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Running head: AOA RATINGS OF 299 WORDS ACROSS 25 LANGUAGES

Ratings of age of acquisition of 299 words across 25 Languages. Is there a cross-linguistic order of words?

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Abstract

We present a new set of subjective Age of Acquisition (AoA) ratings for 299 words (158 nouns, 141 verbs) in 25 languages from 5 language families (Afroasiatic: Semitic languages; Altaic: Turkic language; Indo-European: Baltic, Celtic, Germanic, Hellenic, Slavic and Romance languages; Niger-Congo: Bantu language; Uralic: Finnic and Ugric languages). Adult native speakers reported the age at which they had learned each word. We present comparison of the AoA ratings across all languages by contrasting them in pairs. This comparison shows a consistency in the order of ratings across 25 languages. Data are then analysed (1) to ascertain how demographic characteristics of participants influence AoA estimations and (2) to assess differences caused by the exact form of target question (when did you learn vs. when do children learn this word); (3) to compare ratings obtained in our study to those of previous studies; and (4) to assess the validity of our study by comparison with quasi-objective AoA norms derived from MacArthur-Bates Communicative Development Inventories (MB-CDIs). All 299 words were judged as acquired early (mostly before the age of 6 years). AoA ratings were associated with the rater's social or language status, but not with the rater's age or education. Parents reported words to be learned earlier, and bilinguals later. Estimations of the age at which children learn the words revealed significantly lower ratings of AoA. Finally, comparisons with previous AoA and MB-CDI norms support the validity of the present estimations. Our AoA ratings are available for research or other purposes.

Introduction

A body of research suggests that words acquired earlier in life are processed faster than words learned later. This effect, called the age of acquisition (henceforth AoA) effect, has been observed in various lexical tasks over the last 40 years (Juhász, 2005) in both children and adults. AoA effect plays a significant role in word processing and should be used as a control factor in experiments in which different word stimuli are used. The goal of this paper is to provide fully comparable subjective ratings of AoA obtained with the very same procedure for the same set of words, both nouns and verbs, across 25 languages from 5 different language families. To the best of our knowledge, this is the very first study comprising such a number of diverse languages. Previous studies were typically conducted in one language only or in a pair of languages. Opportunities for cross-linguistic comparisons of previous studies' results were diminished by the fact that these studies also differed in terms of the list of words used and in other significant details of their procedures. The current study also considers the potential effects of the participants' age, education, number of languages known and parental status on AoA ratings.

AoA effect

A large number of studies have examined AoA, and most of the representative studies show an effect of AoA on different tasks performed by children and adults. These are summarised by type of task and language in Table 1. To date, the tasks in which the AoA effect has been evidenced for common words have been: picture naming, word naming, object recognition, word category decision, semantic classification, associations, lexical decision, orthographic decision or sentence reading. It is notable that most of the available studies to date focused on AoA in a single language.

Most of the studies were performed with adults, although three studies report child data (aged from 3 to 10) and two studies had teenagers as participants (aged from 11 to 17). In

the majority of the studies with adults, only students were participants (e.g. Baumeister, 1984; Bonin et al., 2001; Colombo & Burani, 2002; Holmes & Ellis, 2006; Meschyan & Hernandez, 2002; Perez, 2007; Juhasz & Rayner, 2006; Mobaghan & Ellis, 2002; Navarrete et al., 2013; Turner, Valentine & Ellis, 1998). However, some studies contrasted either younger adults with older adults (Barry, Johnston & Wood, 2006; De Deyne & Storms, 2007; Morrison, Hirsh & Duggan, 2003; Sirois, Kremin & Cohen, 2006) or adults suffering from impairments with control groups (Alzheimer's disease: Lambon Ralph & Ehsan, 2006; Lymperopoulou, Barry & Sakka, 2006; cognitive impairments: Morrison, Hirsh & Duggan, 2003; aphasia: Catling, South & Dent, 2013).

Subjective and objective AoA

Subjective AoA

In the majority of AoA studies, subjective AoA ratings were obtained by asking adult native speakers to estimate when they had learned given words, by indicating either the exact age (in years) or an age range on a scale. This procedure has been used widely for both English and other languages such as: Chinese, Dutch, French, German, Greek, Icelandic, Italian, Japanese, Persian, Portuguese, Russian, Spanish and Turkish (see Table 2 for studies on each language). Although there are concerns regarding the validity of such subjective ratings in terms of adults' inability to remember the exact age of word learning (e.g. Morrison, Chappell, & Ellis, 1997), many studies have found these estimates to be predictive of various processing variables in different types of tasks as listed above (list of references is presented in Table 1).

Objective AoA

Objective measurement of AoA has been based on spontaneous speech samples of children of various ages. Once the samples are transcribed and the words occurring in the transcriptions are counted by age groups, it is possible to estimate the AoA of the words present in the samples. The age at which a given word appears in the speech of the majority of children or

reaches an arbitrarily set criterion of cumulative frequency is identified as its AoA. For instance, Piñeiro and Manzano (2000) defined the AoA of a word as the age range in which the word's cumulative frequency reaches 10% of its total frequency (in a given sample). They analysed transcriptions of spontaneous speech of 200 children aged 11 to 49 months (divided into eleven age intervals of 2 to 4 months), and for each word they calculated its overall token frequency in the sample (total frequency). AoA was calculated only for words of which the total frequency equalled at least 10 (298 word types). They assessed cumulative frequency by age intervals, and the lowest age interval in which a criterion of 10% of total frequency for a given word was reached was assumed to be this word's AoA. They differentiated AoA from the first time uttered (FTU), explaining that the FTU indicates the age interval within which a specific word may appear for the first time, whereas AoA shows approximately the age at which the same word begins to receive a determined meaning in the active vocabulary of the child (Piñeiro & Manzano, 2000). However, the AoA norms estimated on the basis of spontaneous speech production of children may (1) not include all the vocabulary utilized by children, (2) depend strongly on the context of data collection and (3) be limited in that it does not include words comprehended but not yet produced by children.

Norms for the MacArthur-Bates Communicative Development Inventories (Fenson et al., 1993, 2007) (henceforth MB-CDI) also act as a source of information on the age at which children learn words. In the MB-CDI studies, parents of young children (aged from 8 to up to 36 months, depending on the language) assess which of the words listed their children have comprehended and/or produced. On the basis of parental reports, it is possible to determine how many children in a given age range know the particular words. These indices allow one to establish the age at which the majority of children understand or say the items. The AoA ratings obtained by this procedure should be treated as quasi-objective as they rely heavily on an indirect measurement of vocabulary knowledge: the parental report. Yet, MB-CDI in itself

has been validated by independent direct testing of the child vocabulary and was found highly reliable (e.g. Dale, 1991; Dromi, Maital, Sagi, & Bornstein, 2000; Elin Thordardotir & Ellis Weismer, 1996; Heilmann, Ellis Weismer, Evans, & Hollar, 2005; Thai, O'Hanlon, Clemmons, & Fralin, 1999).

Another method to assess objective AoA is elicitation of children's verbal production using picture naming (Morrison et al., 1997). In this procedure, participants are shown a set of pictures of common objects or activities which they have to name. To obtain the AoA, participants are classified by age and the AoA of a given word is considered to be the mean age of the group in which the picture is correctly named with relatively high frequency (usually, equal to or greater than 75%). This method has been used in several studies focusing on a total of seven languages (see Table 2 for detailed references): Chinese, English, French, Icelandic, Italian, Russian and Spanish. Researchers examined different age ranges from 2 to 15 years, usually 2 to 11 years. Objective AoA ratings have also been calculated on the basis of word definitions provided by participants aged 5 to 21 years (Gilhooly & Gilhooly, 1980).

Although some researchers prefer to use objective ratings (e.g. Morrison et al., 1997), results obtained by the two methods have proven to be highly correlated, at least for some languages. Carroll and White (1973b) correlated subjective AoA ratings collected from 62 adult speakers of English with objective measures of AoA (ratings of how often different age groups use some words in reading and writing) and obtained a coefficient of .85. Gilhooly and Gilhooly (1980) found a correlation of .93 between ratings of AoA provided by 70 psychology students and the standardized Crichton/Mill Hill vocabulary norms for children aged 5 to 11 years (Gilhooly & Gilhooly, 1980). Additionally, they reported a correlation of .84 ratings and accuracy in a word defining task in which children aged 5 to 13 years were asked to describe the meaning of words. Similarly, a correlation ($r = .76$) between subjective AoA and objective AoA (defined as the age at which 75% of children in a given age group

knew the name for an object in a picture naming task) was found by Morrison, Chappell and Ellis (Morrison et al., 1997). Other studies (De Moor, Ghyselinck, & Brysbaert, 2000; Jorm, 1991; Lyons, Teer, & Rubenstein, 1978) have also provided evidence for the validity of subjective AoA ratings as a psycholinguistic variable.

Methodological aspects of AoA studies

Scales used in AoA studies

In the majority of subjective AoA studies, one of four types of scales was used: a 11-point scale based on equivalent age, a 9-point scale utilized for the first time by Carroll and White (1973), a 7-point scale introduced by Gilhooly and Logie (1980) or a 5-point scale. These scales were mostly used as a variant of Likert-type scales (see descriptions in Table 3) in studies where norms for other psycholinguistic variables such as familiarity, imageability, concreteness, meaningfulness, visual complexity, name and image agreement, and subjective frequency were collected in addition to AoA (e.g. Akinina et al., 2014; Alario & Ferrand, 1999; Bakhtiar et al., 2013; Barca et al., 2002; Bird et al., 2001; Bonin et al., 2003; Cuetos et al., 1999; Della Rosa et al., 2010; Dimitropoulou et al., 2009; Ferrand et al., 2008; Gilhooly & Logie, 1980; Liu et al., 2011, 2007; Manoiloff et al., 2010; Moreno-Martínez et al., 2014; Nishimoto et al., 2005; Pind et al., 2000; Raman et al., 2013; Salmon et al., 2010; Shao et al., 2014; Sirois et al., 2006; Snodgrass & Yuditsky, 1996; Stration et al., 1975; Tsaparina et al., 2011; Vinson et al., 2008). Other scales have sometimes been modified according to the objectives of the specific study. For example, Auer and Bernstein (2008) used an 11-point scale with the last point set at age 21 as they assumed that many of their stimuli would be assessed as acquired after the age of 13 years.

Other studies (Cuetos, Samartino, & Ellis, 2012; De Deyne & Storms, 2007; Della Rosa et al., 2010; Ferrand et al., 2008; Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012; Stadthagen-Gonzalez & Davis, 2006) did not use an explicit scale; rather, participants were

asked to provide their subjective AoA directly in years, e.g. to type the number “3” if they thought they had learned a given word at the age of 3 years, and “N” or “X” if they did not know the word at the time of data collection (Ferrand et al., 2008, Kuperman et al., 2012). Ferrand et al. argued that participants find the scaleless instruction easier to follow. Moreover, this kind of measure returns more precise information about the AoA of particular words.

Target/experimental question in subjective AoA studies

Most AoA studies discuss the exact form of the target question used to elicit the AoA ratings in far less detail than they discuss the scale used. A review of 54 publications revealed that the majority of the subjective AoA studies did not state the exact form of the question at all (Akinina et al., 2014; Alario & Ferrand, 1999; Alonso, Fernandez, & Díez, 2014; Bakhtiar et al., 2013; Christopher Barry, Johnston, & Wood, 2006; Bird et al., 2001; Bonin, Boyer, Méot, Fayol, & Droit, 2004; Bonin et al., 2003; Bonin, Perret, Méot, Ferrand, & Mermillod, 2008; Cameirao & Vicente, 2010; Colombo & Burani, 2002; Cuetos et al., 1999, 2012; De Deyne & Storms, 2007; Della Rosa et al., 2010; Dimitropoulou et al., 2009; Johnston, Dent, Humphreys, & Barry, 2010; Lyons et al., 1978; Manoiloff et al., 2010; Marques, Fonseca, Morais, & Pinto, 2007; Moors et al., 2012; Moreno-Martínez et al., 2014; Nishimoto et al., 2005; Nishimoto, Ueda, Miyawaki, Une, & Takahashi, 2012; Raman et al., 2013; Schock, Cortese, Khanna, & Toppi, 2012; Schröder, Gemballa, Ruppín, & Wartenburger, 2011; Sirois et al., 2006; Stration et al., 1975; Tsaparina et al., 2011; Vinson et al., 2008; Walley & Metsala, 1992; Winters Jr, Winter, & Burger, 1978). In the remaining papers, the wording “When do you think you learned this word?” is most frequently used (e.g. Auer Jr & Bernstein, 2008; Barca et al., 2002). Some authors report the definition of word learning used in their studies (Kuperman et al., 2012; Moors et al., 2012; Shao et al., 2014; Stadthagen-Gonzalez & Davis, 2006), explaining that the AoA of a word is the age at which participants

would have understood that word if somebody had used it in front of them, even if they did not themselves use, read or write it at the time.

All studies have so far focused on participants' own experience of word learning. This method may return ratings that overestimate the AoA of some relatively new words (e.g. a computer). So far, no study has used a question concerning adult participants' opinions on the word learning of today's children: "When do children learn this word?". To avoid task discrepancy in the way estimations were elicited, we followed the most frequent pattern of target question ("When have you learned this word?") in the current study. However, as we expected that the exact form of the target question might reveal differences in the estimations, we conducted a one-language control study in which a question on current children's experience was used.

Word classes in AoA studies

The vast majority of both objective and subjective AoA ratings have been gathered for nouns only (e.g. Alario & Ferrand, 1999; Álvarez & Cuetos, 2007; Bakhtiar et al., 2013; Barbarotto et al., 2005; Barca et al., 2002; Barry et al., 1997; Bonin et al., 2003; Cannard & Kandel, 2008; Carroll & White, 1973a, 1973b; Chalard et al., 2003; Cortese & Khanna, 2007, 2008; Cuetos et al., 1999, 2012; De Deyne & Storms, 2007; Della Rosa et al., 2010; Dimitropoulou et al., 2009; Ghyselinck et al., 2000; Grigoriev & Oshhepkov, 2013; Iyer et al., 2001; Johnston et al., 2010; Liu et al., 2011; Lotto et al., 2010; Lyons et al., 1978; Manoilloff et al., 2010; Marques et al., 2007; Moreno-Martínez et al., 2014; Morrison et al., 1997; Nishimoto et al., 2005, 2012; Pérez & Navalón, 2005; Pind et al., 2000; Raman et al., 2013; Salmon et al., 2010; Schröder et al., 2011; Sirois et al., 2006; Snodgrass & Yuditsky, 1996; Stration et al., 1975; Tsaparina et al., 2011; Winters Jr et al., 1978). Other word classes have been included in only 17 studies (Akinina et al., 2014; Alonso et al., 2014; Bird et al., 2001; Brysbaert et al., 2014; Bonin, Boyer, et al., 2004; Cameirao & Vicente, 2010; Colombo & Burani, 2002;

Ferrand et al., 2008; Ghyselinck et al., 2003; Gilhooly & Hay, 1977; Gilhooly & Logie, 1980; Kuperman et al., 2012; Moors et al., 2012; Piñeiro & Manzano, 2000; Schock et al., 2012; Shao et al., 2014; Stadthagen-Gonzalez & Davis, 2006). However, in most of these studies, even if verbs or other word classes were included, nouns were still the dominating category (in terms of number of items). Only two megastudies included all possible word classes, comprising as many as 30,000 words: one for English (Kuperman et al., 2012) and one for Dutch (Brysbaert et al., 2014). The present study is the first which aims to make available AoA ratings for a balanced number of nouns and verbs in a wide range of languages, thereby making it possible to compare AoA of both word classes cross-linguistically.

Word set size in AoA studies

The size of the word set for which AoA ratings were collected also differed between studies, from 80 (Barbarotto et al., 2005) to as many as 30,000 (Brysbaert et al., 2014; Kuperman et al., 2012), but mostly between 100 and 850 words (for 72% of the 64 studies reviewed). In some cases, the size of the dataset depended on the number of pictures accompanying the study (e.g. 260 pictures of the Snodgrass & Vanderwart (1980) picture set was used in: Barry, Morrison, & Ellis, 1997; Dimitropoulou et al., 2009; Pind et al., 2000; Raman et al., 2013; Snodgrass & Yuditsky, 1996; Tsaparina et al., 2011). In the current study, we used a limited set of 299 words, which had previously been used in a cross-linguistic naming study and had been shown to have the same meaning in 34 languages (Haman, Łuniewska & Pomiechowska, 2015; Haman, Mieszkowska, et al, 2015).

AoA across languages

In the studies mentioned above, subjective AoA has been estimated in 14 different languages, mostly Indo-European. For Germanic languages, data have been gathered for Dutch, English, German, Icelandic and Norwegian. For Romance languages, data are available for French, Italian, Portuguese and Spanish. Other Indo-European languages studied are Greek, Persian

and Russian. The only languages outside the Indo-European family so far which have AoA ratings are Chinese, Turkish and Japanese (see Table 2).

However, there are no fully comparable ratings of objective or subjective AoA obtained with the very same procedure across languages. Some of the AoA studies are based on the same set of words linked to the Snodgrass and Vanderwart object pictures (e.g. Barry et al., 1997 (English); Pind et al., 2000 (Icelandic); Snodgrass & Yuditsky, 1996 (English); Tsaparina et al., 2011 (Russian)). However, although the same set of words was rated in these studies, the data collection procedure varied. In the studies by Snodgrass and Yuditsky (1996) and Pind and colleagues (2000), participants were asked to rate when they thought they had learned the words that they saw accompanied by the Snodgrass and Vanderwart pictures (black-and-white version); in the study by Tsaparina et al. (2011), participants saw a colorized version of the pictures (Rossion & Pourtois, 2004), whereas in the Barry et al. study (1997) participants saw only written words. Also, different measurement scales were used in the studies: Tsaparina et al. used a 5-point scale, while a 7-point scale was used by Barry et al. and Pind et al., and a 9-point scale was used in the study by Snodgrass and Yuditsky. Different procedures and measurement scales make the results obtained in these studies hard to compare cross-linguistically, as ratings may depend on both the exact stimulus form and the type of scale used.

The current study

The motivation for our study was both practical and theoretical. First, because of the existence of the AoA effect (viz. the observation that words acquired earlier in life are processed faster than words learned later, as described above), we planned to use AoA ratings as a factor for the construction of cross-linguistic lexical tasks (Haman, Łuniewska & Pomiechowska, 2015). Second, by performing the AoA study in a uniform way across such a wide range of languages, we aimed to obtain new evidence for the classic claim of a universal

pattern in early meaning acquisition among languages (Clark, 1979; 1995; 2001). Clark argued that children's early words in various languages fall into a small number of the same semantic categories like: people, food, body parts, clothing, animals, vehicles, toys, household objects, routines and activities or states (Clark, 2009, p. 76). This argument was based on cross-linguistic speech diaries analysis and comparison of its results with the MB-CDI's list of the first 50 words in American English (Fenson et al, 1994). Clark further argues that in the course of lexical development over the second and third years of life, children elaborated the semantic domains by adding new words into and subdividing the domains (Clark, 1995). Although the current study is not limited to children's early words, about 95% of words used in the study fall into categories indicated by Clark. Thus, we assumed that universality of early semantic categories and the process of their elaboration in child language may be also reflected in the age of acquisition order of words similar across languages.

Therefore, we collected data on subjective AoA ratings in 25 languages to assess how stable the ratings can be cross-linguistically and to check their validity by comparing them between language pairs and with previous AoA scores. We expected the ratings to be correlated between language pairs, and we predict that the more similar two languages or cultures are, the higher the correlation coefficients will be.

Additionally, we analyse how demographic characteristics of participants (their gender, age, education, being a parent or not, and language status) influence their AoA estimations. We expected that the AoA of the majority of the words would not depend on participant age. There are some words that might have been acquired earlier by younger and later by older participants, according to the availability of the objects and action depicting the words when the participants were growing up. Specifically, we predicted that several words labelling new artefacts (e.g. a computer) and more recently introduced activities (e.g. to surf) would be rated as acquired relatively earlier in life by the younger group and later by the older group. We did

not expect the AoA ratings to depend on participants' education level and gender. However, we did assume that being a parent (having or recently having had small children who are acquiring language) may influence adults' ability to assess when they themselves learned the words – i.e., their ratings may be affected by fresh experience with their own children.

As bilingual children typically have smaller vocabulary sizes than their monolingual peers (if measured in one language only), they may acquire some words later than monolinguals (Bialystok, Luk, Peets, & Yang, 2010). We predict that adults who report that they speak more than one language at a level similar to that of native speakers and who began their second language learning in childhood will estimate that they learned words later than monolinguals.

In the current study, we also assessed whether two different target questions, “When have you learned this word?” vs “When do children learn this word?”, affect ratings for words. As stated above, children might nowadays learn words for recently introduced objects and activities at a young age whereas older participants might have been more advanced in age at the time of introduction of said objects and activities.

Besides comparison with previous AoA data, we adopted another method of validity estimation, following the study by Lind et al. (2015). We compared our data to available norms for MB-CDIs in 9 languages: American English (Dale & Fenson, 1996), Croatian (Kuvac et al., 2009), Danish (Bleses et al., 2008), German (Szagun, Stumper & Schramm, 2009), Italian (Camaioni et al., 1991), Mexican Spanish (Dale & Fenson, 1996), Russian (Eliseeva & Vershinina, 2009), Swedish (Eriksson & Berglund, 1999) and Turkish (Aksu-Koç et al., 2009).

For a given pair of data (MB-CDI vs AoA), the percentage of children who know a given word at a certain age (obtained from MB-CDIs norms) was contrasted with the mean AoA of the same word (obtained in the current AoA study). The higher the proportion of

children who were reported to know the word, the lower we expected the AoA for a given word to be. Thus, we expected negative correlations between the MB-CDI norms and the AoA ratings.

Although MB-CDIs are now available in 61 languages (Dale & Penfold, 2011), normative data for single words have so far only been published for 6 out of the 25 languages included in our sample (Jørgensen et al. 2009). Thus, in the case of these 6 languages (Danish, German, Italian, Russian, Swedish and Turkish), we were able to compare our AoA ratings with the MB-CDI norms in exactly the same language. MB-CDI norms were also available for another three languages which are very close to the ones from our sample. Thus, we compared the AoA ratings in Serbian, Spanish, and both British and South African English to the MB-CDI norms to the available MB-CDI norms for Croatian, Mexican Spanish and American English, respectively). The available MB-CDI norms were either downloaded from the Wordbank (<http://wordbank.stanford.edu/>; in the case of all Turkish data and Croatian Words & Sentences part) or the CLEX website (<http://www.cdi-clex.org/>; in the case of the remaining data).

There are two versions of the MB-CDI, namely Words & Gestures (adapted mostly for toddlers aged 8–18 months and assessing both word production and comprehension) and Words & Sentences (designed for assessment of word production only in older children, mostly aged 16 to 36 months). We used both MB-CDI versions for Danish, Russian, Turkish, American English, Serbian and Mexican Spanish. Thus for these languages we analysed norms obtained from children aged 8 to 36 months. Swedish norms were available only for the Words & Gestures part and hence only for children aged 8 to 16 months, whereas German and Italian norms were available only for children aged 18 to 36 months in the Words & Sentences part.

For 7 of the 9 languages used in the comparisons, the MB-CDI norms included ratings for both receptive and expressive vocabulary. Although in our AoA study participants were asked to estimate when they could understand the word, which explicitly taps receptive vocabulary knowledge, we contrasted our results with both receptive and expressive norms from MB-CDIs. However, it was expected that receptive MB-CDI norms would have a stronger relation to our AoA results than would the expressive MB-CDI norms.

Method

Participants

Participants were 827 adults, a minimum of 20 per language (total range: 20 to 124, $M = 31$, $SD = 21$; Table 4). Data from 31 participants were excluded from the analyses for reasons described in detail in the Data Processing section below. Participants whose data were included in subsequent analyses were 622 females (78%) and 174 males, aged 18 to 80 ($M = 30.8$, $SD = 12.3$). Participants were recruited in a variety of ways: mostly via academic communication (lecturers informing students about the study) or by social media (e.g. Facebook), but also through neighbourhood networks and chain-referral sampling. Participants received certificates of participation on request, and participants for some languages also received course credits. All participants reported their education level, occupation, country of residence, native language, number of spoken and used languages, and number and age of their children.

Twenty-three of the participants described above took part in the control study where the target question was replaced with the one concerning word knowledge in children. They were all Polish native speakers (17 female; age: $M = 38.6$, $SD = 10.7$). None of these participants participated in the study where the main question ("When did you learn the word?") was used.

Stimuli

The same sets of 158 nouns and 141 verbs (total of 299 words) were used in each language. The words were selected in a previous online picture naming study (Haman, Łuniewska and Pomiechowska, 2015; Haman, Mieszkowska et al., 2015) conducted in 34 languages, including each of the languages considered in the current study. As the words were selected based on the picture naming study, they labelled imaginable objects and actions.

In the naming study, 93 competent raters (native speakers of 34 different languages) named 1024 pictures (507 object and 517 action pictures). Each participant first assessed whether the pictures easily evoked a single word in his/her native language. The rater then provided words in her/his native languages for objects and actions presented in the pictures and then typed the English equivalents of these words. Additionally, for purposes not linked to the present study, participants provided ratings of the picture style. All pictures in the naming study had previously been used in various psycholinguistic studies (with both children of various ages and with adults) in a total of 15 languages. They were gathered from 8 sources, representing different picture styles (line drawings, photos, colour drawings etc.).

Data from 76 raters who completed more than 25% of the procedure were used to select the most widely shared meanings. Haman and colleagues selected words on the basis of the highest agreement of naming (computed on the English translations). The pictures illustrating the selected words had thus been assessed by the majority of the judges across languages as easily evoking one word or several words similar in meaning. Words for objects and actions were selected separately. This procedure, together with AoA ratings, was initially designed as a basis for the construction of LITMUS Cross-linguistic Lexical Tasks for the assessment of word knowledge in bilingual and multilingual children (Haman, Łuniewska and Pomiechowska, 2015).

25 language versions of the online procedure

Lists of target words for each language were obtained as described above. In each language, the list of target words consisted of the labels provided by native speakers of this language during the naming study (Haman, Łuniewska and Pomiechowska, 2015; Haman, Mieszkowska et al., 2015).

Instructions for the current study and all other information were first prepared in English. However, in order to avoid inconsistencies, collaborators speaking all languages involved were consulted at the stage of preparing the English version and again while target language versions were being prepared. Thus, adaptations of the procedure and the instructions for languages other than English were not mere translations of the English version; rather, they were pre-prepared during the first stage of study design. After preparing the model English version, all materials (the website, instruction, examples etc.) were translated into each of the languages involved by native speakers who were also researchers (linguists or psycholinguists, mostly co-authors of the present paper).

Procedure

The procedure was available online via a website designed exclusively for the purposes of the study (www.words-psych.org). The website was made available in all 25 languages, so participants could use their native language exclusively while using the website. After entering the website, participants were instructed to download a file and open it in Microsoft Excel (or Open Office). The file contained four sheets. The first sheet presented basic information about the study and the instructions, and the second sheet contained questions on the demographics of the participants. The lists of nouns and verbs were presented on the third and fourth sheets, respectively. All the instructions, questions and words were presented in the mother-tongue of the participants.

Participants were asked to decide at what age they had learned the words presented in the two sheets. The instruction was: “For each word please estimate the age (in years) at which you think you learned this word; that is, the age at which you would have understood that word if somebody had used it in front of you, even if you did not use, read or write it at the time”. The exact form of the question was: “When did you learn the word?”. Participants were asked to type a number from 1 (if they thought they had learned the word when they were one year old) to 18 (if they thought they had learned the word when they were 18 or older). They were encouraged to guess the age if they were not sure and not to spend too much time on any single word. If they did not know the word, they were asked to enter “X” in the box. Both the instruction and the target question used in the current study closely matched those used in Kuperman, Stadthagen-Gonzalez & Brysbaert (2012), who in turn followed the instructions proposed by Stadthagen-Gonzalez & Davis (2006). Although many studies used Likert scales rather than a continuous scale (from 1 to 18 or up to participants’ current age), we decided to use the latter one, following the remark of Kuperman et al. (2012) that “[Likert-like scale] artificially restricts the response range and is also more difficult for participants to use” (p. 980). Also, Ghyselinck et al. (2003) state that using a continuous scale makes the instructions given to participants as simple as possible.

To ensure that the participants understood the instructions, we provided four examples of both nouns and verbs acquired early and later in life. The examples were presented in a table that looked similar to the one filled out by the participants. Explanatory comments were added to the table (e.g. “Someone estimates that s/he learned the word ‘to ask’ at the age of 3 years.”).

The words on both the noun and the verb list were presented in a random order, generated individually for each participant during the file downloading. In the Nouns and Verbs sheets, below the list of words, a short thank-you note was presented together with a

reminder of the other sheet (“Thank you for filling in the table for nouns. Have you filled the table for verbs as well?”). Each participant was given the full list of all 299 words. Task duration was about half an hour. After filling in the file, participants were asked to upload it via the website or send it as e-mail attachment to the address reserved for the purposes of the study.

For 2 out of 25 languages, Hebrew and Luxembourgish, a paper and pencil version of the procedure was applied. In these two languages, the files were downloaded from the website by an experimenter, then printed and distributed among the participants. The instructions and organization of the sheets were identical to those in the online procedure. The only reason for running the study off-line for these two languages was difficulty with recruitment for online participation.

In the control study that addressed if the question form affects the ratings, the procedure was the same as that described above. The only modified factors were the target question form (“When do children learn this word?” instead of “When have you learned the word?”) and the descriptions of the examples (“Someone estimates that children learn the word ‘to ask’ at the age of 3 years.”). The control study was run only in Polish in an across-subjects design. Participants of the control study did not participate in the main study, as this could have affected Polish ratings in both designs.

Data processing

In the first step of data processing, we excluded data from any respondent who did not follow the procedure of ratings collection. Data from 16 respondents were excluded as they reported that they were not native speakers of the language in which they completed the survey.

Additionally, we removed data from 9 respondents who did not provide demographic information and from 6 who had assessed less than 50% of 299 words. Altogether data of 31 respondents (3.8%) were removed from the database. Most of the remaining participants

(84%) assessed more than 95% of the words. Only 2% of the participants provided estimations for less than 75% of the words. Participants who did not provide data for all items skipped some of the words in the file by leaving those lines blank. The blank lines were located in various parts of the files and were equally distributed across the items.

The second step aimed at removing all outliers from further analyses. We defined outliers as disproportionally high or low values for both the word and the participant in a given language. We excluded ratings meeting both of the following two criteria: (1) being 3 SD higher (or lower) than the mean for that word in a given language, and (2) being 3 SD higher (or lower) than the average estimation provided by a given participant inside a word class. Thus, to be an outlier, a single estimation of AoA of a particular word had to be both very late in comparison to other words learned by that participant, and very late in comparison with the average AoA of that word in the same language. In this step, we removed 137 of the 125,879 ratings for nouns, and 110 of the 113,174 for verbs (both about 1%).

Although the instruction allowed participants to type “X” if they did not know a given word, there were no “X” answers. Thus, we did not include this type of response in the analysis.

Results

Descriptive results

The ratings obtained for each of the 25 languages are presented in the supplemental material. All of the words in the set were reported to be acquired between 1 and 12 years of age and 98% of the words were assessed as known to children younger than 7 years.

Cross-linguistic comparison

The AoA ratings in all languages are significantly correlated (Spearman rho adjusted for split-half reliabilities range from .60 to .96; Table 5). The highest correlations were obtained for

Polish and Slovak (adjusted $r_S = .96$), Maltese and Greek (adjusted $r_S = .93$), British and South African English (adjusted $r_S = .91$). The adjusted coefficients were the lowest for Hungarian correlated with Italian (adjusted $r_S = .62$), Irish (adjusted $r_S = .64$), and Hebrew (adjusted $r_S = .65$); see Figure 1.

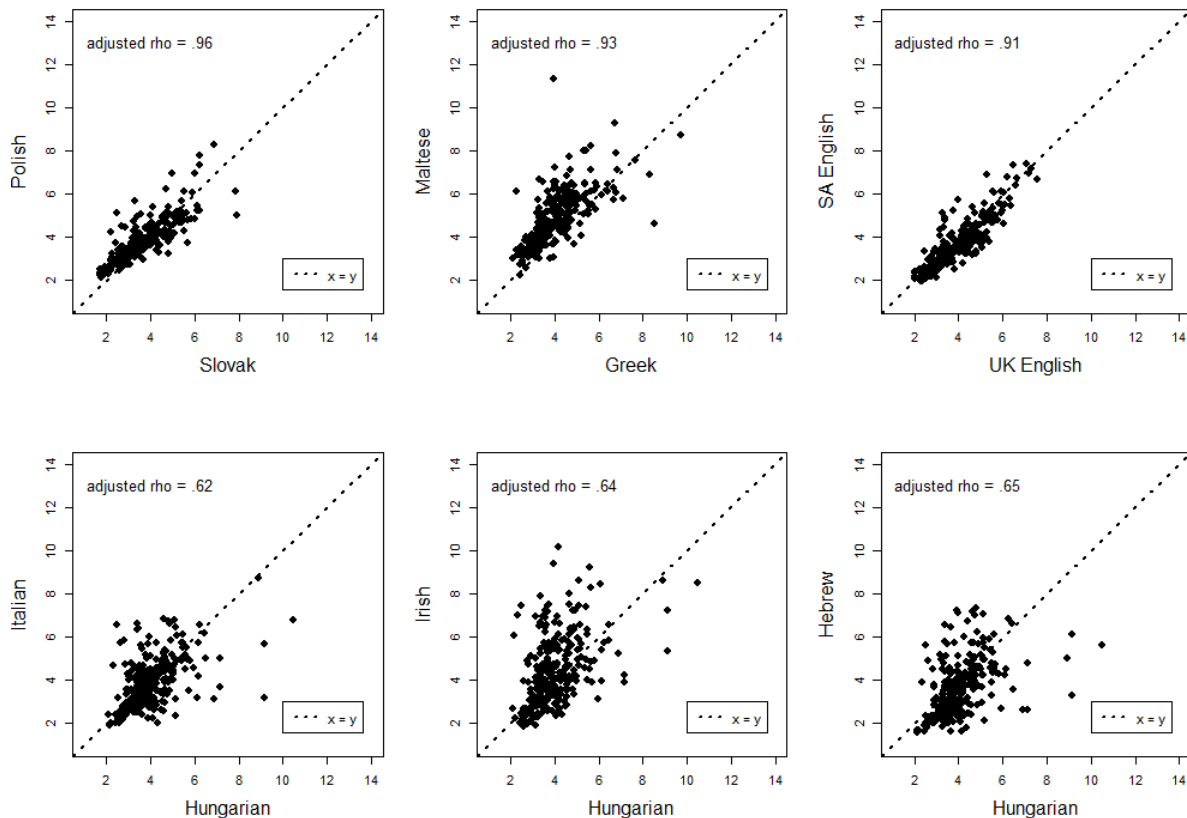


Figure 1. Highest (upper row) and lowest (lower row) correlations in language pairs.

Although the order of word acquisition is similar across all the languages studied, there are significant differences in raw ratings of words between languages (see Figure 2). Most of the words from our list were acquired between 2 and 8 years, and the vast majority of them are reported to have been learned between 3 and 5 years. However, there are three evident exceptions among the languages: (1) Finnish, in which words are reported to be acquired earlier than in the other languages, and the majority of the words are acquired by the age of 4

years, and (2) Maltese and isiXhosa, in which words are reported to be acquired relatively later.

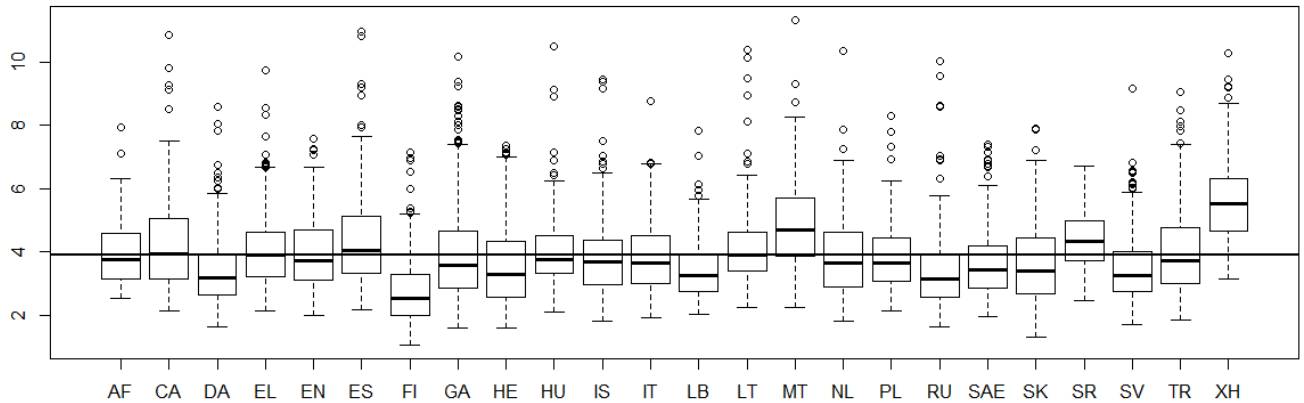


Figure 2. Means for AoA ratings across 25 languages. The dots represent the words which are outliers. Horizontal line shows overall mean for all languages.

AF – Afrikaans, CA – Catalan, DA – Danish, EL – Greek, EN – British English, ES – Spanish, FI – Finnish, GA – Irish, HE – Hebrew, HU – Hungarian, IS – Icelandic, IT – Italian, LB – Luxembourgish, LT – Lithuanian, MT – Maltese, NL – Dutch, PL – Polish, RU – Russian, SAE – South African English, SK – Slovak, SR – Serbian, SV – Swedish, TR – Turkish, XH – isiXhosa.

Target questions

To account for possible differences in results due to the form of target question, we conducted

a control study in which 23 Polish participants answered the modified target question ((1)

“When have you learned this word?” replaced with (2) “When do children learn this word?”).

Their AoA ratings were compared to those of 32 Polish speakers who answered the original

question. The groups differed in age ($M_1 = 38.61$, $SD_1 = 10.65$; $M_2 = 24.94$, $SD_2 = 7.28$; $t =$

6.10 , $p < .001$) and years of education ($M_1 = 17.09$, $SD_1 = 2.09$; $M_2 = 13.91$, $SD_2 = 2.33$; $t =$

5.21 , $p < .001$), but not in gender ($\chi^2(1, N=55) = .09$, $p = .77$), parenting ($\chi^2(1, N=55) = .26$, $p =$

$.61$) nor in number of known languages ($\chi^2(1, N=55) = .01$, $p = .93$).

Results show that although the two sets of ratings are strongly correlated ($r_s = .93$, $p < .001$),

they differ significantly in terms of absolute numbers (see Figure 3). It appears that

participants reporting their own experience in word learning provided significantly higher

AoA ratings than those assessing when children acquire the words ($M_1 = 3.84$, $SD_1 = 1.0$; $M_2 = 3.34$, $SD_2 = .95$; $t = 6.09$, $p < .001$). This trend was observed for 92% of the words (see Figure 3).

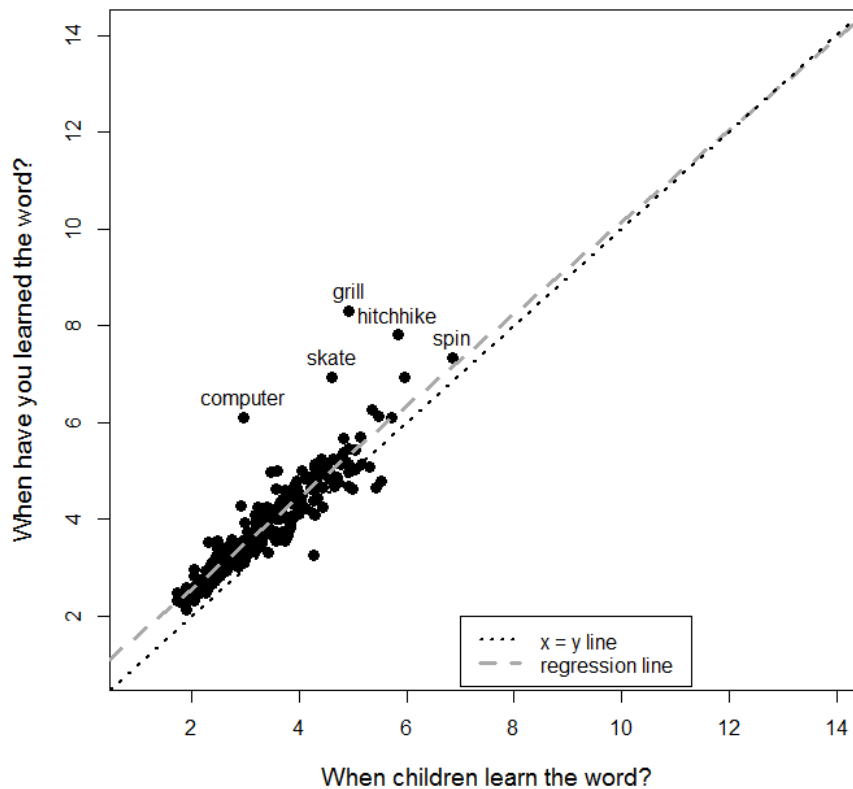


Figure 3. Relation between two target questions (Polish control study).

Reliability of the data

To check the reliability of participants' ratings, we randomly divided participants into two groups. The correlation in AoA ratings between the groups was very high and was significant for both nouns ($r_s(156) = .99$, $p < .001$) and verbs ($r_s(139) = .99$, $p < .001$).

This procedure was repeated to calculate split-half reliability coefficients per language. The coefficients were, in general, very high (Table 4). For 22 out of 25 languages, the coefficients were higher than .90. The only coefficients lower than .85 were obtained for isiXhosa ($r_s(297) = .68$, $p < .001$), Maltese ($r_s(295) = .75$, $p < .001$) and Irish ($r_s(295) = .78$, $p < .001$).

AoA ratings vs demographic variables: Gender

We compared the estimations provided by all male participants ($N = 168$) to those provided by female participants matched to them by age ($M_1 = 30.64$, $SD_1 = 12.43$; $M_2 = 31.17$, $SD_2 = 12.12$; $t = .49$, $p = .69$), education level ($M_1 = 15.30$, $SD_1 = 4.64$; $M_2 = 15.24$, $SD_2 = 4.78$; $t = .35$, $p = .94$) and first language. We found no significant difference in mean ratings provided by men and women ($M_1 = 4.18$, $SD_1 = 1.13$; $M_2 = 3.96$, $SD_2 = 1.06$; $t = .95$, $p = .06$).

AoA ratings vs demographic variables: Age

As we assumed, there is no significant correlation between participants' age and average AoA ratings for words ($r(771) = -.07$, $p = .07$). To validate our prediction about differences in AoA for particular words, we compared the estimations given by the youngest (aged 18–20, $M = 19.3$, $SD = .7$, $N = 180$, 151 females) to those given by the oldest participants (aged 40–80, $M = 52.2$, $SD = 8.5$, $N = 140$, 102 females). The results (Table 6, Figure 4) validated our hypothesis, although the order of word acquisition was similar in the two groups ($r_s(297) = .89$, $p < .001$).

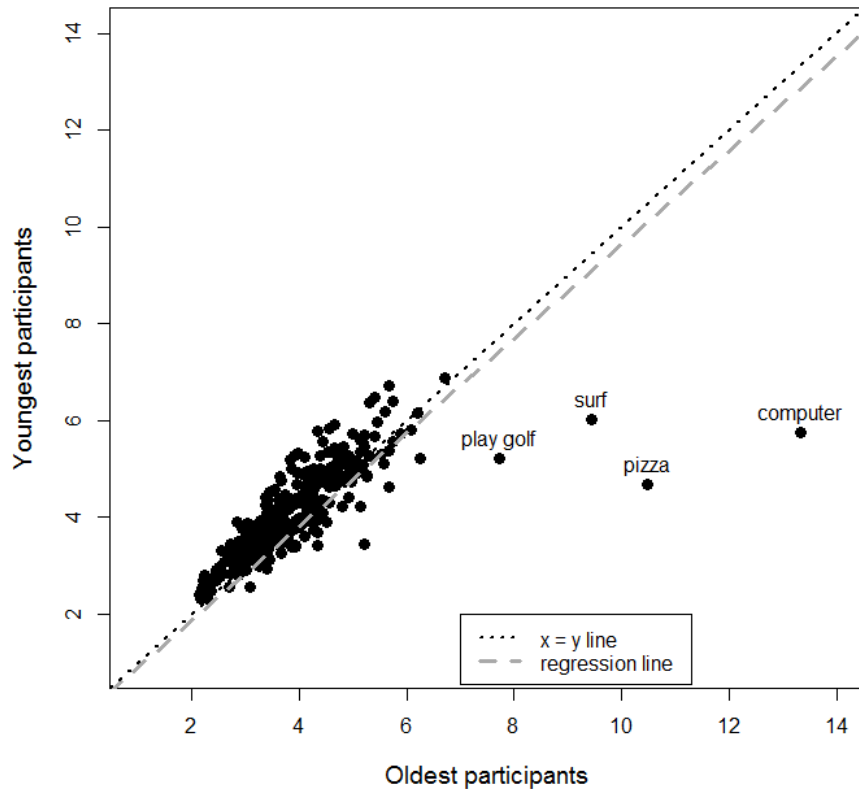


Figure 4. AoA estimations in different age groups.

AoA ratings vs demographical variables: Education

No relationship was found between estimated AoA of words and participants' education measured in years ($r(771) = -.05$, $p = .16$).

AoA ratings vs demographic variables: Parenting

To check whether being a parent affects AoA ratings, we selected 119 participants who reported that they had at least one child aged younger than 10 years (i.e. their youngest child had to be maximally 10 years old). We chose this criterion to include only participants who had relatively recent memories of their children acquiring vocabulary. This group of parents was compared to a control group of participants speaking the same language matched in age ($M_1 = 36.11$, $SD_1 = 6.83$; $M_2 = 36.36$, $SD_2 = 10.36$; $t = -.22$, $p = .82$), education ($M_1 = 16.29$, $SD_1 = 4.53$; $M_2 = 16.16$, $SD_2 = 4.63$; $t = .21$, $p = .83$) and gender ($\chi^2(1, N = 238) = 1.68$, $p =$

.38)). In the control group, 32 participants reported that they had children aged between 11 and 32 years, and the remaining 87 participants did not have children.

It emerged that parents of children in preschool and in the early school years judged that they had learned the target words earlier than the control group. They reported acquiring 294 out of 299 words (99%) earlier than the control group, and the mean rating provided by parents was significantly lower than that provided by non-parents ($M_1 = 3.41$, $SD_1 = 1.21$; $M_2 = 3.94$, $SD_2 = 1.15$; $t = -3.44$, $p < .001$). However, the order of word acquisition was almost exactly the same in both groups ($r_s(297) = .98$, $p < .001$, see Figure 5).

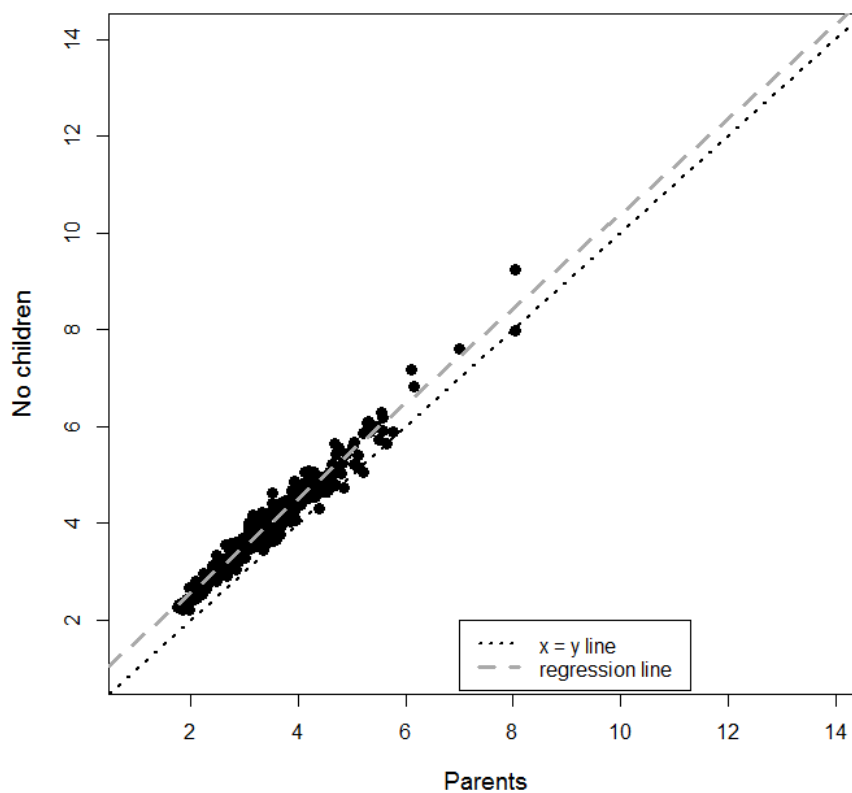


Figure 5. AoA estimations of people having and not having children younger than 10 years.

AoA ratings vs demographic variables: *Participants' languages*

When asked about their language skills, 376 participants (49%) reported that they could speak one language at native-like level, 293 (38%) two languages and 90 (12%) three languages.

Nine people reported that they spoke four or more languages at native level and 5 did not answer this question. To check whether the number of languages spoken affects estimations of AoA in the first language, we divided the participants into groups: those speaking one language and those speaking two or three languages.

The groups of monolingual and bi- or trilinguals did not differ in terms of age ($M_1 = 29.0$, $SD_1 = 11.7$; $M_2 = 30.6$, $SD_2 = 12.9$; $t = -1.85$, $p = .06$) and education ($M_1 = 15.4$, $SD_1 = 3.9$; $M_2 = 15.2$, $SD_2 = 4.0$; $t = -.76$, $p = .45$). However, multilingual participants systematically reported that they had acquired words later than monolinguals – they estimated a higher AoA of 288 words (96%). The difference in mean ratings by the two groups was significant ($M_1 = 3.72$, $SD_1 = .97$; $M_2 = 4.05$, $SD_2 = .98$; $t = -4.19$, $p < .001$). Again, the results of the two groups were highly correlated ($r_s(297) = .98$, $p < .001$).

Correlations with previous AoA data

In order to assess their validity, the AoA ratings were compared with previous AoA norms. From all of the AoA norms available which were mentioned in the introduction, we selected the ones that contained at least 30 words from our sample and were collected in the same languages. Thus, we correlated our data with previous norms for Dutch, English, German, Greek, Icelandic, Italian, Russian, Spanish and Turkish (Table 7).

The coefficients were calculated separately for nouns and for verbs. Our ratings were significantly correlated with previous data in the same and very closely related languages (American and British English, European and Mexican Spanish). We obtained significant and high correlations with existing AoA norms that included both subjective and objective AoA estimation. Correlations with objective AoA (8 studies, range: .44 – .63, $M = .56$) were slightly lower than those with subjective ratings (33 studies, range: .29 – .92, $M = .75$). There

was no single study with AoA norms available for which the correlation with our AoA results was not significant.

Correlations with MB-CDI data

For a given pair of data (MB-CDI vs AoA), a percentage of children who know a given word at a certain age (obtained from the MB-CDI norms for that language) was contrasted with the mean AoA of the same word (obtained in the current AoA study). As predicted, a consistent pattern of significant (negative) correlations was found for all data pairs, although in two languages the correlations were significant in some age groups only. Table 8 presents exact values of coefficients. All correlations for receptive vocabulary ratings were significant, and they were mostly moderate correlations (r : range $-.18$ to $-.59$, $M = -.43$). For expressive vocabulary, correlations were in general slightly weaker (r : range $.10$ to $-.68$, $M = -.39$). The only non-significant correlations were obtained for the expressive scores of the youngest age groups' (children younger than 10 months) and of some older age groups of Spanish and Turkish speakers (Spanish: 8 to 15 months, Turkish: 8 to 13 months).

Discussion

In the current study, we presented a new set of subjective AoA ratings for 299 words in 25 languages from 5 different language families. The ratings are highly reliable in terms of internal consistency, and their validity was confirmed in comparisons with data from previous studies. The presented ratings suggest that, although the languages differ in terms of absolute AoA of words (as reported by adults), the order of word learning is very similar across all languages studied in the age range 0 to 6 years. The latter finding may indirectly support the statement about a universal pattern of early meaning acquisition among languages (Clark, 1979, 1995, 2009). The former effect (differences in the absolute numbers obtained for AoA in different languages; see Figure 2) may be due to various factors not controlled for in the current study (e.g. cultural biases related to different cultural views of language

development).¹ However, such post-hoc explanations are of speculative nature, and more cross-linguistic studies assessing objective AoA would be needed to confirm the universality of word order acquisition and/or the cross-linguistic differences in the exact age when particular words are acquired.

The present paper describes the first study in which AoA ratings were obtained for such a wide range of languages with the use of an identical procedure. The obtained ratings suggest that the words included in the study are all acquired early – mostly in the first 7 years of life – in all languages considered. Thus, the ratings obtained in the current study constitute close to a fully comparable database of words across languages, because of both the standardisation of the procedure across the languages and the similarity of the results. Thus, the ratings may be used as a measure of “word difficulty” in cross-linguistic studies on word learning or processing by preschool children. The ratings may also be applied in the adaptation of experiments from one language to another as this process often needs to control for word AoA across languages.

Our analysis also has methodological implications for the future AoA studies. It reveals that the target question used widely for obtaining subjective AoA ratings (“When have you learned the word?”) may in fact lead participants to overestimation of AoA. Changing the question to the one concerning word acquisition in children (“When do children learn this word?”) as well as the analysis of the responses of parent participants indicate that existing AoA ratings may yield an overly conservative AoA. Both parents answering the traditional AoA question and participants answering the question about children learning words provided significantly lower AoA estimations.

In contrast to Kuperman and colleagues (2012) who reported women to give slightly higher estimations of AoA, we found no gender difference in AoA ratings. Comparison of

¹ We thank the anonymous reviewer for pointing out this possibility.

answers of polarised age groups shows that, in general, AoA estimations are independent of age. This does not support the results reported by Kuperman and colleagues (2012) who found a marginal but significant ($r = .07$) correlation between participants' age and the AoA ratings they provided. However, this incongruence may be affected by the specificity of the word list we applied. The reason for the difference between the Kuperman et al. and our findings may lie in the type of stimuli used: we used a set of relatively simple words labelling imaginable objects or actions, which were acquired early in life. Thus, Kuperman et al.'s explanation of the age differences – that older participants gave higher estimations because they had a broader age range to choose from – is not directly applicable to our data set.

Although, in general, the presented AoA ratings do not depend on participants' age, the exact AoA of some words may differ between younger and older adults. In particular, the labels of the most modern objects and activities (e.g. new-tech tools) were estimated to be acquired by older people at the later stages of their life, which replicates the results of Bird et al. (2001). Thus, similarly to Cuetos and collaborators (2012), we suggest that for studies of AoA effects in older participants, appropriate norms should be used rather than those based on estimations obtained from young adults.

As was the case in the results of Kuperman and collaborators (2012), we did not find any correlation between the education level of the participants and the ratings they provided. However, in contrast to the study by Kuperman et al., in the present study this result was expected because the stimuli consisted of simple words typically acquired by toddlers or preschoolers.

Particularly noteworthy was the finding that AoA estimations depend on number of languages spoken by the participants: the more languages the participants spoke at a native-like level, the higher the AoA they provided. This result is in line with known patterns of

lexical development in bilinguals who may learn some words later than their monolingual peers (Bialystok et al., 2010).

Finally, the correlations with previous subjective and objective AoA ratings as well as MB-CDI norms validate the current norms in the case of all languages for which any previous AoA norms or MB-CDI norms are available.

Study limitations

In the current study, we aimed at collecting AoA ratings in a wide range of languages. As we based our AoA ratings on a set of words selected according to the criterion of sharing meaning across the languages (Haman, Mieszkowska, et al., 2015), non-translatable words were not included in our word lists. This criterion significantly reduced the number of possible items to only 158 nouns and 141 verbs out of the more than 1000 words. Thus, the number of words used in the current study is limited, especially in comparison to the four most extensive word sets used by Kuperman et al. (2012) and Bysbaert et al. (2014): 30,000; Alonso et al. (2014): 7,149; and Moors et al. (2012): 4,300. However, most AoA studies have used a smaller number of words, with the average number of items around 450 and the median number of items being about 220 items (estimated for 60 publications including ratings for AoA). Given that the words were selected to be translatable across languages, our dataset does not contain any items specific for some of the languages and cultures, even those included in the naming study by Haman, Mieszkowska et al. (2015).

The AoA ratings presented in the current paper suggest that all of the words included in our set are typically acquired by the age of 7 years. This makes them all “early words”, from the point of view of mature speakers, and limits the usability of the current dataset in studies of AoA effects in adults. However, the ratings are still appropriate for experiments concerning AoA effects in children in different languages.

Conclusions

The present study provides AoA ratings for 158 nouns and 141 verbs in 25 languages. All 299 words were judged as acquired early in life, mostly in preschool age. This together with high validity of the ratings leads to the conclusion that the current paper presents a fully comparable database of subjective AoA of 299 words in 25 languages. The database may be useful for a wide range of studies, of both single-language or cross-linguistic design, where controlling for stimulus words parameters is required.

Acknowledgments

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Table 1. AoA effect in different types of tasks in adults and children

Task	Language	Children [age]	Adults
Picture naming	Dutch		Severens et al. (2005)
	English	Gerhand & Barry (1999) [14-15 years]	Barry et al. (1997); Barry, Hirsh, Johnston, & Williams (2001); Barry et al. (2006); Belke et al. (2005); Bogka et al. (2003); Brown & Watson (1987); Carrol & White (1973b); Catling, South, & Kevin Dent (2013); Garlock, Walley, & Metsala (2001); Holmes & Ellis (2006); Jorm (1991); Kittredge, Dell, Verkuilen, & Schwartz (2008); Lachman, Shaffer, & Hennrikus (1974); Lambon Ralph & Ehsan (2006); Lyons et al. (1978); Meschyan & Hernandez (2002); Morrison, Ellis, & Quinlan (1992); Morrison, Hirsh, & Duggan (2003); Walley & Metsala (1992)
	French		Bonin, Chalard, Méot, & Fayol (2002); Bonin, Fayol, & Chalard (2001); Chalard & Bonin (2006); Laganaro & Perret (2011)
	Greek		Bogka et al. (2003); Lympelopoulou, Barry, & Sakka (2006)
	Italian	D'Amico, Devescovi, & Bates (2001) [5-6 years]	Bates, Burani, D'Amico, & Barca (2001); Colombo & Burani (2002); Navarrete, Scaltritti, Mulatti, & Peressotti (2013)
	Persian		Bakhtiar et al. (2013)
	Spanish		Pérez (2007); Wilson, Cuetos, Davies, & Burani (2013)
	Turkish		Raman (2011)
Word naming	Dutch		Brysbaert (1996); Brysbaert, Lange, & Van Wijnendaele, I. (2000)
	English	Coltheart, Laxon, & Keating (1988) [9-10 years]	Barry et al. (2001); Barry and Gerhand (2003); Brysbaert & Cortese (2010); Cortese & Schock (2013); Meschyan & Hernandez (2002); Mobaghan & Ellis (2002)
	French		Bonin, Barry, Méot, & Chalard (2004)
	Italian		Bates et al. (2001); Wilson, Ellis, & Burani (2012)
	Japanese		Havelka & Tomita (2006)
	Turkish		Raman (2011)
Object recognition	English	Ellis & Morrison (1998) [3-6 years]	
Word category decision	Chinese		Bai, Ma, Dunlap, & Chen (2013)
	English		Holmes & Ellis (2006)
Semantic classification	Dutch		Brysbaert, Wijnendaele, & Deyne (2000)
	English		Barry et al. (1997); Lambon Ralph & Ehsan (2006); Lyons et al. (1978); Moore, Smith-Spark, & Valentine (2004); Morrison & Gibbons (2006)
Associations	Dutch		Brysbaert et al. (2000); De Deyne & Storms (2008)
Lexical decision	Dutch		Baumeister (1984); Brysbaert, Lange, & Van Wijnendaele, I. (2000); De Deyne & Storms (2007)
	English	Assink, van Well, & Knuijt (2003) [11-17 years]	Assink et al. (2003); Barry et al. (2006); Baumeister (1984); Brysbaert & Cortese (2010); Cortese & Schock (2013); Holmes, Jane Fitch, & Ellis (2006); Stadthagen-Gonzalez, Bowers & Damian (2004); Turner, Valentine, & Ellis (1998)
	French		Bonin et al. (2001)
	Italian		Colombo & Burani (2002); Spataro, Longobardi, Sarauilli, & Rossi-Arnaud (2013)
	Spanish		González-Nosti, Barbón, Rodríguez-Ferreiro, & Cuetos (2014); Wilson et al. (2013)

Ortographic decision	Italian	Adomi, Manfredi & Proverbio (2013)
Sentence reading	English	Juhasz & Rayner (2006); Morrison, Hirsh, Chappell, & Ellis (2002)

Table 2. Existing subjective and objective AoA norms in different languages

Language	Subjective ratings	Objective ratings
Chinese	Liu et al. (2007)	Liu et al. (2011)
Dutch*	Brysbaert et al. (2014); De Deyne & Storms (2008); Ghyselinck et al. (2000); Ghyselinck et al. (2003); Moors et al. (2012); Shao et al. (2014)	
English*	Auer Jr & Bernstein (2008); Barry et al. (1997); Bird et al. (2001); Carroll & White (1973a, 1973b); Cortese & Khanna (2007, 2008); Gilhooly & Hay (1977); Gilhooly & Logie (1980); Iyer et al. (2001); Johnston et al. (2010); Khanna & Cortese (2011); Kuperman et al. (2012); Salmon et al. (2010); Schock et al. (2012); Snodgrass & Yuditsky (1996); Stadthagen-Gonzalez & Davis (2006); Stration et al. (1975); Winters Jr et al. (1978)	Morrison et al. (1997)
French*	Alario & Ferrand (1999); Bonin, Boyer, et al. (2004); Bonin et al. (2003, 2008); Ferrand et al. (2008); Sirois et al. (2006)	Cannard & Kandel (2008); Chalard et al. (2003)
German*	Schröder et al. (2011)	
Greek*	Dimitropoulou et al. (2009)	
Icelandic*	Pind et al. (2000)	Pind et al. (2000)
Italian*	Barca et al. (2002); Colombo & Burani (2002); Della Rosa et al. (2010)	Barbarotto et al. (2005); Lotto et al. (2010)
Japanese	Nishimoto et al. (2005, 2012)	
Norwegian	Lind et al. (2015)	
Persian	Bakhtiar et al. (2013)	
Portuguese	Cameirao & Vicente (2010); Marques et al. (2007)	
Russian*	Akinina et al. (2014); Tsaparina et al. (2011)	Grigoriev & Oshhepkov (2013)
Spanish*	Alonso et al. (2014); Cuetos et al., (1999, 2012); Manoiloff et al. (2010); Moreno-Martínez et al. (2014)	Álvarez & Cuetos (2007); Pérez & Navalon (2005)
Turkish*	Raman et al. (2013)	

* Languages used in the current study.

Table 3. The most popular scales used in the studies on subjective AoA

Scale	Description	Examples of studies
5-point	1 = 3 years or earlier, 2 = 4 to 6 years, 3 = 7 to 9 years, 4 = 10 to 12 years, 5 = 13 years or later	Akinina et al. (2014); Alario & Ferrand (1999); Bonin, Boyer, et al. (2004); Bonin et al. (2003); Dimitropoulou et al. (2009); Manoiloff et al. (2010); Tsaparina et al. (2011)
7-point	1 = 2 years or earlier, 2 = 3 or 4 years, 3 = 5 or 6 years, 4 = 7 or 8 years, 5 = 9 or 10 years, 6 = 11 or 12 years, 7 = 13 years or later	Barca et al. (2002); Barry et al. (1997); Bird et al. (2001); Bonin et al. (2008); Cortese & Khanna (2007, 2008); Liu et al. (2011); Moreno-Martínez et al. (2014); Pind et al. (2000); Salmon et al. (2010); Schock et al. (2012); Schröder et al. (2011); Sirois et al. (2006); Snodgrass & Yuditsky (1996)
9-point	1 = 2 years or earlier, 2 = 3 years, 3 = 4 years, 4 = 5 years, 5 = 6 years, 6 = 7 or 8 years, 7 = 9 or 10 years, 8 = 11 or 12 years, 9 = 13 years or later	Cameirao & Vicente (2010); Carrol & White (1973); Iyer et al. (2001); Lyons et al. (1978); Mobaghan & Ellis (2002); Nishimoto et al. (2005, 2012); Shao et al. (2014); Stration et al. (1975); Vinson et al. (2008); Walley & Metsala (1992); Winters Jr et al. (1978)
11-point	based on equivalent age, 1 = earlier than 2 years, 2 = 2 years, 3 = 3 years, ..., 10 = 10 years, 11 = 11 years or later	Alonso, Fernandez, & Díez (2014); Bakhtiar, Nilipour, & Weekes (2013)
continuous	years given in exact numbers: 1 = 1 year, 2 = 2 years, ..., 18 = 18 years etc.	Brysbaert et al. (2014); Cuetos, Samartino, & Ellis, (2012); De Deyne & Storms, (2007); Della Rosa et al., (2010); Ferrand et al., (2008); Ghyselincx, Custers & Brysbaert (2003); Gilhooly & Logie (1980); Kuperman, Stadthagen-Gonzalez, & Brysbaert, (2012); Stadthagen-Gonzalez & Davis, (2006)

Table 4. Characteristics of the participants included in the analysis per language

	Language	N	Age		Females	
			M	SD	N	Percent
1	Afrikaans	37	35.89	15.00	18	49%
2	Catalan	20	34.65	18.35	11	55%
3	Danish	23	32.22	11.20	23	100%
4	Dutch	22	31.68	11.69	15	68%
5	English (British)	124	21.26	4.93	96	77%
6	English (South African)	42	30.48	14.76	33	79%
7	Finnish	24	32.79	9.70	23	96%
8	German	21	30.00	10.48	15	71%
9	Greek	34	26.24	8.68	28	82%
10	Hebrew	21	31.81	10.20	18	86%
11	Hungarian	21	46.86	14.36	17	81%
12	Icelandic	23	42.09	13.02	20	87%
13	Irish	20	36.15	13.54	14	70%
14	isiXhosa	27	32.00	16.84	18	67%
15	Italian	25	23.04	7.31	22	88%
16	Lithuanian	28	30.82	9.17	26	93%
17	Luxembourgian	22	38.27	12.59	16	73%
18	Maltese	21	32.95	13.26	18	86%
19	Polish	32	24.94	7.28	25	78%
	Polish: revised question	23	38.61	10.65	23	74%
20	Russian	36	35.39	10.30	31	86%
21	Serbian	33	19.64	0.99	26	79%
22	Slovak	33	25.67	9.77	30	91%
23	Spanish	22	27.36	7.54	16	73%
24	Swedish	23	37.65	15.08	15	65%
25	Turkish	39	29.56	4.33	31	79%
	TOTAL	796	30.08	12.35	622	78%

Table 5. Matrix of adjusted correlation of all languages with split-half reliabilities per language

Split-half reliability		CA	DA	NL	EN BR	EN SA	FI	DE	EL	HE	HU	IS	GA	XH	IT	LT	LB	MT	PL	RU	SR	SK	ES	SV	TR
.91	Afrikaans (AF)	.85	.79	.85	.82	.89	.80	.85	.81	.78	.72	.76	.80	.86	.78	.75	.84	.82	.86	.75	.79	.88	.80	.84	.83
.91	Catalan (CA)		.77	.77	.74	.77	.75	.81	.84	.76	.65	.75	.80	.72	.77	.74	.82	.84	.86	.74	.75	.81	.84	.82	.78
.92	Danish (DA)			.88	.86	.85	.84	.83	.87	.81	.72	.82	.78	.76	.79	.76	.87	.85	.87	.78	.79	.85	.80	.90	.80
.92	Dutch (NL)				.85	.83	.84	.89	.84	.79	.72	.82	.76	.76	.80	.75	.90	.84	.86	.78	.80	.85	.78	.88	.77
.99	English (British) (EN BR)					.91	.82	.83	.83	.81	.66	.75	.80	.69	.84	.70	.84	.82	.85	.79	.80	.84	.82	.84	.76
.94	English (South African) (EN SA)						.81	.82	.83	.81	.67	.78	.77	.74	.78	.73	.83	.83	.85	.84	.79	.84	.81	.85	.78
.94	Finnish (FI)							.86	.81	.78	.70	.81	.76	.75	.77	.74	.90	.86	.86	.80	.77	.87	.76	.88	.79
.92	German (DE)								.87	.82	.77	.78	.76	.77	.82	.76	.91	.89	.89	.80	.84	.88	.83	.87	.82
.89	Greek (EL)									.83	.66	.79	.77	.84	.90	.76	.84	.93	.90	.79	.84	.90	.85	.82	.86
.96	Hebrew (HE)										.65	.71	.68	.73	.78	.70	.80	.90	.85	.79	.75	.81	.84	.81	.78
.87	Hungarian (HU)											.66	.64	.70	.62	.68	.73	.69	.72	.70	.69	.78	.69	.71	.68
.91	Icelandic (IS)												.77	.70	.71	.72	.85	.77	.78	.77	.73	.83	.71	.83	.75
.78	Irish (GA)													.78	.73	.76	.83	.82	.80	.70	.72	.76	.76	.75	.79
.68	isiXhosa (XH)														.68	.67	.79	.81	.78	.71	.74	.76	.75	.77	.79
.93	Italian (IT)															.65	.83	.90	.87	.73	.80	.84	.81	.77	.75
.92	Lithuanian (LT)																.78	.71	.80	.83	.76	.83	.73	.79	.76
.91	Luxembourgish (LB)																	.91	.91	.83	.82	.91	.82	.91	.82
.75	Maltese (MT)																		.91	.75	.81	.86	.88	.85	.83
.91	Polish (PL)																			.84	.87	.96	.85	.88	.85
.95	Russian (RU)																				.78	.88	.77	.84	.78
.93	Serbian (SR)																					.90	.80	.84	.75
.89	Slovak (SK)																						.83	.91	.82
.92	Spanish (ES)																							.80	.82
.90	Swedish (SV)																								.80
.93	Turkish (TR)																								.80

All correlations significant – $p < .001$. Spearman's rank correlation coefficients adjusted for split-half reliabilities higher than .85 are printed in bold.

Table 6. List of 19 words with significantly different AoA ratings between youngest and oldest participants

Word	Youngest		Oldest		Difference	t
	M	SD	M	SD		
computer	5.76	2.42	13.33	5.60	-7.56	-16.07***
pizza	4.69	2.17	10.49	5.62	-5.81	-12.46***
surf	6.03	2.60	9.43	5.69	-3.40	-6.38***
play golf	5.23	2.49	7.72	4.95	-2.49	-5.29***
television	3.44	1.50	5.22	3.77	-1.79	-5.25***
sewing machine	5.78	2.22	4.34	1.99	1.44	5.99***
fry	5.26	1.74	3.90	1.89	1.37	6.65***
boil	5.18	1.85	3.83	1.85	1.36	6.46***
knit	5.32	1.89	3.99	2.22	1.33	5.73***
thermometer	5.83	2.61	4.56	2.37	1.27	4.42***
needle	4.85	1.90	3.65	1.42	1.20	6.17***
grate	5.25	2.02	4.09	2.40	1.16	4.65***
sew	4.99	1.92	3.85	1.81	1.14	5.37***
shave	5.56	2.28	4.44	2.41	1.12	4.21***
peel	4.76	1.95	3.66	1.60	1.10	5.33***
sweep	4.52	1.79	3.45	1.44	1.07	5.72***
comb	3.89	1.44	2.84	1.18	1.05	6.98***
sweater	4.40	1.87	3.37	2.22	1.04	4.14***
stir	4.56	2.13	3.55	1.40	1.01	4.83***

*** - $p < .001$ with Bonferroni correction.

Note: All other words in the sample were assessed as acquired at approximately the same age by both groups.

Table 7. Correlation coefficients (Pearson's *r*) of our AoA ratings and previous data

Language		Type of AoA rating	Part of speech	N	<i>r</i>
Dutch	Brysbaert et al. (2014)	Subjective	N	44	.69***
			V	45	.78***
	Ghyselinck et al. (2000)	Subjective	N	84	.29**
	Ghyselinck et al. (2003)		N	102	.91***
	Moors et al. (2012)	Subjective	N	115	.41***
			V	102	.68***
Shao et al. (2014)	Subjective	V	86	.80***	
English	Bird et al. (2001)	Subjective	V	79	.86***
	Cortese & Khanna (2008)	Subjective	N	78	.85***
			V	114	.83***
	Gilhooly & Logie (1980)	Subjective	N	50	.86***
			V	34	.69***
	Iyer et al. (2001)	Subjective	N	139	.80***
	Johnston et al. (2010)	Subjective	N	139	.85***
	Kuperman et al. (2012)	Subjective	N	155	.75***
			V	140	.81***
	Morrison et al. (1997)	Objective	N	87	.59***
			N	118	.63***
	Salmon et al. (2010)	Objective (75%)	N	118	.92***
			N	100	.77***
	Schock et al. (2012)	Subjective	N	37	.58***
	Snodgrass & Yuditsky (1996)	Subjective	N	118	.84***
	Stadthagen-Gonzalez et al. (2009)	Subjective	V	47	.79***
German	Schröder et al. (2011)	Subjective	N	60	.71***
Greek	Dimitropoulou et al. (2009)	Subjective	N	120	.87***
Icelandic	Pind et al. (2000)	Objective	N	116	.52***
		Subjective	N	122	.84***
Italian	Barca et al. (2002)	Subjective	N	47	.68***
			N	53	.83***
	Della Rosa et al. (2010)	Objective	N	59	.63***
			N	63	.63***
	Lotto et al. (2010)	Objective (75%)	N	65	.83***
Russian	Akinina et al. (2014)	Subjective	V	104	.69***
	Grigoriev & Oshhepkov (2013)	Objective	N	122	.49***
	Tsaparina et al. (2011)	Subjective	N	119	.75***
Spanish	Alonso et al. (2014)	Subjective	N	143	.92***
			V	65	.82***
	Álvarez & Cuetos (2007)	Objective	N	121	.44***
	Cuetos et al. (1999)	Subjective	N	99	.85***
	Cuetos et al. (2012)	Subjective	N	112	.55***
	Manoiloff et al. (2010)	Subjective	N	115	.61***
	Moreno-Martínez et al. (2014)	Subjective	N	85	.78***
	Pérez & Navalon (2005)	Objective	N	76	.52***
N			76	.53***	
Turkish	Raman et al. (2013)	Subjective	N	119	.72***

*** $p < .001$; ** $p < .01$

N – number of words for which comparisons were possible, Part of speech: N – nouns, V – verbs.

Note: Objective (75%) – objective AoA defined as the age at which 75% of children at a given age group knew the word (Morrison et al., 1997).

Table 8. Correlations (Pearson's r) between AoA ratings and MB-CDI norms for receptive and expressive word knowledge

Language	N	Age in months	CDI Expressive	Receptive	
Danish	116 ^a	8	-.20*	-.37***	
		9	-.09	-.31***	
		10	-.21*	-.37***	
		11	-.21*	-.42***	
		12	-.34***	-.47***	
		13	-.30**	-.45***	
		14	-.31***	-.50***	
		15	-.38***	-.52***	
		16	-.42***	-.54***	
		17	-.43***	-.55***	
		18	-.48***	-.56***	
		19	-.50***	-.57***	
		20	-.57***	-.58***	
		16	-.44***		
		17	-.48***		
		18	-.51***		
		19	-.53***		
		20	-.56***		
		21	-.58***		
		22	-.61***		
	23	-.60***			
	24	-.61***			
	25	-.59***			
	26	-.58***			
	27	-.57***			
	28	-.55***			
	29	-.53***			
	30	-.50***			
	31	-.49***			
	32	-.46***			
	33	-.41***			
	34	-.42***			
	35	-.39***			
	36	-.38***			
	German	152 ^b	18	-.40***	
			19	-.46***	
20			-.39***		
21			-.41***		
22			-.40***		
23			-.43***		
24			-.44***		
25			-.42***		
26			-.46***		
27			-.44***		
28			-.45***		
29			-.43***		
30	-.42***				
Italian	154 ^b	18	-.39***		
		19	-.33***		
		20	-.41***		
		21	-.46***		
		22	-.48***		
		23	-.53***		
		24	-.53***		
		25	-.54***		
		26	-.50***		
		27	-.50***		
		28	-.48***		
		29	-.49***		
30	-.51***				
31	-.41***				

Ratings of age of acquisition 53

		32		-.49***	
		33		-.49***	
		34		-.41***	
		35		-.40***	
		36		-.41***	
		8		-.15	-.55***
		9		-.21	-.51***
		10		-.31**	-.50***
		11		-.30**	-.51***
	87 ^a	12		-.30**	-.48***
		13		-.29**	-.52***
		14		-.33**	-.52***
		15		-.35***	-.47***
		16		-.38***	-.50***
		17		-.38***	-.52***
		18		-.31**	-.45***
		18		-.22**	
		19		-.35***	
		20		-.36***	
		21		-.29***	
Russian		22		-.39***	
		23		-.36***	
		24		-.36***	
		25		-.38***	
		26		-.37***	
	144 ^b	27		-.41***	
		28		-.40***	
		29		-.39***	
		30		-.41***	
		31		-.40***	
		32		-.48***	
		33		-.40***	
		34		-.50***	
		35		-.45***	
		36		-.40***	
		8		NA	-.31***
		9		-.02	-.24*
		10		-.22*	-.42***
		11		NA	-.28**
	112 ^a	12		-.29**	-.50***
Swedish		13		-.23*	-.43***
		14		-.40***	-.56***
		15		-.34***	-.54***
		16		-.46***	-.59***
		8		-.04	-.18*
		9		.01	-.27**
		10		-.08	-.24**
		11		-.10	-.27**
	95 ^a	12		-.10	-.30**
		13		-.11	-.31**
		14		-.21*	-.32***
		15		-.18*	-.32***
		16		-.19*	-.33***
		16		-.42***	
		17		-.42***	
		18		-.44***	
		19		-.52***	
		20		-.52***	
		21		-.57***	
	129 ^b	22		-.57***	
Turkish		23		-.60***	
		24		-.64***	
		25		-.65***	
		26		-.67***	
		27		-.68***	
		28		-.67***	
		29		-.66***	

Ratings of age of acquisition 55

		16	-.43***	-.53***
		16	-.51***	
		17	-.49***	
		18	-.53***	
		19	-.57***	
		20	-.56***	
		21	-.64***	
		22	-.57***	
	118 ^b	23	-.59***	
		24	-.60***	
		25	-.58***	
		26	-.60***	
		27	-.61***	
		28	-.53***	
		29	-.58***	
		30	-.53***	
		8	.00	-.26**
		9	-.01	-.25**
		10	-.01	-.30**
		11	-.12	-.32***
		12	-.09	-.37***
	107 ^a	13	-.17	-.36***
		14	-.16	-.34***
		15	-.16	-.38***
		16	-.22*	-.39***
		17	-.27**	-.41***
		18	-.25**	-.43***
		16	-.37***	
		17	-.40***	
		18	-.42***	
		19	-.47***	
		20	-.49***	
		21	-.48***	
		22	-.50***	
	151 ^b	23	-.51***	
		24	-.54***	
		25	-.56***	
		26	-.57***	
		27	-.56***	
		28	-.55***	
		29	-.56***	
		30	-.55***	

*** p <.001; ** p < .01; * p <.05, NA – no correlation because of no variance in MB-CDI norms (no children know the words).

^a - Words & Gestures version, ^b - Words & Sentences version.

N – number of words for which comparisons were possible.

Note: MB-CDI norms in % of children in a monthly age interval who know the words either actively or passively.