Length of residence

Does it make a difference in older bilinguals?

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Among papers considering L2 performance, a subset take into account the length of residence (LOR) in the country where the L2 is spoken. In about half of these, LOR makes no difference for performance of at least one variable measured. Since those who reside in an L2 environment for many years tend to be older, the beneficial effects of longer LOR may at some point be counteracted by declines due to aging. This article draws on research in cognitive aging to consider how age could impact L2 performance. This is particularly important when investigating the effects of LOR or age of L2 acquisition since LOR, age of acquisition, and age at testing are linearly dependent variables, making conclusions based on any of these variables problematic. We argue that aging is a largely ignored confound in the literature on L2 attainment, particularly for studies that include older adults in their samples.

Keywords: Length of residence, aging, second language performance

1. Introduction

Learning a second language to a degree that can be classified as "native-like" is less successful in adulthood than childhood. Many have asked why Arnold Schwarzenegger, previous body-building champion and governor of California, still has his accent after years in the United States (having first left Austria for England with little English at age 21, then for a more permanent stay in the U.S. the same year). Henry Kissinger himself referred to his German accent in English in 1986 at age 73, when he had been in the United States for 48 years (having arrived at age 15). https://www.youtube.com/watch?v=1fhCoqixAXI. Why have they not lost their accents after such long residence in the U.S.?

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Researchers have considered various explanations for the different levels of success attained by different L2 learners.[1] These factors include the age at which second language (L2) acquisition commenced or the age of immigration (which is considered the age at which immersion in the second language started), length of residence in the L2-speaking environment (LOR), type of input received (including learning environments), language learning aptitude, learning motivation, and personal and group attitudes towards the two languages. The two main influences that have been investigated are those that are endogenous (primarily, biological age) versus those that are exogenous (amount or type of L2 input). The focus of research investigating these factors typically aims to determine which of the two best explains degree of L2 attainment. Rarely are the two considered as interacting forces. The present article considers how age and length of residence in an L2 environment may interact, focusing not only on the age at first exposure to or immersion in the L2 but also age at the time of testing.

2. The age-length-onset problem

A number of studies have shown a clear relationship between the age of onset of the L2 (AO) and later performance in the L2 (e.g., Abrahamsson & Hyltenstam, 2008, 2009; Bialystok & Hakuta, 1999; Birdsong & Molis, 2001; DeKeyser, 2000; Flege, 2009; Flege, Munro, & MacKay, 1995, 1996; Granena & Long, 2013; Johnson & Newport, 1989; MacKay, Flege, & Imai, 2006). This effect has been shown for several types of language tasks, including degree of perceived foreign accent, lexis and collocational knowledge, and morphosyntax. However, a common issue when comparing groups of participants who differ in AO is that other variables often correlate with AO, creating troublesome confounds. For example, when comparing two groups of adults who are roughly the same age but who differ in terms of AO, these groups will necessarily differ in LOR. In turn, if LOR is controlled, the groups will differ in age. This is, of course, because one's age of L2 onset and length of residence combined result in age at time of testing. This relationship is captured, simply, in the equation: **Age = AO + LOR**. Thus, given any two of these variables, one can predict the third. This three-way linear relationship has been described as the age-length-onset problem in second language acquisition research by Stevens (2006). Because of the collinearity of these three variables, the covariance shared by each of the three variables and another variable, such as L2 performance, is also collinear. What this means for bilingualism research is that it is nearly impossible

1. We are using the term "successful L2 attainment" to refer to patterns of performance on language tasks that resemble those seen among L1 speakers of the same language.

to isolate each of the variables in order to draw conclusions about their independent contributions to L2 performance.

Most research investigating one of these variables typically attempts to control for variables other than the one of interest, either by matching participant groups, limiting participant selection to a restricted range, or including the additional variables as covariates in analyses. In a number of studies, these variables are simply omitted, or reported and then ignored. Unfortunately, among this trio of factors, it is not possible to control for two of them in order to investigate the third. Thus, at least one variable is generally uncontrolled, creating a persistent problem of confounding. A look at a few L2 acquisition studies will demonstrate this.

Commonly in a sample of bilinguals, AO shows a negative linear correlation with LOR. That is, when tested as adults, those participants with earlier AO will have spent a longer time in the L2 country of residence. For example, Flege et al. (2010) compared three groups of L2 learners that differed in AO (7–13 years old, 17–19 years old, and 23–35 years old). Predictably, the group with the earliest AO had the longest LOR: 42 years on average for AO 7–13, 37 years for AO 17–19, and 33 years for AO 23–35. Another example is seen in Weber-Fox and Neville (1996). They divided their L2 learners into 5 groups based on age of L2 acquisition ranges (1–3, 4–6, 7–10, 11–13, and >16 years). Participants in the first four AO groups were very similar in age (between 19–21 years). This resulted in a very strong correlation between AO and LOR with earlier AO associated with longer LOR (see Figure 1). In the fifth group of participants (AO > 16 years), LOR is held constant

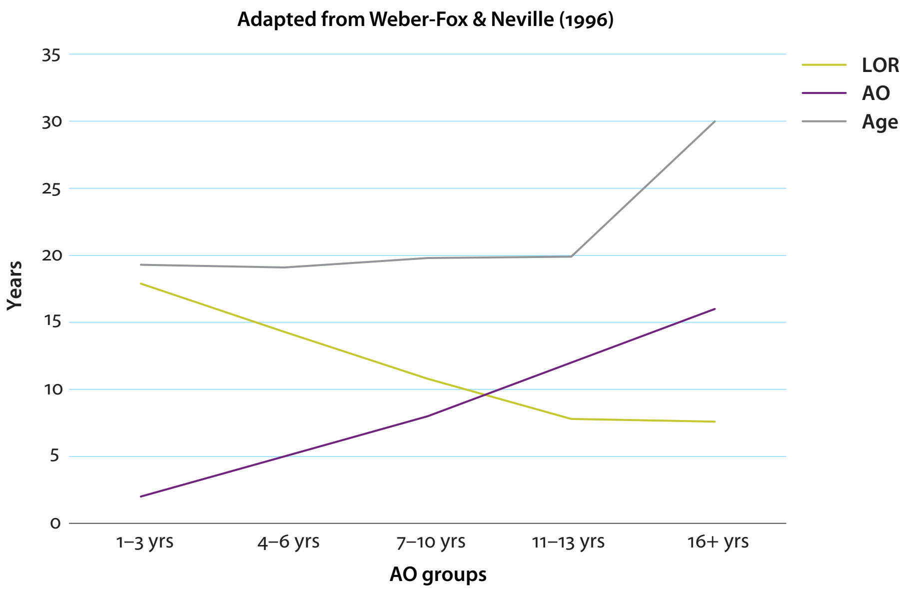

Figure 1. Relation between AO, LOR, and age at testing in Weber-Fox & Neville (1996)

with the fourth group, but now the groups differ in age at testing. Thus, it is impossible to determine whether better performance on the L2 language tasks is due to earlier AO or longer LOR.

Matching the groups in terms of LOR controls for confounds between LOR and AO, but still leaves one confound, age at testing. Studies like Abrahamsson and Hyltenstam (2009) and DeKeyser (2000) investigated L2 performance differences between early and late L2 acquirers who were matched for mean LOR. Matching them for mean LOR, however, results in groups that differ at age of testing (see Figure 2). Do the results showing better performance by the younger AO group reflect AO effects, age effects, or a combination of the two?

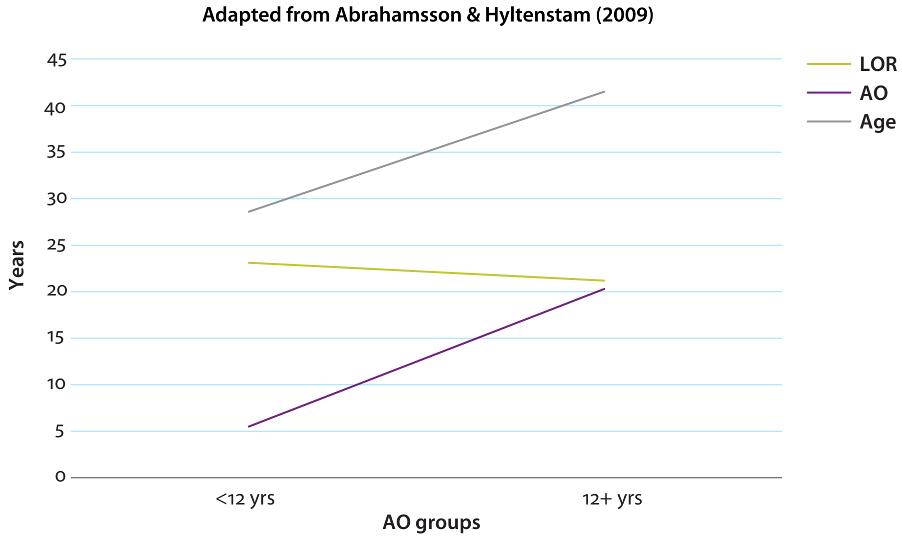

Figure 2. Relation between AO, LOR, and age at testing in Abrahamsson & Hyltenstam (2009)

If one is interested in determining the relative contributions of AO and LOR on L2 performance, this problem of an age confound leads to severe interpretability issues. To illustrate this, consider a Principal Components Analysis (PCA) conducted by Flege (2009) on two different data sets with 240 participants each. Simple correlations between the variables revealed significant correlations between AO, LOR, and age at testing, with each of these variables also showing significant correlations with degree of L2 accent. Using PCA, Flege found that AO, L1 proficiency, and L2 use loaded onto the first factor while LOR and age at testing loaded onto the second factor. Each of these factors was a significant predictor of L2 accent when entered into a step-wise multiple regression analysis. Although age showed a stronger loading on factor 2 than LOR, the results were interpreted as reflecting LOR effects when in fact age was also a significant contributing factor. While the

PCA was able to provide evidence that the contributions to L2 accent were separable for two of the factors (AO separated from LOR and age), since LOR and age loaded onto the same variable, we cannot know whether one of the two is driving the effect or whether both contribute.

One way to resolve this constant problem of collinearity is to determine that one of the variables is irrelevant to the measure of interest, in this case, L2 performance. If one or more of the variables is thought to have no causal effects on the performance, then omitting or ignoring that variable is unproblematic. This is in fact the strategy most often employed in L2 research, particularly as it relates to the variable age at testing. We argue here, though, that age at testing is a potential influential variable when including older adults and should not be omitted or ignored.

3. Research on age of L2 onset and LOR effects

In the past half century, most attention has been paid to the study of AO effects on L2 attainment. This is partly due to the formulation of testable hypotheses such as the Critical Period Hypothesis and the Sensitive Period Hypothesis (e.g., Lenneberg, 1967; Granena & Long, 2013). These hypotheses posit that a window of opportunity is available in early life for optimal language learning and that learning beyond this period results in less than optimal (i.e., non-native-like) L2 competence or performance. While evaluating the evidence in favor or against these hypotheses is beyond the scope of the present article, we do acknowledge the robust finding that AO shows a primarily linear relation with L2 performance in adulthood with earlier AO being associated with better L2 outcomes (e.g., Birdsong, 2005, 2006). In order to understand this relation, however, we should consider ways in which AO interacts with other relevant factors such as LOR and age at testing (among others) rather than attempt to isolate AO as an independent predictor.

Relatively fewer studies have sought to investigate the impact that LOR has on L2 performance. There are strong theoretical reasons for LOR being an important factor in L2 attainment. LOR is typically used as a proxy for amount of L2 exposure. It seems quite reasonable that more L2 exposure would be associated with better L2 outcomes. There are several assumptions that are made when LOR is considered, however. The first is that the participants had little or no meaningful L2 input before the time of immigration; a second assumption is that the immersion in the L2 environment upon immigration dramatically increased the amount of L2 input received. For a number of immigrants, this is indeed the case. However, in many samples of bilinguals, this may indeed be a flawed assumption with LOR being a poor measure of total L2 input either because L2 learning began before immigration, as is the case with many L2 English speakers, or because L2 input remained low even after immigration due to residence in an immigrant enclave. Most studies do not report whether the age of immigration is actually the AO for all participants, but those that do sometimes find that they are different. Tanner, Inoue, and Osterhout (2014) reported that mean age of immigration was 23.9 years old while mean age of initial exposure to L2 (English) was 11.6 years old. The authors chose to use age of immigration in their analyses instead of age of exposure, so it is unclear whether age of exposure linked to L2 performance or whether the two variables correlated.

Further assumptions in using LOR as a variable are that living in the L2 environment results in high L2 input throughout the duration of residence and that the degree of L2 input is similar for all participants. These assumptions are at least as problematic as the first two. Evidence for high levels of dissimilarity among participants in amount of L2 input can be seen in studies that included measures of L1 and L2 use. Language use most likely refers to production of language, but for the moment we will assume that it also approximately reflects amount of language input. In a sample of 138 Italian-English adult bilinguals living in Canada, MacKay et al. (2006) report a range of L2 use from 10 – 94% with a mean of 53%, reflecting a roughly even distribution from low to high values. The LOR of the participants ranged from 13 to 53 years. Another study found that participants' occupation played a role in LOR effects on L2 performance, even when L2 use was about the same (Flege & Liu, 2001). In this case, students showed LOR effects but non-students did not. The authors propose that the *type* or *quality* of L2 input and use and not just the amount can have important implications for L2 development. Of course, it is quite difficult for researchers to obtain a clear picture of language use as this factor is dynamic (changing over time, not necessarily in a predictable manner) and dependent on a variety of other factors such as initial L2 performance, occupation, spouse's languages, location, family size, and religion, among others. But it is precisely the highly dynamic nature of language use that makes the assumption of uniformity of L2 input a potential problem for the LOR variable as a predictor of L2 attainment. Birdsong (2009) points out that some immigrants may reside in the L2 environment for decades and yet still be isolated from L2 contact. Thus, if LOR is being used as a proxy for L2 input, it should be accompanied by appropriate considerations or controls of L2 use.

A commonly cited statement is that a LOR of 5–10 years or longer is unlikely to significantly influence L2 performance (e.g., Bylund, Abrahamsson, & Hyltenstam, 2012; DeKeyser, Alfi-Shabtay, & Ravid, 2010). This is partly based on the idea that stabilization can occur in L2 development, leaving the L2 user with a fossilized, functional language system that exhibits characteristics of a stage of development prior to native-like attainment (Long, 2003; Selinker, 1972). With respect to accent, Schwarzenegger and Kissinger would seem to exemplify such stabilization. However, the claim that LOR has no effect after 10 years is not fully justified. LOR has been found to correlate with L2 performance in a number of studies with a mean LOR of longer than 10 years (Abrahamsson, 2012; Flege, 2009; Flege et al., 1995; Flege, Takagi, & Mann, 1995; Granena & Long, 2013; Piske, MacKay, & Flege, 2001; Saito, 2013). Therefore, it seems that for a variety of long-term residents, L2 proficiency may in fact continue to develop.

It should be noted, however, that some of these studies did not consider the confound that LOR often has with AO. For example, Piske et al. (2001) found a significant negative correlation between LOR and foreign accent in the L2, but the correlation became non-significant once AO was partialled out because of the linear relationship between LOR and AO. Abrahamsson (2012), on the other hand, found the correlation between LOR and performance on a grammaticality judgment task remained significant after partialling out the effect of AO. Thus, the problem of multicollinearity between these (and other) variables obscures a clear understanding of the relation between LOR and L2 attainment.

A few researchers have considered whether LOR and AO interact in their effect on L2 performance, and some interesting findings suggest they might. Baker and Trofimovich (2005) found an effect of LOR on L2 pronunciation only for those with an earlier AO and not for those with a later AO. Mean AOs for the early groups were 8.8 and 8.9 years and for the late groups, 22.6 and 24.9 years. This finding suggests that LOR may matter more following earlier stages of cognitive or language development than following late ones and is in line with the consistent finding of LOR effects among child immigrants (e.g., Asher & Garcia, 1969; Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; Jang, Dunlop, Wagner, Kim, & Gu, 2013; Flege et al., 2006; Winitz, Gillespie, & Starcev, 1995). A different outcome was seen for lexical knowledge. Granena and Long (2013) reported an effect of LOR on lexical and collocational knowledge only for the late AO group (AO range from 16–29 years old). They argue that lexical knowledge typically increases over the lifespan, so it is not expected to reach an endstate the way pronunciation or morphosyntax might be expected to. Additional research looking not only at the separate contributions of AO and LOR but also their interaction should elucidate how LOR influences L2 outcomes and may resolve some of the inconsistencies in findings with regard to LOR and L2 performance.

Perhaps one of the reasons for the inconsistent findings with regard to LOR and L2 performance is that LOR may affect some aspects of language more than others. As Table 1 demonstrates, most studies of LOR and L2 performance have focused on degree of perceived foreign accent. Of those, some report an effect of LOR and others do not. The same is true for other aspects of phonological production and morphosyntax. There are two studies that found LOR effects on some tasks but not others, among younger and older adults. Granena and Long (2013) found LOR to correlate with lexical and collocational knowledge, but not with pronunciation or morphosyntax, in the same participants. Bartning, Lundell, and Hancock (2012) found an effect of LOR on formulaic language, but not on morphosyntax. These studies suggest that LOR may have a stronger effect on some aspects of L2 development than others, but there is not enough research to date to draw any firm, specific conclusions on the degree of LOR influence on different aspects of L2 performance.

Table 1. Studies investigating the relation between LOR and L2 performance grouped according to whether the samples included participants under or over age 55. Within each group, the studies are ordered by mean age of sample (by the oldest mean if multiple groups were included).

Study	N	Ages (range)	Ages (mean)	LOR mean (range)	Task	LOR-L2 finding
Yamada et al. (1994)	144	13–31	19	1–15 yrs	Pronunciation	+
Linck, Kroll & Sunderman (2009)	25	Not reported	20.6	3 months	Lexical retrieval	+
McDonald (2000: Exp 1)	28	18–25	[22 & 23][1]	4.1 & 14.8 yrs (3–24)	Grammar	None
McDonald (2000: Exp 2)	24	18–24	[21 & 21]	7.8 & 18.6 yrs (6–23)	Grammar	+
Jia et al. (2006)	131	8–46	20.5 & 24.4	1.3 & 3.7 yrs (0–5)	Speech perception, pronunciation	None
Bialystok & Miller (1999)	61	18–47	24 & 25	Means ranged from 4–12 yrs (1–23)	Grammar	+
Flege, Yeni-Komshian & Liu (1999)	240	17–47	26	14.6 yrs (8 min.)	Accent, grammar	+
Granena & Long (2013)	65	19–47	26.3	13 yrs	Pronunciation, morphosyntax	None
Granena & Long (2013)	65	19–47	26.3	13 yrs	Lexicon and collocations	+
Baker & Tofimovich (2005) (late bilinguals)	20	16–43*	25.8 & 29.5	0.9 & 6.9 yrs	Pronunciation	None

Table 1. (*continued*)

Study	N	Ages (range)	Ages (mean)	LOR mean (range)	Task	LOR-L2 finding
Weber-Fox & Neville (1996)	61	19–34*	Ranged from 19 to 30	Means ranged from 7.6 to 17.9 yrs (1–16+)	Grammar	+
Moyer (2004)	25	25–35	[30]	6 yrs (range > 20 yrs)	Pronunciation	+
Saito & Brajot (2013)	39	21–43	31.4	4.1 yrs (8 mos – 13 yrs)	Pronunciation	+
Baker (2010)	30	20–38*	29.5, 27.3, & 32.1	0.2, 3.0, 9.8 yrs	Pronunciation, perception	None
Tsukada et al. (2005) (adults)	36	23–41	30.4 & 32.3	3.0 & 4.8 yrs (2–6)	Speech perception, pronunciation	None
Bohn & Flege (1992)	20	Not reported	28 & 33	0.6 & 7.5 yrs	Accent	+
Flege, Bohn & Jang (1997)	80	20–45	33, 28, 28, & 31	0.7 & 7.3 yrs	Accent	+
Flege et al. (2006) (adults)	108	23–41	20.3 & 33.1	3 yrs (2–4) & 4.8 yrs (4–6)	Accent	None
Flege & Fletcher (1992)	30	18–53	23, 26, & 34	0.7 & 14.3 yrs	Accent	+
Babcock et al. (2012)	56	18–52*	34.8	7.3 yrs (3–23)	Morphosyntax	+
Flege & Liu (2001)	62	21–45	30.7 & 34.9	2.7 & 6.6 yrs (0.5–15.5)	Listening comprehension, grammar, phonological perception	+
Yeni-Komshian, Flege & Liu (2000)	240	Not reported	26 (group means ranged from 21–35)	Means ranged from 12–20 yrs	Pronunciation	None
Flege (1988) (adults)	30	25–45*	35.0, 28.4, & 30.5	1.1, 1.1, & 5.1 yrs	Accent	None
Tanner et al. (2014)	20	24–49	35.2	10.6 yrs (5–27)	Morphosyntax	None

Table 1. (*continued*)

Study	N	Ages (range)	Ages (mean)	LOR mean (range)	Task	LOR-L2 finding
Abrahamsson & Hyltenstam (2009: Exp 2)	41	20–50	30.9 & 37.2	25 yrs (12–42)	Phonetic production & perception, grammar, inferencing, idioms	None
Aoyama et al. (2004) (adults)	16	32–48*	39.9	1.6 yrs	Pronunciation	None
Ingvalson, McClelland & Holt (2011)	55	Not reported	29.8, 31.0, & 42.2	<2 – 10+ yrs	Pronunciation	+
Flege, Takagi & Mann (1995)	240	29–47	43.7 & 35.0	1.6 & 20.8 yrs	Pronunciation	+
55+						
Tahta, Wood & Loewenthal (1981)	109	9–77	27.15	>2 yrs	Accent	None
Wolfram (1985)	16	10–55	[32]	1–7 yrs	Pronunciation	+
Bartning, Forsberg & Hancock (2009)	30	19–55	[36]	1–30 yrs	Formulaic language	+
Bartning, Forsberg & Hancock (2009)	30	19–55	[36]	1–30 yrs	Morphosyntax	+
Abrahamsson (2012)	200	21–63	40	23 & 26 yrs	Grammar, phonological perception	+
Flege, Munro & MacKay (1995)	240	Not reported	44	31.5 yrs (15–44)	Accent	+
Flege, Munro & MacKay (1996)	240	24–56	44.1	31.5 yrs (15–44)	Pronunciation	None
Saito (2013)	88	30–70	45.9	17.8 yrs (6–42)	Pronunciation	+
Thompson (1991)	36	Not reported	46.5 & 44	2–42 yrs	Pronunciation	+
Meador, Flege & MacKay (2000)	72	36–60*	48	35 yrs (18–48)	Word recognition in noise	None
MacKay, Meador & Flege (2001)	72	36–60*	48	35 yrs (min. 18)	Speech perception	None
McAllister, Flege & Piske (2002: Exp 2)	20	14–66*	28.7, 34.7, 45.9, & 48.9	3.5, 3.8, 18.1, & 18.1 yrs	Speech perception	None

Table 1. (*continued*)

Study	N	Ages (range)	Ages (mean)	LOR mean (range)	Task	LOR-L2 finding
Piske, MacKay & Flege (2001)	72	Not reported	49–51	Means ranged from 29–42 yrs	Accent	+
Larson-Hall (2006)	30	20–66	29 & 52	1.1 & 23.2 yrs	Pronunciation	+ (short LOR); – (long LOR)
Bartning, Lundell & Hancock (2012)	30	19–60	[27, 28, & 53]	1–30 yrs	Morphosyntax	None
McAllister, Flege & Piske (2002: Exp 1)	60	29–71*	43, 48, & 53	17, 17, & 24 yrs	Speech perception	+
DeKeyser (2000)	57	16–81	55	35.6 & 33.7 yrs	Grammar	None
MacKay, Flege & Imai (2006)	138	40–72	57	39 yrs	Accent	None
Flege, MacKay & Imai (2010)	54	Not reported	53–59	13–53 yrs	Accent	+

1 Values in brackets are estimated means based on the range, assuming normal distribution
* Estimated range based on mean and standard deviation

4. The influence of age at testing

Let us return to the third variable in the problem of three-way collinearity: age at time of testing. This variable has received very little attention in the L2 acquisition literature and thus has been typically ignored as a possible contributing factor and sometimes even unreported. Abrahamsson (2012) considers the possibility that age might affect L2 performance, but rules out its potential effect vis-à-vis a grammaticality judgment task, saying "There were no relevant reasons to believe that age as such would have an impact on the participants' L2 intuitions." The rich field of cognitive aging, however, provides ample evidence that age at testing does impact language performance, particularly when including older adults, as many second language acquisition studies investigating long LORs do.

The large body of literature on language in healthy aging demonstrates age-related declines in certain language abilities such as lexical retrieval, speech perception in suboptimal environments, and implicit prediction during sentence comprehension (e.g., Ben-David et al., 2011; Federmeier, Kutas, & Schul, 2010;

Goral, Spiro, Albert, Obler, & Connor, 2007, Shafto & Tyler, 2014), while other language abilities, such as comprehension of basic sentences and word knowledge, remain stable or even improve with age (Bialystok & Luk, 2011; for a review, see Burke & Shafto, 2008). The changes associated with aging are gradual and thus the age at which these changes "begin" is not easily identifiable. For the most part, age-related changes in language performance are readily seen in individuals in their 70s (e.g., Feyereisen, 1997), but careful observers have noted performance declines starting in the 50s (Connor, Spiro, Obler, & Albert, 2004; Goral et al., 2007; Verhaegen & Poncelet, 2013), and declines in gray matter volume and white matter microstructure in the brain start even earlier (e.g., Giorgio et al., 2010).

Most of the research on language and aging has focused on performance in the native language, but because age-related declines in language performance are believed to be linked to declines in neural functioning, both languages of a bilingual should be affected. Therefore, the field of cognitive aging has important implications for research on L2 acquisition, particularly when investigating phenomena such as LOR and its effects on L2 attainment. In order to include participants who have reached an asymptote in their L2 development, second language acquisition researchers tend to select L2 learners who have lived in the L2 environment for decades. If these same individuals began acquiring the L2 in adulthood, this may very well put them in the older adult age range, usually above 50–55 years of age. Yet, there has been very little consideration of how cognitive aging contributes to L2 performance, much less the interaction between aging and other influential variables that contribute to L2 performance such as AO and LOR. Hopp (2007), for example, found a significant correlation between age at testing and L2 reading speed (with older age associated with slower reading speeds), but he did not consider the effect of LOR or how LOR and aging may interact.

A study by MacKay et al. (2006) is one of the few that explicitly investigated how age at testing is related to L2 performance. The authors created six subgroups that were matched on AO but differed in mean chronological age at time of testing ranging from 40 to 72 years of age. Unsurprisingly, because of the collinearity between these three factors, these six groups also differed in terms of LOR, with the older age groups demonstrating longer LORs than the younger age groups. MacKay et al. found no differences between the six groups on perceived foreign accent. This study might provide evidence that L2 pronunciation is unaffected by age at testing, but the lack of a finding does not necessarily imply the lack of an effect, and a single study is not sufficient to draw that conclusion. Furthermore, we do not know whether the relation found between age at testing and other aspects of language performance (e.g., access to the lexicon or interpretation of syntax) is similar to that seen for pronunciation.

Comparisons between individuals with short LOR and long LOR are indeed often comparisons between younger and older adults. Therefore, any positive effect that LOR might have on L2 performance may be counteracted by declines in performance due to aging. This idea is articulated by Gollan and Silverberg (2001) in reference to the incidence of Tip-of-the-Tongue (TOT) states during lexical retrieval. The authors argue that exposure to words decreases lexical retrieval difficulties (seen in lower TOT rates), so age should negatively correlate with TOT rates, similar to the LOR argument found in many second language acquisition papers. Their prediction was borne out among their bilinguals aged 17 to 61. However, they point out that including bilinguals at higher ages would likely result in a U-shaped pattern as TOTs tend to increase among older adults (Burke, MacKay, Worthley, & Wade, 1991). Thus, the increases gained by additional exposure may at some point be canceled out and even overridden by decreases caused by the neurocognitive aging process.

In fact, there are reasons to think that aging might even have a greater effect on L2 than L1, as already noted by Birdsong (2006). One proposal in cognitive aging is that automatic language skills are better preserved while controlled processing skills decline with age (e.g., Harley, Jessiman, & MacAndrew, 2011). Processing in the L2 is often less automatic than in the L1 (Segalowitz, 2003; Segalowitz & Hulstijn, 2005). The level of automaticity may depend on L2 proficiency (Favreau & Segalowitz, 1983) and/or use, but even L2 speakers with high levels of proficiency or use may not evidence the same degree of automaticity as that seen in native speakers (e.g., Silva & Clahsen, 2008). Moreover, controlled processing requires greater involvement of cognitive control (i.e., executive function skills), which declines in most individuals with advancing age (e.g., Braver & West, 2008). Thus, L2 performance may be influenced by the cognitive aging process even more than L1 performance.

In order to investigate whether age at testing might counteract the positive effects of LOR on L2 performance, we reviewed a set of studies that examined LOR effects in L2 performance. We excluded studies that failed to report age at testing or those that reported LOR but did not investigate its contribution to L2 performance. We identified 47 studies investigating aspects of L2 performance that included LOR in their analyses and participants' age at testing (see Table 1).

Since the effect of age at testing on L2 performance has rarely been explicitly tested, we used an indirect measure to test the idea that including older adults in the sample may influence the results. If LOR indeed contributes positively to L2 attainment, and continues to do so, to some degree, even past ten years of residence in the L2 environment, this positive effect may be masked by a counteracting effect due to cognitive declines associated with aging. Thus, we predicted that we should see more positive effects of LOR on L2 performance when the study samples included only younger adults and that we should observe more null findings as the age range of the participants increased due to the counteracting effects of aging.

First, we divided the studies into those with participants exclusively under 55 years of age and those with participants 55 or above.[2] In the younger samples, 57.1% of the studies ($n = 28$) found a positive relation between LOR and L2 performance while 47.4% of the studies with participants above 55 ($n = 19$) found a relation (see Table 2). We then used a higher age cutoff to create a subgroup made up of studies that included participants 60 and older. In the 60+ group ($n = 11$), only 3 of the studies (27.0%) found a benificial LOR effect whereas 7 (57.1%) reported no LOR effect, and one study in this group showed a *negative* relation between LOR and L2 performance (Larson-Hall, 2006). Figure 3 demonstrates this trend that the proportion of studies reporting no LOR effect on L2 performance increases as the upper age range of the sample increases.

Table 2. Summary of the proportion of studies finding an LOR effect when dividing the studies by different age cut-offs

	Total studies	# finding positive relation	% finding positive relation	# not finding relation	% not finding relation	# finding negative relation	% finding negative relation
<55	28	16	57.1%	12	42.9%	0	0%
55+	19	9	47.4%	9	47.4%	1	5.3%
60+	11	3	27.0%	7	63.6%	1	9.1%

The trends reported here provide only indirect evidence that age at testing can counteract the beneficial LOR effects vis-à-vis L2 performance. Nevertheless, we observe that the inclusion of older adult participants in a subset of the studies is associated with an increased proportion of null effects of LOR, as predicted. Some of the null effects reported may in fact be masking a nonlinear interaction between LOR and age at testing with L2 performance which would manifest as an inverted U-shaped function. Unfortunately, none of the studies we reviewed here investigated whether this type of a nonlinear relationship exists, and thus it is still an open question for future research whether LOR and age at testing interact with each other to produce the pattern of results we propose might exist.

As both the LOR and the aging effects may be gradual, it is possible that one may outweigh the other in certain individuals and across certain samples, or even that the two variables interact differently for different domains of language, which could lead to the varied findings we see in this literature. A controlled study

2. Some studies reported mixed results across groups or experiments. We have included these as separate studies in the count.

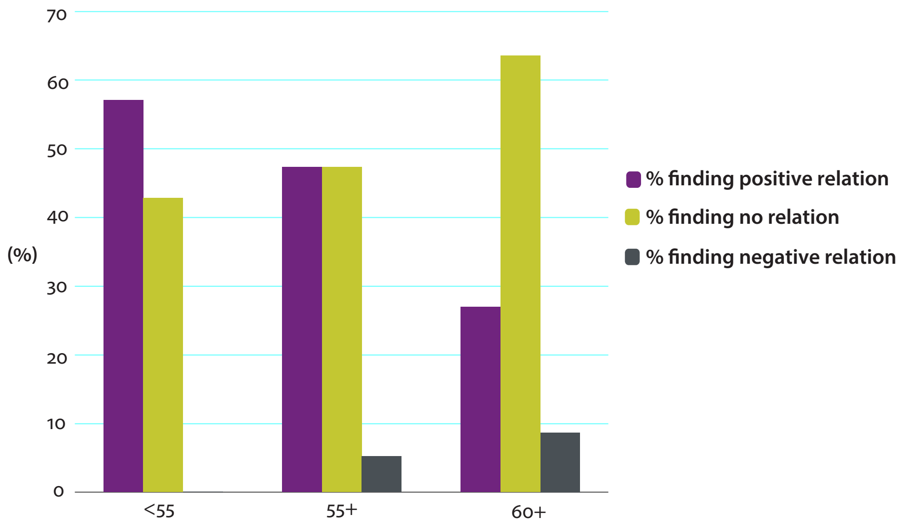

Figure 3. Summary of findings of the relation between LOR and L2 performance separated by the age range of the participants

investigating the interaction between LOR and aging is clearly warranted given the pattern we have found here hinting at diminished gains in L2 as a function of LOR and age at testing.

5. Conclusion

L2 learners vary widely in their acquisition of the language with a variety of intersecting variables impacting their patterns of L2 performance. Chief among them are age of acquisition and length of residence in the L2 environment. Another variable that is inherently confounded with age of acquisition and length of residence but is often ignored is age at testing. Drawing on the research on language changes associated with aging, we have argued that age at testing may influence performance on L2 language tasks when older adults are included in the sample, leading to a higher incidence of null effects for LOR on L2 performance as the upper end of the age range of the sample increases.

There is no clear cutoff for when aging effects may begin to appear as aging is a gradual process just as L2 development is. As well, of course, there will be individual differences in the way that certain aspects of language performance may decline with advancing age, and these will interact with other variables such as age of L2 acquisition, LOR, as well as other psycho-social variables not discussed here (e.g., density of social networks, the type of learner/acquirer the person was when younger, etc.). Indeed, there is reason to believe that age-related decline in language performance may occur more in the L2 than in the L1, because L2 performance may involve the same types of executive control behaviors that decline in advancing age. Thus, it is imperative that second-language researchers interested in LOR effects consider the potential effects of aging on how their participants perform.

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