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Disadvantages of Linguistic Origin

Evidence from Immigrant Literacy Scores

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Ingo Isphording[1]

Disadvantages of Linguistic Origin – Evidence from Immigrant Literacy Scores

Abstract

This study quantifies the disadvantage in the formation of literacy skills of immigrants that arises from the linguistic distance between mother tongue and host country language. Combining unique cross-country data on literacy scores with information on the linguistic distance between languages, gaps in literacy test scores are estimated. Linguistically distant immigrants face significant initial disadvantages of linguistic origin that exceed existing differentials across wage distributions and between employed and unemployed subpopulations. The importance of the linguistic origin increases with the age at migration, confirming the linguistic Critical Period hypothesis. Assimilation in literacy scores is moderate and does not offset the initial disadvantage.

JEL Classification: F22, J15, J24, J31

Keywords: Linguistic distance; literacy; human capital; immigrants

January 2013

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1 Introduction

The information age and the accompanying rapid transformation of labor market demands drastically increases the need for skills including literacy and numeracy (OECD 2000). By the rise of information and communication technology usage, every occupation demands a minimum level on literacy and language ability. The OECD defines literacy as "the ability to understand and employ written information in daily activities, at home, at work and in the community – to achieve one's goals, and to develop one's knowledge and potential" (OECD 2000). As such, literacy comprises the productive functions of language that are rewarded in the labor market, e.g. the usage of language to store information, communicate with co-workers and to order one's thoughts (Crystal 2010). The labor market effects of literacy have gained considerable attention in the literature (Vignoles et al. 2011, Finnie and Meng 2005, Dougherty 2003, Gonzalez 2000, Charette and Meng 1994). Figure 1, computed from data of the International Adult Literacy Survey used in this study, highlights the importance of literacy skills in the labor market. Considerably higher average levels of literacy can be found in the employed subpopulation, as well as along the wage distribution.

A group especially prone to insufficient levels of literacy are immigrants from distant linguistic backgrounds. Low levels of literacy are a factor negatively affecting the social and economic integration of immigrants (Ferrer et al. 2006, Kahn 2004). Non-native speaking immigrants face an economic decision to acquire a host-country language (Selten and Pool 1991, Chiswick and Miller 1995). One important cost factor in this human capital investment is the linguistic distance between mother tongue and host country language. The linguistic distance, the degree of dissimilarities between languages in terms of pronunciation, grammar, script, vocabularies etc., is expected to impose initial hurdles, to decrease the efficiency of language acquisition, to rise the costs of skill investment, and finally to have consequences on labor market success and integration (Chiswick and Miller 1999). The literature on linguistic barriers in the language acquisition of immigrants mainly comprises of qualitative or small scale quantitative studies in the linguistic literature. The multidimensionality of linguistic differences makes it difficult to analyze its effect on the language acquisition empirically in large scale micro data studies. A noteworthy and innovative approach has been undertaken by Chiswick and Miller (1999) using average test scores of language classes to proxy linguistic differences. The major disadvantage of this approach is the restriction language differences towards English.

Against this background, this study aims at quantifying the linguistic barriers in the literacy skill formation. Data on literacy scores from the International Adult Literacy Survey (IALS) are combined with a unique measure of the linguistic distance from the Automatic Similarity Judgment Program by the German Max Planck Institute of Evolu-

tionary Anthropology based on differences in pronunciation between mother tongue and the host country language. The resulting dataset covers 9 host countries receiving immigrants from 70 sending countries and includes 1,559 individual observations. Regressing literacy scores on the linguistic distance yields estimates of score differentials with respect to the linguistic origin of an immigrant.

The study contributes to the existing literature in three ways. First, the cross-sectional design of the IALS data allows to control for destination and origin country specific characteristics simultaneously, which were omitted in previous studies using national datasets. Second, the usage of objective literacy scores allows to confirm results for subjective measures of language skills by Chiswick and Miller (1999), Van der Slik (2010) and Isphording and Otten (2011, 2012) and avoids issues of measurement error in these self-reported indicators (Charette and Meng 1994, Dustmann and van Soest 2001, de Coulon and Wolff 2007). Finally, the study specifically addresses the influence of linguistic origin over time of residence and offers additional evidence for the so-called Critical Period hypothesis which states that the necessary effort for acquiring a language is increasing with the age at arrival of an immigrant (Newport 2002).

The results indicate a strong negative effect of the linguistic distance on the achieved literacy score. To give a rough quantification: Linguistically distant immigrants (e.g. a Turk in the Netherlands) face significant initial disadvantages of linguistic origin that are comparable to the disadvantage of having formal education of ISCED 1 (primary education) compared to ISCED 5 (short-cycle tertiary education). In line with the Critical Period hypothesis, this negative effect is mainly observable for late arrivals who immigrated at an age of 12 or older. The effect of linguistic origin decreases over time of residence, although the convergence does not offset the initial disadvantage. Compared to differences in average literacy scores across the wage distribution and between employed and unemployed individuals illustrated in Figure 1, the score differentials by linguistic origin are economically significant in size.

This study is organized as follows. Section 2 describes the data sources, specifically the measurement of linguistic differences between languages, Section 3 outlines the empirical strategy. Section 4 discusses the regression results against the significance of literacy skills in the labor market. Section 5 concludes.

2 Data

This study utilizes data from the public use file of the International Adult Literacy Study (IALS). The IALS represents a unique data source on adult's literacy skills and socioeconomic characteristics over the period of 1994 to 1998 (OECD 2000). Regarding the

migration background, not all participating countries offer the necessary information on the origin of immigrants. The sample is therefore restricted to immigrants to Switzerland, the Netherlands, Sweden, Great Britain, Italy, Slovenia, Czech Republic, Finland and Hungary. The key advantage of the IALS data is the direct measurement of individual literacy scores. Immigrants are defined as those individuals who were not born in the country of assessment. No further sample restrictions are applied. Three different dimensions of literacy are assessed independently in the IALS: prose literacy (the knowledge to understand and use information in texts), document literacy (the skills to use information stored in documents like forms, schedules, tables etc.) and quantitative literacy (the skill to locate numbers found in printed materials and to apply simple arithmetic operations). A score between 0 and 500 is assigned to task booklets in the respective official language of a region. The reported scores of the immigrant subpopulations differ in means. Highest average scores are found in the Czech Republic, the lowest average in Slovenia (see Table 1). The usage of these objective test scores circumvents measurement error issues of self-reported measures of language ability (Charette and Meng 1994, Dustmann and van Soest 2001, de Coulon and Wolff 2007).[1]

To identify linguistic barriers in the formation of literacy skills, the literacy test scores are regressed on a measure of linguistic distance between mother tongue and host country language. The measurement of linguistic distance stems from the Automatic Similarity Judgment Program, which has been developed by the German Max Planck Institute of Evolutionary Anthropology to explain geographical distribution and historical development of languages. This approach aims at measuring the number of so-called *cognates*, words in different languages sharing a common ancestor. The number of cognates can be approximated by measuring differences in pronunciations between languages (Serva 2011).

The measurement of similarities in pronunciations relies on a direct comparison of word pairs having the same meaning across different languages. These words are taken from a 40-item sublist of the so-called Swadesh list (Swadesh 1952). This deductively derived list includes words that are believed to be culturally independent and which are represented in any of the world's languages. These words comprise basic words of human communication (e.g. *I, You, One*), body parts (e.g. *Eye, Nose, Tooth*) or environmental

[1]Specific answers to the test booklet do not indicate a literacy level with certainty. Due to the restricted number of questions, individuals with different levels of literacy might still produce the same set of answers. To take this uncertainty into account, the IALS data provides 5 different plausible values of literacy scores for every individual. To take into account this sampling procedure of the IALS (see Murray (1997) for further details), I follow the established method to use the simple average of the 5 plausible values of test scores as the outcome variable. Standard errors are then computed taking into account the replicate weights offered by IALS. This method takes into account unspecified intra-cluster correlation, but ignores the stratification of the sampling. Brown and Micklewright (2004) show that this method might produce slightly overstated standard errors in some cases.

concepts (e.g. *Water, Stone, Night*). For each word, the respective representation in a language is expressed in a phonetic script. To assess the dissimilarity of two words, the Levenshtein distance, i.e. the number of sounds that have to be changed, to be removed or added to transfer the word of one language into the same word in a different language is calculated. To take into account potential similarities by chance due to shared phonetic inventories, the average across the word pairs is normalized. For technical details of the computation see Bakker et al. (2009). Table 2 gives some computational examples.

The approach yields a continuous descriptive measure of the differences in pronunciation between two languages as the proxy for the number of cognates, and thus, on the approximative linguistic difference between the languages. Wichmann et al. (2010) show that the linguistic distance measured by differences in pronunciation is a strong predictor for family relations of languages. Table 3 lists the closest and furthest languages in the used sample with regard to some destination languages. Closest distances emerge within the same language family (Germanic languages for English and German, Romance languages for French and Slavic languages for Czech). The closest linguistic distance different from zero in the present sample is faced by Serbian-speaking immigrants in Slovenia, the largest distance by Turkish immigrants in the Netherlands. Previous applications of this measure of linguistic distance can be found in Isphording and Otten (2011) and Isphording and Otten (2012). The complete matrix of linguistic distances can be found in Table 8 in the appendix.

3 Empirical Strategy

To identify systematic disadvantages of linguistic origin in the literacy scores, the following equation is estimated separately for each of the three literacy scores using multivariate linear regressions:

$$\begin{aligned} Y &= \beta_0 + \beta_1 LD + \beta_2 LD \times YSM + \beta_3 LD \times Age_{Entry12} \\ &\quad + \beta_4 YSM + \beta_5 Age_{Entry12} + X'\gamma + \varepsilon. \end{aligned}$$

Y indicates the literacy score in one of the three dimensions. LD is the calculated linguistic distance towards the host country language. Following Chiswick and Miller (1995), the exposure to a foreign language is a main determinant of the language acquisition of an immigrant. The interaction term between years since migration (YSM) and the linguistic distance accounts for a convergence over time of residence between native and non-native speakers in literacy scores. The linguistic distance is also interacted with

a binary indicator for arrival in the host country at the age of 12 or older ($Age_{Entry12}$). This definition is consistent with the linguistic Critical Period hypothesis (Newport 2002). Previous psychobiological literature indicates that early childhood language acquisition is not hindered by linguistic differences until a certain age threshold. The Critical Period hypothesis states that learning efficiency in foreign languages strongly decreases with adolescence. Following this hypothesis, the interaction effect is expected to be negative, indicating a higher impact of linguistic origin for late arrivals. The main effects of years since migration and arrival at age 12 or older, β_4 and β_5, indicate the effects for the subpopulation of native-speaking immigrants with $LD = 0$.

The X comprises of the control variables gender, the individual and parental education (in ISCED groups)[2], birth cohort indicators and the geographic distance between capitals of destination and origin. Country-wise descriptive statistics on the explanatory variables are reported in Table 1.

The cross-national design of the IALS allows to control simultaneously for origin- and destination-fixed effects by including indicators for 9 receiving and 70 sending countries. These fixed effects capture potentially omitted receiving country characteristics, e.g. differences in language acquisition support, or selective migration policies favoring skilled immigrants. Potentially omitted sending country characteristics can be differences in media exposure to foreign languages or differences in the quality of the education system. As linguistic and geographic distance both vary on the level of origin- and destination-country permutations, they are not collinear with either the set of origin- or destination-country indicators.

Unobservable heterogeneity might also arise on the level of combinations of origin and destination in terms of a "community" effect (Van Tubergen and Kalmijn 2005). Unfortunately, I cannot include combined destination-origin fixed effects, as this would eliminate almost any variation in the variable of interest, the linguistic distance. Therefore, potential correlates of literacy skills such as discriminatory behavior towards specific immigrant groups or enclave effects in language acquisition remain unobservable. Still, I assume that due to the high number of origin and destination countries, origin- and destination-specific community effects should not systematically bias the parameters of interest.

[2]The underlying question for the educational information is: *What is the highest level of schooling you have completed?* Information is coded into ISCED codes, omitting ISCED category 4, *Post-secondary non-tertiary education* including vocational training. In the estimations ISCED 0 and ISCED 1 are used as comparison group.

4 Results

Regression results of literacy scores on the linguistic distance and its interactions with age at migration and years since migration are summarized in Table 4. The specifications are estimated separately for each dimension of literacy, prose, document and quantitative. The main effect of linguistic distance displays the initial disadvantage for young arrivals immigrating at the age of 11 or younger. This relationship for young arrivals turns out to be significant in the prose and the quantitative literacy, but remains insignificant for document literacy. Confirming the Critical Period hypothesis, the negative effect strongly increases for late arrivals throughout all dimensions of literacy, indicated by the interaction between age of entry at the age of 12 or older and the linguistic distance.[3] The effect of linguistic distance can be quantified in differences in predicted means, fixing covariates at their sample means: the initial disadvantage of linguistic origin of a linguistically distant immigrant (e.g. a Turk in the Netherlands, $LD = 102.33$) accounts for 33.5 (*13.1*, 25.3) points in the prose (*quantitative*, document) scale. It increases to 79.2 (*66.1*, 67.5) points for immigrants who arrived at the age of 12 or later. This strong disadvantage is roughly comparable to the disadvantage of having no formal schooling or schooling of ISCED 1 (only primary schooling) compared to ISCED 5 (short-cycle tertiary education).

The main effects of age at arrival and years since migration indicate the influence on literacy scores for native speakers and remain small in levels and mostly insignificant. Native speakers do not face a disadvantage by immigrating at an old age, as they acquired their language skills already as their mother tongue prior migration. Neither do they face an assimilation process by time of residence.[4]

The interactions between linguistic distance, the age at entry and the years since migration are illustrated in predicted means in Figure 2. A similar pattern arises for all three dimensions of literacy in the upper panels (a), (b) and (c). Though the linguistic distance has no significant effect for childhood immigrants (the dark grey line is almost vertical), it drastically decreases the test scores for later arrivals (light grey line). The time of exposure to the host county language, indicated by the years since migration, does

[3] The Critical Period is believed to end with adolescence, although some scholars (e.g. Chiswick and Miller 2008) claim a continuous decrease in learning efficiency rather than a specific threshold. Robustness checks indicate that the results are not sensitive to the choice of the actual threshold, see Table 7 in the appendix.

[4] One concern might be that the results are solely driven by the difference between native-speaking immigrants and non-native speakers. Therefore, I repeat the estimations on a subsample excluding native speakers with a linguistic distance of zero. This leads to a reduced sample of 878 observations, while the fit of the regressions decreases slightly. The results of this robustness check are summarized in Table 6. Compared to the estimations in Table 4 the general pattern remains the same, although the coefficients of interest become larger. The now missing natural control group of native speakers renders the quantitative interpretation of the results difficult, but I conclude that the results are not solely driven by the comparison of native speakers and non-native speakers.

not significantly affect the literacy scores of native speakers. A more distant linguistic background increases the assimilation rate, although only marginally (Figure 2, panels (d), (e), (f)). The convergence does not compensate the large initial disadvantage of linguistic origin.

Concerning the control variables, women experience disadvantages in the quantitative and document literacy, but not in the prose literacy. Younger birth cohorts show higher levels of literacy. Strongest determinant for the literacy scores is the level of formal schooling. The ISCED level indicators show a highly significant positive partial correlation to the literacy scores that increases with the accomplished degree. Parental education shows a similar but less distinct pattern.

Gender differences in estimates are reported in Table 5. The general pattern seems to be independent of gender. Differences arise in the relevance of the Critical Period hypothesis. Here, the female results are more distinct than the male counterparts. Insignificant main effects of linguistic distance in the document and quantitative literacy and strong negative interaction terms with age at entry at age 12 or older confirm the Critical Period hypothesis, while the picture remains fuzzy for the male subsample.

The general pattern that can be concluded from the results is a moderate effect of linguistic distance on the average literacy scores for young arriving immigrants, which is distinctively larger for late arrivals who immigrated at the age of 12 or later. Time of residence leads to an increase in exposure to the destination country language and has a moderate positive effect on the literacy scores. The convergence in literacy scores does not make up for the initial disadvantage, which prevails even a long time after immigration. Disadvantage of age at arrival and the assimilation profile cannot be observed for immigrating native speakers with zero linguistic distance. Although the small number of observations does not allow for a direct estimation of labor market disadvantages of linguistic origin, the magnitude of the results indicates the importance of linguistic barriers on the labor market. The initial disadvantage of linguistically distant immigrants exceeds average differences between employed and unemployed or the difference along the wage distribution displayed in Figure 1.

5 Conclusion

Insufficient language proficiency is a significant hurdle for the integration and assimilation of immigrants into labor markets of receiving countries. The literacy acquisition in the host country language is crucially influenced by the linguistic origin of an immigrant. Immigrants with a linguistically distant background face distinctively higher costs to reach a sufficient level of command of a language. Against this background, I aim at

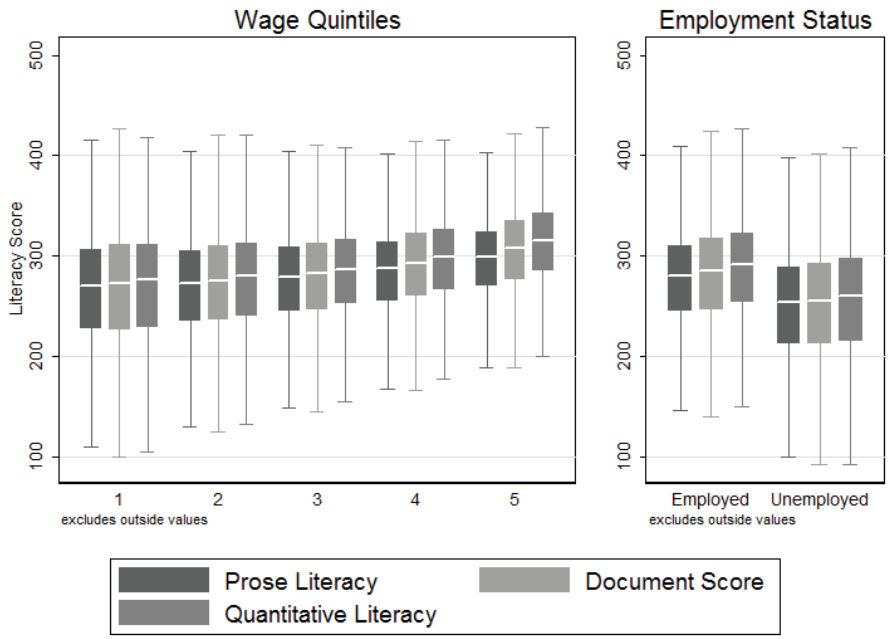
quantifying the disadvantage of linguistic origin in literacy test scores.

Literacy test scores from the International Adult Literacy Survey are regressed on a novel measure of linguistic distance between the mother tongue and the destination country language of immigrants. The results indicate significant differences in literacy scores among immigrants that can be attributed to their respective linguistic origin. Linguistically distant immigrants face a strong disadvantage in literacy scores that is distinvtively larger for late arrivals immigrating at the age of 12 or older. This increasing importance of the linguistic origin by age at arrival confirms the linguistic Critical Period hypothesis. Although I observe a moderate convergence in test scores over time of residence, the disadvantages in literacy scores prevail over a long period after immigration. The differentials in literacy scores by linguistic origin exceed the average difference in literacy scores between the employed and unemployed subpopulations as well as the increase in average literacy scores along the wage distribution. As such, the linguistic origin is expected to have a significant influence on the economic success of immigrants in the host country, as directly estimated by Isphording and Sinning (2012) and Bleakley and Chin (2004) for the US.

These results broaden the previous evidence on the heterogeneity by linguistic origin using national datasets (Chiswick and Miller 1999, Van der Slik 2010, Isphording and Otten 2012) to a cross-national perspective. By using objective measures of literacy, the results confirm the previous findings on the effect of linguistic distance on subjective indicators of language ability and allow for a quantification of effects. The operationalization of the concept of linguistic distance offers important insights into a previously unobservable source of heterogeneity in the assimilation of immigrants, attributed to the "black box" of cultural barriers and differences (Epstein and Gang 2010).

6 Tables and Figures

Figure 1: Literacy and Labor Market Outcomes (Box-Whisker-Plots)



Notes: – Own calculations from IALS data. – Boxes bordered at 25th and 75th percentile, median line indicated at 50th percentile. – Whiskers of 1.5 × interquartile range.

Table 1: DESCRIPTIVES

	All	CH(G)	CH(F)	CH(I)	N	SW	GB	I	SL	CZ	FIN	HU
Female	0.54	0.57	0.53	0.52	0.49	0.55	0.50	0.58	0.53	0.59	0.42	0.59
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Age at entry 12 or older	0.78	0.88	0.79	0.77	0.53	0.74	0.68	0.43	0.65	0.45	0.61	0.51
	(0.41)	(0.32)	(0.41)	(0.42)	(0.50)	(0.44)	(0.47)	(0.50)	(0.48)	(0.50)	(0.49)	(0.51)
Born before 1940	0.11	0.30	0.20	0.14	0.09	0.17	0.13	0.01	0.08	0.09	0.01	0.26
	(0.32)	(0.46)	(0.40)	(0.35)	(0.29)	(0.38)	(0.34)	(0.08)	(0.27)	(0.30)	(0.12)	(0.45)
Born 1940-49	0.18	0.18	0.20	0.27	0.19	0.22	0.16	0.06	0.19	0.53	0.09	0.27
	(0.39)	(0.39)	(0.40)	(0.44)	(0.40)	(0.42)	(0.37)	(0.25)	(0.39)	(0.51)	(0.29)	(0.45)
Born 1950-59	0.24	0.19	0.22	0.20	0.26	0.28	0.26	0.20	0.32	0.19	0.17	0.03
	(0.43)	(0.40)	(0.42)	(0.40)	(0.44)	(0.45)	(0.44)	(0.40)	(0.47)	(0.39)	(0.37)	(0.18)
Born 1960-69	0.32	0.24	0.24	0.24	0.30	0.21	0.29	0.41	0.26	0.11	0.23	0.26
	(0.47)	(0.43)	(0.43)	(0.43)	(0.46)	(0.41)	(0.46)	(0.49)	(0.44)	(0.32)	(0.43)	(0.45)
Born 1970-84	0.14	0.08	0.14	0.15	0.16	0.12	0.16	0.33	0.15	0.08	0.50	0.18
	(0.35)	(0.27)	(0.34)	(0.35)	(0.37)	(0.32)	(0.37)	(0.47)	(0.36)	(0.28)	(0.50)	(0.39)
Years since migration	17.85	22.96	20.49	23.26	22.50	20.90	21.40	21.95	26.39	33.41	13.81	29.47
	(11.94)	(13.07)	(12.77)	(12.42)	(12.33)	(13.18)	(12.35)	(10.77)	(12.03)	(16.01)	(11.73)	(21.50)
No Schooling	0.01	0.00	0.00	0.03	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.03
	(0.08)	(0.00)	(0.00)	(0.18)	(0.23)	(0.17)	(0.16)	(0.12)	(0.10)	(0.00)	(0.00)	(0.17)
ISCED 1	0.28	0.15	0.24	0.26	0.14	0.21	0.11	0.03	0.08	0.26	0.00	0.04
	(0.45)	(0.36)	(0.43)	(0.44)	(0.35)	(0.41)	(0.32)	(0.18)	(0.28)	(0.45)	(0.00)	(0.19)
ISCED 2	0.16	0.22	0.16	0.30	0.25	0.11	0.42	0.30	0.41	0.44	0.47	0.21
	(0.37)	(0.42)	(0.37)	(0.46)	(0.43)	(0.32)	(0.49)	(0.46)	(0.49)	(0.50)	(0.50)	(0.41)
ISCED 3	0.30	0.46	0.36	0.32	0.36	0.47	0.18	0.48	0.40	0.22	0.37	0.30
	(0.46)	(0.50)	(0.48)	(0.47)	(0.48)	(0.50)	(0.38)	(0.50)	(0.49)	(0.42)	(0.49)	(0.47)
ISCED 5	0.08	0.08	0.08	0.03	0.00	0.05	0.07	0.05	0.05	0.00	0.01	0.12
	(0.27)	(0.28)	(0.27)	(0.18)	(0.00)	(0.22)	(0.26)	(0.21)	(0.22)	(0.00)	(0.11)	(0.33)
ISCED 6/7	0.17	0.07	0.16	0.06	0.20	0.13	0.19	0.13	0.04	0.08	0.16	0.31
	(0.37)	(0.26)	(0.36)	(0.24)	(0.40)	(0.33)	(0.39)	(0.34)	(0.20)	(0.27)	(0.36)	(0.47)
Linguistic Distance	66.76	47.62	48.95	27.59	45.08	70.78	40.64	27.94	27.25	31.68	51.12	10.06
	(40.79)	(45.68)	(38.75)	(39.89)	(42.99)	(42.43)	(47.11)	(38.10)	(21.09)	(29.35)	(46.20)	(29.96)
Distance between capitals	3751.11	815.41	933.17	1222.35	4626.63	10814.46	4559.22	2376.89	680.39	1502.03	1460.44	659.64
	(4280.29)	(303.03)	(468.30)	(1838.76)	(4265.05)	(3854.37)	(4244.19)	(2945.99)	(1633.83)	(1889.67)	(2446.70)	(387.50)
Prose Literacy	207.84	217.36	241.77	230.75	261.24	262.93	243.47	250.36	212.10	260.32	265.96	253.72
	(83.91)	(76.17)	(69.06)	(56.77)	(52.65)	(59.75)	(87.56)	(52.16)	(61.26)	(56.52)	(84.57)	(51.89)
Document Score	204.84	218.34	257.01	238.76	265.89	266.42	242.54	248.88	209.17	266.64	266.33	252.97
	(87.52)	(85.42)	(64.83)	(60.79)	(58.52)	(60.56)	(93.35)	(55.71)	(66.65)	(66.87)	(77.14)	(58.39)
Quantitative Literacy	214.15	237.49	262.23	238.87	264.60	269.84	248.22	254.45	221.59	273.52	262.17	261.62
	(85.54)	(79.19)	(65.28)	(62.22)	(59.43)	(61.48)	(89.68)	(56.45)	(66.57)	(71.23)	(73.34)	(70.68)
Observations	2106	154	295	341	133	146	180	81	283	37	70	26

Notes: – Weighted means and standard deviations (in parantheses) by country. – CH(G): Switzerland (German), CH(F): Switzerland (French), CH(I): Switzerland (Italian), N: Netherlands, SW: Sweden, GB: Great Britain, I: Italy, SL: Slovenia, CZ: Czech Republic, FIN: Finland, HU: Hungary.

Table 2: Linguistic Distance: Computational Examples

Word	Spanish	English	Distance
you	*tu*	yu	1
not	*no*	nat	2
Person	*persona*	pers3n	2
Night	*noCe*	nEit	3
Mountain	*monta5a*	maunt3n	5

Source: Brown (2008).

Table 3: Closest and Furthest Languages

English				**German**			
Closest		Furthest		Closest		Furthest	
Language	*Distance*	*Language*	*Distance*	*Language*	*Distance*	*Language*	*Distance*
Dutch	63.22	Tamil	100.81	Swiss-German	48.34	Tamil	100.2
Norwegian	64.12	Turkish	101.04	Dutch	51.50	Hebrew	100.39
Swedish	64.40	Finnish	102.27	Norwegian	64.92	Indonesian	101.75
Danish	69.63	Somalian	103.03	Swedish	66.56	Malay	101.75
German	72.21	Vietnamese	104.06	Danish	66.96	Korean	104.3
French				**Czech**			
Closest		Furthest		Closest		Furthest	
Language	*Distance*	*Language*	*Distance*	*Language*	*Distance*	*Language*	*Distance*
Catalano	71.6	Irish	100.22	Slovak	32.59	Hebrew	99.55
Italian	73.89	Hungarian	100.65	Croatian	43.74	Vietnamese	99.72
Portuguese	74.36	Vietnamese	101.81	Serbian	43.74	Korean	99.85
Romanian	74.39	Japanese	101.94	Serbo-croatian	43.95	Chinese	101.12
Friulano	74.54	Korean	102.74	Polish	44.93	Japanese	101.76

Notes: – Source: Own calculations using programs for calculating ASJP distance matrices (Version 2.1), see `http://email.eva.mpg.de/~wichmann/software.htm`.

Table 4: Literacy and Linguistic Origin

	Prose	Document	Quantitative
Linguistic Distance	-0.328**	-0.128	-0.247*
	(0.09)	(0.10)	(0.11)
Ling. Dist. × Age at entry 12 or older	-0.446***	-0.518***	-0.413***
	(0.06)	(0.07)	(0.08)
Ling. Dist. × years since migration	0.013***	0.008**	0.011***
	(0.00)	(0.00)	(0.00)
Age at entry 12 or older	0.397	7.211†	9.333*
	(4.15)	(3.68)	(3.79)
Years since migration	-0.333	0.054	0.106
	(0.22)	(0.22)	(0.22)
Female	2.686	-8.694**	-17.621***
	(2.21)	(2.49)	(2.74)
Born 1940-49	30.436***	32.123***	25.491***
	(5.40)	(5.93)	(5.44)
Born 1950-59	37.270***	45.309***	40.902***
	(5.25)	(5.67)	(5.37)
Born 1960-69	35.115***	39.948***	36.678***
	(6.75)	(7.34)	(7.15)
Born 1970-84	50.196***	54.610***	42.278***
	(8.45)	(8.81)	(8.51)
ISCED 2	26.925***	26.830***	22.465***
	(3.48)	(3.81)	(3.94)
ISCED 3	52.008***	57.721***	58.877***
	(3.50)	(3.82)	(3.89)
ISCED 5	68.633***	65.066***	65.026***
	(4.28)	(4.71)	(5.05)
ISCED 6/7	78.334***	75.788***	76.834***
	(3.43)	(3.73)	(3.92)
Parents: ISCED 1	11.804†	10.320	11.091†
	(5.82)	(6.17)	(6.06)
Parents: ISCED 2	5.980	5.963	7.634
	(6.10)	(6.48)	(6.10)
Parents: ISCED 3	13.444†	12.657	17.285*
	(6.88)	(7.60)	(7.55)
Parents: ISCED 5	12.467†	16.517*	10.961
	(6.94)	(7.31)	(7.08)
Parents: ISCED 6/7	5.664	-0.679	-0.711
	(6.15)	(6.72)	(6.64)
Distance between capitals	-0.007	-0.008	-0.010*
	(0.01)	(0.00)	(0.00)
Destination-fixed effects	yes	yes	yes
Origin-fixed effects	yes	yes	yes
R^2	0.602	0.589	0.569
N	1521	1521	1521

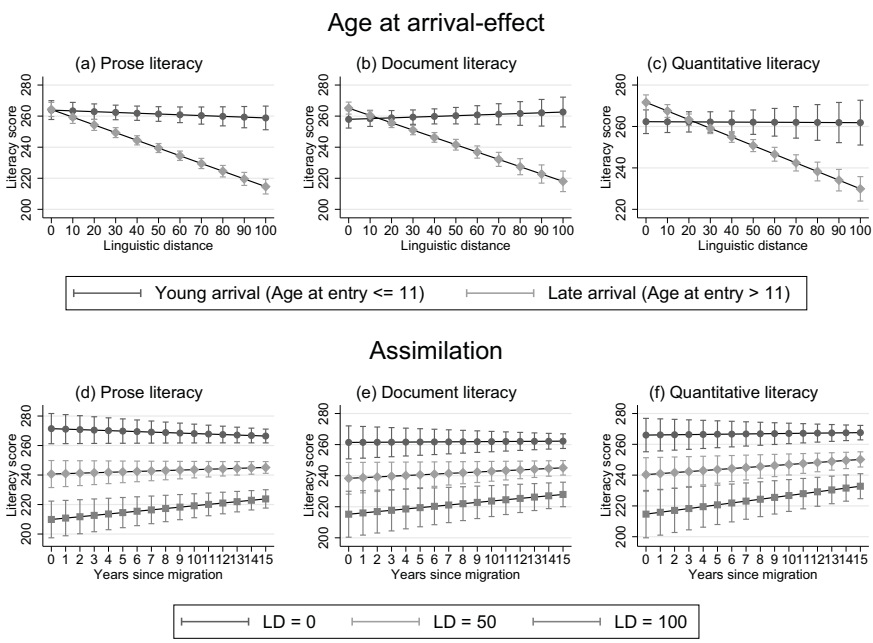
*Notes: – Significant at: ***0.1% level; **1% level; *5% level; †10% level. – Standard errors in parantheses, computed using replicate weights and mean of plausible values to take sampling structure into account. – Education base category: ISCED1/No schooling. – Reference birth cohort: Born before 1940. – The dependent variable: Literacy test scores (range 0-500).*

Table 5: Literacy and Linguistic Origin: Gender Differences

	Men			Women		
	Prose	Document	Quantitative	Prose	Document	Quantitative
Linguistic Distance	-0.274**	-0.146†	-0.225*	-0.277**	-0.026	-0.149
	(0.08)	(0.08)	(0.09)	(0.09)	(0.11)	(0.09)
Ling. Dist. × Age at entry 12 or older	-0.529***	-0.505***	-0.397***	-0.389***	-0.641***	-0.570***
	(0.10)	(0.10)	(0.10)	(0.09)	(0.11)	(0.09)
Ling. Dist. × years since migration	0.009***	0.006*	0.005†	0.014***	0.009**	0.015***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age at entry 12 or older	9.807†	15.149*	20.125**	-12.498	-0.249	1.665
	(5.21)	(5.66)	(5.75)	(9.32)	(9.18)	(8.58)
Years since migration	0.099	0.619*	0.745*	-0.710*	-0.612†	-0.575†
	(0.23)	(0.24)	(0.28)	(0.27)	(0.30)	(0.29)
Born 1940-49	23.157**	21.437**	10.192	38.286***	43.966***	46.764***
	(6.52)	(6.16)	(6.03)	(7.57)	(8.53)	(7.78)
Born 1950-59	41.594***	49.708***	39.822***	26.804**	37.798***	44.449***
	(6.68)	(7.99)	(7.72)	(9.16)	(8.34)	(8.35)
Born 1960-69	48.550***	53.986***	44.440***	18.331†	23.869*	30.220**
	(7.23)	(7.83)	(8.39)	(9.61)	(9.82)	(9.72)
Born 1970-84	61.787***	69.886***	50.053***	41.432**	47.623**	47.498***
	(10.00)	(10.53)	(10.94)	(12.38)	(12.80)	(11.63)
ISCED 2	32.284***	33.407***	28.236***	10.470	8.967	4.328
	(5.77)	(5.52)	(5.86)	(6.20)	(7.51)	(6.67)
ISCED 3	44.957***	55.948***	53.876***	50.095***	49.221***	49.887***
	(5.35)	(5.46)	(5.28)	(6.67)	(8.07)	(7.53)
ISCED 5	63.326***	59.439***	56.837***	56.276***	51.409***	53.167***
	(6.51)	(6.20)	(6.12)	(6.57)	(7.69)	(7.32)
ISCED 6/7	79.161***	84.523***	80.118***	66.640***	53.898***	58.813***
	(6.35)	(7.40)	(6.11)	(6.54)	(6.97)	(6.16)
Parents: ISCED 1	13.857**	10.739*	20.588***	28.156**	26.858***	19.943**
	(4.75)	(4.19)	(5.18)	(7.58)	(6.38)	(6.35)
Parents: ISCED 2	12.715*	5.636	15.784**	13.160†	18.377*	14.311*
	(5.35)	(4.42)	(5.10)	(6.79)	(6.82)	(6.54)
Parents: ISCED 3	15.178*	8.864	20.995*	23.976**	24.878**	19.189**
	(6.73)	(7.46)	(8.09)	(6.99)	(6.76)	(6.76)
Parents: ISCED 5	16.344†	18.864†	25.114**	31.994**	42.727***	25.387**
	(8.26)	(9.77)	(8.14)	(9.70)	(8.01)	(8.47)
Parents: ISCED 6/7	11.120*	1.492	12.433†	25.746*	21.122*	10.587
	(4.96)	(5.16)	(6.19)	(9.77)	(9.44)	(8.89)
Distance between capitals	-0.034*	-0.030†	-0.044*	0.008	0.002	0.002
	(0.02)	(0.02)	(0.02)	(0.00)	(0.01)	(0.01)
Destination-fixed effects	yes	yes	yes	yes	yes	yes
Origin-fixed effects	yes	yes	yes	yes	yes	yes
R^2	0.689	0.678	0.651	0.649	0.641	0.635
N	871	871	871	650	650	650

*Notes: – Significant at: ***0.1% level; **1% level; *5% level; †10% level. – Standard errors in parantheses, computed using replicate weights and mean of plausible values to take sampling structure into account. – Education base category: ISCED1/No schooling. – Reference birth cohort: Born before 1940. – The dependent variable: Literacy test scores (range 0-500).*

Figure 2: Interaction Effects: Linguistic Distance, Age at Entry and Years since Migration



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7 Appendix

Table 6: Literacy and Linguistic Origin, Excluding Native Speakers

	Prose	Document	Quantitative
Linguistic Distance	-0.854*	-0.980*	-1.193**
	(0.37)	(0.37)	(0.38)
Ling. Dist. × Age at entry 12 or older	-0.551***	-0.514**	-0.385*
	(0.13)	(0.14)	(0.14)
Ling. Dist. × years since migration	0.016*	0.021**	0.018**
	(0.01)	(0.01)	(0.01)
Age at entry 12 or older	10.010	14.672	9.871
	(10.79)	(11.30)	(10.96)
Years since migration	-0.419	-0.555	-0.261
	(0.52)	(0.58)	(0.56)
Female	-4.323	-12.758*	-22.006***
	(4.34)	(4.94)	(4.87)
Born 1940-49	24.008**	29.889**	24.075**
	(7.78)	(7.98)	(7.41)
Born 1950-59	42.114***	56.657***	51.278***
	(9.86)	(9.95)	(9.34)
Born 1960-69	37.870**	50.707***	44.676***
	(10.89)	(11.82)	(10.85)
Born 1970-84	63.871***	84.299***	64.132***
	(12.90)	(14.04)	(13.25)
ISCED 2	15.975*	8.681	2.198
	(7.34)	(7.52)	(7.19)
ISCED 3	41.896***	46.049***	43.908***
	(5.77)	(6.24)	(5.89)
ISCED 5	69.831***	59.532***	58.103***
	(7.50)	(9.30)	(9.66)
ISCED 6/7	82.016***	82.735***	82.784***
	(5.77)	(7.41)	(6.58)
Parents: ISCED 1	20.155***	17.561**	20.486***
	(4.85)	(5.89)	(5.36)
Parents: ISCED 2	5.388	2.799	3.683
	(8.38)	(9.25)	(8.82)
Parents: ISCED 3	23.711**	19.845*	24.022*
	(7.82)	(9.30)	(9.02)
Parents: ISCED 5	3.312	2.454	7.839
	(9.27)	(8.39)	(8.28)
Parents: ISCED 6/7	-3.648	-16.309*	-13.540†
	(7.22)	(7.81)	(7.59)
Distance between capitals	-0.014	-0.011	-0.014
	(0.01)	(0.01)	(0.01)
Destination-fixed effects	yes	yes	yes
Origin-fixed effects	yes	yes	yes
R^2	0.631	0.646	0.633
N	830	830	830

*Notes: – Significant at: ***0.1% level; **1% level; *5% level; †10% level. – Standard errors in parantheses, computed using replicate weights and mean of plausible values to take sampling structure into account. – Education base category: ISCED1/No schooling. – Reference birth cohort: Born before 1940. – The dependent variable: Literacy test scores (range 0-500). – Native-speakers with LD = 0 are excluded from the estimations.*

Table 7: Different Thresholds for Critical Period

	(1)	(2)	(3)	(4)
Prose literacy				
Linguistic distance	-0.364***	-0.314***	-0.328**	-0.376***
	(0.07)	(0.08)	(0.09)	(0.07)
Ling. Dist. × Age at entry older than 5	-0.388***			
	(0.05)			
Age at entry older than 5	18.941***			
	(3.22)			
Ling. Dist. × Age at entry older than 8		-0.459***		
		(0.05)		
Age at entry older than 8		3.747		
		(4.08)		
Ling. Dist. × Age at entry older than 11			-0.446***	
			(0.06)	
Age at entry older than 11			0.397	
			(4.15)	
Ling. Dist. × Age at entry older than 14				-0.393***
				(0.06)
Age at entry older than 14				-0.149
				(4.58)
R^2	0.596	0.601	0.602	0.601
N	1521	1521	1521	1521
Document literacy				
Linguistic distance	-0.283**	-0.121	-0.128	-0.158†
	(0.09)	(0.10)	(0.10)	(0.09)
Ling. Dist. × Age at entry older than 5	-0.326***			
	(0.05)			
Age at entry older than 5	15.999***			
	(3.23)			
Ling. Dist. × Age at entry older than 8		-0.521***		
		(0.06)		
Age at entry older than 8		8.354*		
		(3.79)		
Ling. Dist. × Age at entry older than 11			-0.518***	
			(0.07)	
Age at entry older than 11			7.211†	
			(3.68)	
Ling. Dist. × Age at entry older than 14				-0.504***
				(0.06)
Age at entry older than 14				10.723*
				(4.94)
R^2	0.580	0.588	0.589	0.589
N	1521	1521	1521	1521
Quantitative literacy				
Linguistic distance	-0.412***	-0.257*	-0.247*	-0.259**
	(0.09)	(0.10)	(0.11)	(0.09)
Ling. Dist. × Age at entry older than 5	-0.214**			
	(0.06)			
Age at entry older than 5	18.472***			
	(3.21)			
Ling. Dist. × Age at entry older than 8		-0.396***		
		(0.06)		
Age at entry older than 8		11.007**		
		(3.87)		
Ling. Dist. × Age at entry older than 11			-0.413***	
			(0.08)	
Age at entry older than 11			9.333*	
			(3.79)	
Ling. Dist. × Age at entry older than 14				-0.418***
				(0.07)
Age at entry older than 14				11.163*
				(4.64)
R^2	0.565	0.568	0.569	0.570
N	1521	1521	1521	1521

*Notes: – Significant at: ***0.1% level; **1% level; *5% level; †10% level. – Standard errors in parantheses, computed using replicate weights and mean of plausible values to take sampling structure into account. – Omitted variables and specification: see Table 4 – The dependent variable: Literacy test scores (range 0-500).*

Table 8: Matrix of Linguistic Distance

Test language	Czech	Dutch	French	German	English	Finnish	Italian	Swedish	Hungarian	Slovenian
Albanian	93.23	95.86	94.03	95.78	95.64	98.77	93.75	98.36	98.54	93.17
Arabic	99.48	100	97.20	98.96	97.95	98.15	96.56	98.02	98.68	98.97
Byelorussian	51.32	92.94	93.05	90.27	90.28	99.13	92.54	91.47	93.68	53.04
Catalano	89.90	89.53	71.60	89.45	86.51	100.94	64.03	93.13	100.33	89.95
Chinese	101.12	99.68	98.74	99.43	98.67	101.52	99.02	99.51	102.53	99.95
Croatian	43.74	90.99	89.18	91.98	87.79	97.89	89.29	89.41	94.55	28.79
Czech	0.00	92.96	90.49	92.04	90.98	97.76	89.52	91.65	94.58	35.40
Danish	94.24	66.92	93.11	66.96	69.63	100.67	90.06	50.73	98.55	91.68
Dutch	92.96	0.00	91.06	51.50	63.22	99.00	87.28	64.95	99.16	90.92
English	90.98	63.22	91.02	72.21	0.00	102.27	89.23	64.40	95.22	90.46
Estonian	98.51	97.77	98.57	95.51	98.77	45.59	97.80	96.95	86.19	97.11
Finnish	97.76	99.00	98.08	96.31	102.27	0.00	100.46	98.11	84.53	97.35
French	90.49	91.06	0.00	95.87	91.02	98.08	73.89	93.95	100.65	90.92
Friulano	92.73	91.04	74.54	95.80	89.96	100.72	64.95	91.28	99.43	92.69
German	92.04	51.50	95.87	0.00	72.21	96.31	87.89	66.56	98.43	88.66
Greek	96.42	96.02	95.08	97.25	97.15	100.2	92.01	96.65	97.60	97.21
Hebrew	99.55	98.29	93.26	100.39	97.49	99.16	98.57	95.79	96.76	100.26
Hungarian	94.58	99.16	100.65	98.43	95.22	84.53	101.03	97.92	0.00	93.94
Indonesian	98.88	101.09	99.91	101.75	99.28	99.41	95.49	100.96	97.98	98.46
Irish	94.08	99.39	100.22	95.20	96.02	96.20	96.93	97.50	100.31	92.09
Italian	89.52	87.28	73.89	87.89	89.23	100.46	0.00	91.12	101.03	87.76
Japanese	101.76	101.92	101.94	100.14	99.39	96.98	99.80	100.34	98.18	102.19
Korean	99.85	99.04	102.74	104.3	99.12	100.18	98.51	99.44	100.92	96.96
Macedonian	50.58	91.08	89.68	89.08	91.21	96.26	87.90	92.85	97.04	35.45
Malay	98.88	101.09	99.91	101.75	99.28	99.41	95.49	100.96	97.98	98.46
Moroccan	99.48	100	97.20	98.96	97.95	98.15	96.56	98.02	98.68	98.97
Norwegian	90.57	63.29	94.38	64.92	64.12	101.21	91.67	45.52	99.17	88.90
Persian	94.93	92.19	91.11	93.89	94.31	97.36	90.31	98.93	99.38	93.92
Polish	44.93	94.55	92.89	96.09	93.80	95.28	91.11	95.28	95.59	46.51
Portuguese	95.49	94.86	74.36	93.59	95.18	99.44	62.50	95.47	99.04	93.82
Punjabi	93.26	92.09	95.56	91.81	97.38	96.34	86.19	93.90	94.43	93.64
Romanian	90.37	87.21	74.39	87.66	85.55	99.53	52.03	92.85	99.25	88.61
Romansch	87.89	90.16	77.73	92.15	89.04	99.23	72.12	91.70	100.48	86.31
Romany (gypsy)	96.49	97.19	92.37	93.05	98.98	98.08	90.51	96.88	97.81	93.33
Russian	60.40	95.19	92.83	94.41	94.02	96.49	95.24	96.67	96.96	56.65
Serbian	43.74	90.99	89.18	91.98	87.79	97.89	89.29	89.41	94.55	28.79
Serbo-croatian	43.95	91.26	89.89	91.49	88.40	96.63	89.40	87.91	96.84	33.94
Slovak	32.59	92.17	90.81	93.05	91.99	98.76	91.53	90.71	95.80	44.26
Somalian	99.00	98.97	100.07	100.15	103.03	97.17	98.90	99.58	100.83	100.14
Spanish	90.55	91.82	81.07	94.69	93.08	99.18	56.51	93.31	102.12	90.90
Swedish	91.65	64.95	93.95	66.56	64.40	98.11	91.12	0.00	97.92	90.22
Swiss-german	89.68	68.27	93.23	48.34	73.51	94.65	90.78	71.17	98.00	87.48
Tamil	97.37	96.93	96.82	100.2	100.81	99.57	99.97	101.62	101.93	98.18
Turkish	98.81	102.33	98.12	99.91	101.04	96.70	98.22	101.35	94.55	98.89
Ukrainian	60.23	95.06	95.41	94.00	97.35	99.12	94.70	92.87	95.77	54.34
Vietnamese	99.72	100.81	101.81	96.14	104.06	97.80	100.39	99.17	98.86	101.25

Notes: – Source: Own calculations using programs for calculating ASJP distance matrices (Version 2.1), see `http://email.eva.mpg.de/~wichmann/software.htm`.