, this study found that print exposure differed significantly between adolescence and old age. This difference depended on the authors' mean publication year, and to a smaller degree also on the literary level and circulation frequency of authors' books. The recognition probability of classic authors increased throughout adolescence and old age whereas the recognition probability of recent authors increased only between adolescence and middle adulthood. This differential effect explains why ART versions with a larger proportion of classic authors produced significant age differences in print exposure whereas ART versions with a larger proportion of recent authors did not produce age differences. Consequently, the mean publication year of an author's works, along with other author variables such as literary level and circulation frequency, should be taken into account when updating the ART.

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Appendix 1

Description of the ART

The German ART comprises 75 fiction authors with at least one bestselling book between the years 2003 and 2015 (*Spiegel* bestseller list, 2016; see Table 3 in Appendix 2). Of the 75 authors, 34 authors were originally published in another language, most of them in English. Only fiction authors were included because the recognition of fiction authors is more strongly correlated to self-reported reading time than the recognition of nonfiction authors (Acheson et al., 2008). As the test aims to measure reading during leisure time, the selected authors are mostly not part of school reading curricula in Germany. We included a few authors who are generally read in school and thus would be recognized by almost every participant (e.g., Heinrich Böll, Rainer Maria Rilke) so that participants with low print exposure would not be discouraged from completing the test. Moreover, we included both popular literature and highbrow literature authors because they are differentially related to social cognition (Mumper & Gerrig, 2017). Our selection included 37 popular literature authors (49.3%; e.g. thriller, crime, history, fantasy, romance, entertainment) and 38 highbrow literature authors (50.7%).

To control for guessing, the ART also includes 50 foil items serving as distractors (see Table 4 in Appendix 3). The ART consists of two parallel test forms (forms A and B, see Appendix 2). The 75 author items were randomly assigned to one of three item sets (set 1, 2, or 3). Form A consists of the author item sets 1 and 2; form B consists of the author item sets 1 and 3. Consequently, both test forms share 25 author items which serve as anchor items that allow the estimation of a latent print exposure variable across both test forms (Embretson & Reise, 2000). Each test form has 25 additional, unique author items. Foil items were randomly assigned to one test form. Overall, each form comprises 50 author items (25 popular literature authors, 25 highbrow literature authors) and 25 foil items.

ART parallel forms comparisons

The corrected hit rate was similar in both forms, A: $M=.46$, $SD=.24$; B: $M=.49$, $SD=.25$; $t(337)=-1.10$, $p=.27$. The false alarm rate did not differ between forms, A: $M=.02$, $SD=.05$; B: $M=.02$, $SD=.04$; $t(337)=0.37$, $p=.71$. The split half reliability of the corrected scores was similarly high for both forms (A: $r=.94$, B: $r=.95$). Our analyses indicated that the psychometric properties did not differ between forms A and B.

Comparison of ART scores between samples

The corrected hit rate was comparable for young adults in both samples, psycholinguistic studies sample: $M=.39$, $SD=.19$; book fair sample: $M=.44$, $SD=.21$, $t(168)=1.49$, $p=.14$. For older adults, the corrected hit rate was similar in both samples, psycholinguistic studies sample: $M=.54$, $SD=0.19$; book fair sample: $M=.62$, $SD=0.21$, $t(65)=1.65$, $p=.10$. As the differences were not statistically significant, data from the two samples were jointly analyzed.

Appendix 2

Table 3 Author items and item characteristics of the Author Recognition Test

Author	Literary level	Mean publica- tion year	Public library circu- lation frequency	Hit rate (%)
<i>Set 1 (Forms A and B)</i>				
Bertolt Brecht	Highbrow	1950	6419	91.0
Thomas Mann	Highbrow	1928	5709	89.5
J. R. R. Tolkien	Popular	1982	2789	88.9
Agatha Christie	Popular	1952	12,697	83.4
Ken Follett	Popular	1996	1811	82.8
Rainer Maria Rilke	Highbrow	1908	3604	81.9
Frank Schätzing	Popular	2004	1333	61.2
T. C. Boyle	Highbrow	2004	3682	61.2
Siegfried Lenz	Highbrow	1983	732	59.8
Nele Neuhaus	Popular	2010	392	58.0
Isabel Allende	Highbrow	2000	1178	56.9
Stefan Zweig	Highbrow	1942	2964	52.2
Paulo Coelho	Popular	2006	630	51.3
Nick Hornby	Popular	2005	843	48.7
Elfriede Jelinek	Highbrow	1992	4584	41.4
Haruki Murakami	Popular	2004	2962	39.4
Wolfgang Herrndorf	Highbrow	2006	79	34.4
Patricia Highsmith	Popular	1978	2620	33.2
Philip Roth	Highbrow	1986	4074	32.1
Paul Auster	Highbrow	2000	2952	29.2
Alice Munro	Highbrow	1998	1267	27.4
Jan Weiler	Popular	2010	86	26.8
Judith Hermann	Highbrow	2007	606	19.5
Rita Falk	Popular	2013	431	19.2
Wolf Haas	Popular	2005	1096	12.2
<i>Set 2 (Form A)</i>				
Theodor Fontane	Highbrow	1876	1817	90.6
Heinrich Böll	Highbrow	1976	2282	81.2
Rosamunde Pilcher	Popular	2001	266	80.3
Donna Leon	Popular	2004	1787	70.0
Stieg Larsson	Popular	2006	533	69.5
John Grisham	Popular	2004	1842	68.6
Henning Mankell	Popular	2004	2448	65.9
Nicholas Sparks	Popular	2006	676	56.5
Ingeborg Bachmann	Highbrow	1962	4193	50.2
Hakan Nesser	Popular	2006	2815	46.6
Bernhard Schlink	Highbrow	2000	1086	45.3
Hans Magnus Enzensberger	Highbrow	1986	1148	39.5

Table 3 (continued)

Author	Literary level	Mean publica- tion year	Public library circu- lation frequency	Hit rate (%)
Ingrid Noll	Highbrow	2003	811	39.0
Elizabeth George	Popular	2002	1754	37.2
Juli Zeh	Highbrow	2008	311	36.8
Ian McEwan	Highbrow	1999	2033	33.6
Rafik Schami	Highbrow	1996	927	33.2
Orhan Pamuk	Highbrow	2003	783	30.9
Diana Gabaldon	Popular	2004	810	22.9
E. L. James	Popular	2012	405	22.9
Fred Vargas	Popular	2008	2746	21.1
Iny Lorentz	Popular	2010	571	20.2
Imre Kertesz	Highbrow	2003	216	17.9
Siri Hustvedt	Highbrow	2004	951	16.6
Alex Capus	Popular	2006	570	13.0
<i>Set 3 (Form B)</i>				
Friedrich Schiller	Highbrow	1792	1783	92.5
Hermann Hesse	Highbrow	1936	9295	87.5
Charlotte Link	Popular	2000	2232	80.8
Günter Grass	Highbrow	1986	1174	79.2
Dan Brown	Popular	2008	225	75.8
Patrick Süskind	Highbrow	1994	647	75.8
John Irving	Highbrow	1998	2126	65.8
Umberto Eco	Highbrow	1993	3261	61.7
Stephenie Meyer	Popular	2011	890	60.0
Jojo Moyes	Popular	2009	82	57.5
Kerstin Gier	Popular	2006	296	49.2
Salman Rushdie	Highbrow	1999	1996	46.7
Nora Roberts	Popular	2003	3586	43.3
Arthur Schnitzler	Highbrow	1916	2212	40.0
Martin Suter	Popular	2006	95	40.0
Wladimir Kaminer	Highbrow	2008	842	38.3
Herta Müller	Highbrow	2000	1483	34.2
Michel Houellebecq	Highbrow	2007	1622	34.2
Daniel Kehlmann	Highbrow	2006	1307	33.3
Sven Regener	Popular	2007	294	27.5
Jonathan Franzen	Highbrow	2008	633	24.2
Andreas Franz	Popular	2004	1710	23.3
Ruth Rendell	Popular	1996	2700	22.5
Heinz Strunk	Popular	2010	229	19.2

Raw circulation frequencies are reported

Appendix 3

Table 4 Foil items of the Author Recognition Test

Form A		Form B	
Foil item	False alarm rate (%)	Foil item	False alarm rate (%)
Elsbeth Stern	4.9	Gregory E. Cox	5.0
Boris Egloff	4.0	Ira H. Bernstein	4.2
Gregory Francis	4.0	Michael Eid	3.3
Thomas Rammsayer	3.6	Martin Hautzinger	3.3
Rick Dale	3.6	Dale Barr	3.3
Roselind Lieb	3.1	Chris Donkin	3.3
Jürgen Margraf	2.7	Michael D. Lee	3.3
Guido Hertel	2.2	Karl Christoph Klauer	2.5
Jürgen Hoyer	2.2	Aljoscha Neubauer	2.5
Amy H. Criss	2.2	Franzis Preckel	1.7
Manfred Amelang	1.8	Oliver Wilhelm	1.7
Detlef Rost	1.8	David A. Balota	1.7
Patrick Bonin	1.8	Richard R. Plant	1.7
Lara L. Jones	1.8	Richard M. Shiffrin	1.7
Christoph Perleth	1.3	Pernille Hemmer	1.7
Brian MacWhinney	1.3	Andre Beauducel	0.8
Peter Borkenau	0.9	Elmar Brähler	0.8
Kurt Hahlweg	0.9	Eibe-Rudolf Rey	0.8
Eric-Jan Wagenmakers	0.9	Bettina Hannover	0.8
Gabriele Helga Franke	0.9	Christiane Spiel	0.8
James S. Adelman	0.4	Lutz F. Hornke	0.0
Melvin Yap	0.4	Jerome Busemeyer	0.0
Andrew M. Olney	0.0	Tal Yarkoni	0.0
Mark W. Greenlee	0.0	Mark Steyvers	0.0
Joseph Magliano	0.0	Ying Alison Cheng	0.0

Names were taken from the editorial boards of *Behavior Research Methods*, Volume 48, and *Diagnostica*, Volume 62

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