International Journal of Bilingual Education and Bilingualism
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rbeb20

Development of cross-language lexical influence

Gert Storms[a], Eef Ameel[a] & Barbara C. Malt[b]
[a] Faculty of Psychology and Educational Sciences, University of Leuven, Leuven, Belgium
[b] Department of Psychology, Lehigh University, Bethlehem, PA, USA

Published online: 11 Jun 2015.

International Journal of Bilingual Education and Bilingualism, 2015
Vol. 18, No. 5, 529–547, http://dx.doi.org/10.1080/13670050.2015.1027142

Development of cross-language lexical influence

Gert Storms[a]*, Eef Ameel[a] and Barbara C. Malt[b]

[a]*Faculty of Psychology and Educational Sciences, University of Leuven, Leuven, Belgium;*
[b]*Department of Psychology, Lehigh University, Bethlehem, PA, USA*

(*Received 5 June 2014; accepted 10 December 2014*)

Bilinguals are often not fully monolingual-like in either language. With respect to the lexicon, recent research demonstrates that their naming patterns for common household objects tend to converge on a common pattern for the two languages. The present study investigates the developmental trajectory of naming of common household objects in Dutch/French bilingual and monolingual children. First, we investigated whether bilingual word diversity for a set of household objects is limited by the demands of learning two languages. We found that children lag behind monolingual controls in terms of vocabulary at young ages, but that they catch up later, ending with as diverse a set of names in each language as the monolinguals. Second, we investigated how the convergence in the adult bilingual lexicon manifests itself over the course of development. We found that naming patterns converge with age following a similarity-driven strategy, a pattern also seen for the monolinguals. However, language-specific exceptions to the similarity principle are acknowledged from age 10 onward by monolinguals, but only from age 14 onward in bilinguals. At all ages, bilinguals show more convergence than monolinguals, and the difference is largest for adults. Together our results indicate that acquisition of naming patterns by bilinguals starts off more or less following the early stages of monolinguals, with separate naming patterns in the two languages, but convergence dominates the later developmental path to a larger extent for bilinguals than for monolinguals.

Keywords: bilingualism; word knowledge; language development; monolingual and bilingual lexicon

Introduction

An English-Dutch translation dictionary will tell you that a *bottle* is a *fles* in Dutch, and a Dutch-English dictionary, similarly, will say that *fles* is *bottle* in English. However, the usage patterns for names for artifacts show systematic differences across languages: Not all *fles* are *bottle* nor vice versa. Similarly, while tennis balls or volley balls are *bal* in Dutch, a ball of string and an eye ball are *bol* instead of *bal* in Dutch (Ameel, Malt, and Storms 2014). In short, translation "equivalents" in different languages are often not truly equivalent. This phenomenon was demonstrated more systematically by Malt et al. (1999), who studied naming of 60 common household containers (shown in photographs) by speakers of English, Spanish, and Chinese. In the current research we consider the implications of this fact for development of naming patterns in bilingual children.

Malt et al. (1999) found that their participants perceived the similarities among the household containers in much the same way, despite the different naming patterns. This

*Corresponding author. Email: gert.storms@ppw.kuleuven.be

finding implies that naming cannot be driven by perceived similarity alone. This in turn suggests that learning how to use words for artifacts is not a simple matter of mapping names onto prelinguistically obvious similarity-based clusters of objects (e.g. wide-mouthed glass food containers). If not, a further implication is that for children, the process of learning to use words as adult speakers of a language might be more challenging than has generally been assumed (e.g. Bloom 2001; Gentner 1982). In support of this possibility, Ameel, Malt, and Storms (2008) found that monolingual children learning their native language displayed only a gradual shaping of word use to the adult naming patterns. Naming was not fully adult-like until age 14 or later. The learning process entailed the addition of new words as well as reorganization of existing lexical categories, as shown by decreasing overextensions and underextensions with age (see also Ameel, Malt, and Storms 2014).

The nonequivalence of word meanings and usage between languages (e.g. the fact that the Dutch *fles* and English *bottle* do not cover the same extension) also raises the question of how bilinguals solve the naming problem in their two languages. Bilinguals must either acquire and maintain separate monolingual-like mappings for their two languages or merge the two mappings into a single converged mapping that differs from those used by monolinguals in the two languages. Using sets of common bottle-like and dish-like objects similar to those used by Malt et al. (1999), Ameel et al. (2005) showed that the naming patterns of early, high-proficiency French-Dutch bilinguals in their two languages converged on a common naming pattern with only minor deviations and that their lexical categories therefore diverge from those of monolingual speakers of the two languages. Investigating in more detail how the convergence in these bilinguals' naming pattern is manifested, Ameel et al. (2009) found evidence for converging category centers: There were higher correlations between typicality ratings for roughly corresponding categories in a bilingual's two languages than between typicality ratings of monolinguals in each language, and the prototypes derived from them fell closer together than the prototypes of monolinguals. Furthermore, bilingual categories had less complex boundaries than monolingual categories, with fewer violations of similarity-based naming.

Given these observations about monolingual child learners and adult bilinguals, what, then, is the developmental trajectory of word meaning and lexical categorization for bilingual children? Bilingual children face a large challenge in having to learn adult-like naming for two distinct languages, while these two naming patterns are not fully equivalent (Ameel et al. 2005, 2009). It is not obvious how they can cope with this cognitively demanding task, especially since their total language input is split between the two languages. With reduced input in each language, they have less exposure to the language specificities compared to their monolingual peers. Given these observations, we examine here the word use of French-Dutch bilingual children in Belgium, aged 5–14. Our investigation explores three aspects of bilingual word learning, as we now detail.

It is possible that bilingual word learning at a general level is curtailed by the demands of learning twice as many words and their corresponding extensions along with the lesser exposure to each one individually. That is, they may end up with fewer words in their vocabulary for each language (Bialystok et al. 2009, 2010; Gollan et al. 2005; although cf. De Houwer, Bornstein, and Putnick 2014). This lesser vocabulary, if it exists, may cause bilinguals to overextend some or all words since they may lack some of the more specialized or lower frequency terms used for portions of a domain by monolinguals. A simpler vocabulary in turn implies less need to engage in an extended period of refining the usage of each language's words. We therefore first ask if the

vocabulary of bilingual children keeps on growing well past the early years of language acquisition and whether bilingual usage shows a long period of evolution toward adult usage patterns, as observed by Ameel, Malt, and Storms (2008) for monolingual children. To investigate growth, we evaluate whether the average number of different names produced by the bilinguals at each age is smaller than the number for age-matched monolinguals, and whether monolinguals and bilinguals at parallel ages differ in the number of names that emerge as the dominant (most frequently given) names for labeling the stimuli. To investigate whether bilinguals display a comparable extended evolution of usage, we compare their patterns of word overextension and underextension and the time course of changes in usage to that of monolinguals.

We then ask how the convergence in the adult bilingual lexicon that was shown by Ameel et al. (2005, 2009) manifests itself over the course of development. Preliminary to doing so, we compare the developmental trajectories of naming patterns for monolingual Dutch- and French-speaking children. Children may start out with shared similarity-based assumptions about word meanings before their lexical categories are reshaped to be more adult-like and language-specific. This idea follows the possibility that children first set up conceptual representations independent of language and only later add language-specific representations for talking about experience (e.g. Bowerman and Choi 2001, 2003; Clark 1993). Since Ameel, Malt, and Storms (2008) found that monolinguals took at least 14 years to master language specificities in naming, under this possibility, the naming patterns of Dutch- and French-speaking monolingual children should correspond initially and decrease after their vocabulary sizes reach the adult level and reorganization of semantic space is completed to conform to language-specific patterns of word use. On the other hand, because Ameel, Malt, and Storms (2008) examined only Dutch-speaking children, we do not yet know whether the initial lexical categories in the stimulus domains studied are actually equivalent for young children speaking different languages. Dutch- and French-speaking children within Belgium share culture to a large extent, making culture-based divergences unlikely. However, since the adult input they receive for word learning presumably reflects some of the language differences, this input may cause their early lexical distinctions to differ. This may be especially true for our data, where the youngest children are 5 years old. By 5, children may have had enough time as word users to display some shaping of lexical categories by language-specific input.

We then can compare the evolution of name similarity in the two languages for monolingual and bilingual children. There are two contrasting possibilities here also. The decreasing convergence hypothesis is that early on, bilingual children do not recognize the incomplete equivalence of words in their two languages and use the same boundaries for naming in the two languages. That is, they have a single set of meanings labeled with names of two languages. Thus, if a child labels two stimuli with the same name in one language (e.g. both *bord* in Dutch), she will do the same in the other language (e.g. name both *assiette* in French) even if adults would not do so. Likewise, if a child distinguishes the two stimuli by name in one language (e.g. *bord* and *schaal* in Dutch), she will do so in the other (e.g. *assiette* and *plat* in French). Under this hypothesis, children may later learn a limited number of deviations from this common naming pattern (e.g. learn some specific objects that get labeled *bord* in Dutch but not *assiette* in French). Still, they never master these language specificities at the same level as the monolinguals, as shown by the results for adult bilinguals in Ameel et al. (2005). According to this hypothesis, the correspondence between naming in the two languages of the bilinguals should decrease with age but remain above the level of naming correspondence between monolinguals.

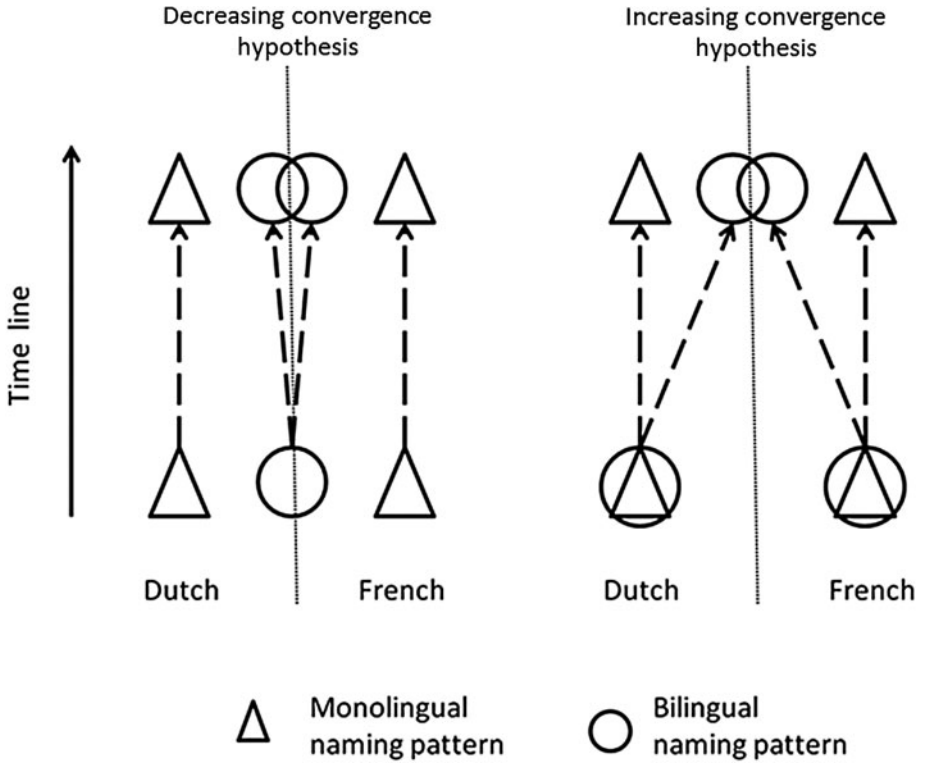

Figure 1. Schematic overview of the developmental naming trajectory of monolingual and bilingual children.

An alternative, the increasing convergence hypothesis, is that bilingual children early on treat their two languages as distinct and follow more or less the developmental path for naming patterns of monolinguals (Genesee 1989; Genesee, Nicoladis, and Paradis 1995). According to this hypothesis, the labeling of specific objects that are named, for instance, *bord* in Dutch but *plat* (and not *assiette*) in French by monolinguals, would be mirrored by bilingual children. According to this hypothesis, only later on, as their knowledge increases and cross-connections in their lexical network become denser, will cross-activation from words in one language to words in the other language reshape their naming patterns to make them more alike in their two languages (e.g. objects named *bord* in Dutch will always be called *assiette* in French). This hypothesis predicts that the name correspondence of the two languages of the bilinguals will begin low but increase with age. A schematic representation of the two hypotheses is displayed in Figure 1.

Method

Participants

Data from 152 monolingual Dutch speakers, 151 monolingual French speakers, and 131 bilingual participants were used. Some of these data were taken from previously published studies, as indicated below. Although the participants we call "monolinguals," all had some formal education in the other language from the age of 10 or 11 onward,

their knowledge of that language was very limited, and it was not used regularly. The bilinguals all had a Dutch-speaking mother and a French-speaking father or vice versa, and both parents consistently spoke their own language in raising their children from birth onward. Older participants (the 14-year-old group and adults) typically additionally had English instruction between the ages of 14 and 18, but none of them used English on a regular basis.

For the monolingual Dutch naming task, data for adults were those of the 32 native speakers of Dutch described in Ameel et al. (2005). All these participants were students or research assistants at the Psychology Department of the University of Leuven, Belgium. Additionally, data for 120 monolingual Dutch children were taken from Ameel et al. (2008), gathered from five different age groups: 25 five-year olds, 25 eight-year olds, 25 ten-year olds, 25 twelve-year olds, and 20 children of fourteen years old. All the monolingual Dutch children attended schools in the Leuven area.

The naming data for the 29 adult monolingual French language users, all students of the Psychology Department of the University of Liège, Belgium, were also taken from Ameel et al. (2005). The sample of 122 additional monolingual French participants consisted of 25 five-year olds, 25 eight-year olds, 25 ten-year olds, 24 twelve-year olds, and 23 fourteen-year olds, who attended schools in the area of Wavre and Brussels, both in Belgium. These data were gathered for the current study and have not been described elsewhere.

The naming data of the 25 bilingual adults were taken from Ameel et al. (2005). They were all students from the universities of Leuven, Brussels, and Louvain-la-Neuve in Belgium except for one participant, who was a research assistant. The 106 bilingual children were living in different regions in Belgium and were recruited via advertisements. The child sample consisted of 17 five-year olds, 22 eight-year olds, 26 ten-year olds, 15 twelve-year olds, and 26 fourteen-year olds. These data were also gathered for the current study and have not been described elsewhere.

Materials

The stimulus set consisted of 73 pictures of household storage containers and was the same set referred to as the "bottles set" in earlier publications of Ameel and colleagues (Ameel, Malt, and Storms 2008, 2014; Ameel et al. 2005, 2009). The containers were selected to be likely to be labeled as *bottle* or *jar* in American English or else to share one or more salient features of typical bottles and jars. In Dutch and French, common labels for the pictured objects are *fles* or *bus*, and *bouteille* or *flacon*, respectively. (Note that, in keeping with our prior discussion, these terms are not directly equivalent to English *bottle* or *jar* and do not cover exactly the same group of referents [Ameel et al. 2005].) Care was taken to include objects that displayed the full existing variability within the storage container domain. The widely varying objects allow a sensitive comparison of the naming patterns of the different participant groups (Malt et al. 1999).

The stimuli were color photographs of the selected objects. They were taken on a neutral background with a constant camera distance and lens setting to preserve relative size and with a ruler clearly visible in front of the object for additional size information. Because the labels of the objects, which often contained information on the product in both Dutch and French, were clearly visible, additional information about the content of the contained substance (e.g. mustard) was not necessary. Figure 2 shows six of the stimuli.

Figure 2. Six examples of the stimulus set.

A questionnaire was used to determine the language background of the bilingual participants. The questionnaire asked for age and sex, where the participant was raised, what language was spoken at home by the father and the mother, what language was used in primary and, if applicable, secondary school and in leisure activities, what language the participant used most, and in which of the two languages she thinks spontaneously. The questionnaire also asked the participant (or her parent, in case of the youngest children) to indicate her proficiency in both languages on a seven-point rating scale, ranging from 1 for "not at all proficient" to 7 for "very proficient; native-like". Such self-reported proficiency measures have been shown to correspond well with direct performance evaluations (Dufour and Kroll 1995; Kroll et al. 2002). Average scores for the different age groups are shown in Table 1.[1] The questionnaire resembled the one used in Malt and Sloman (2003), but the wording of the questions was adapted for the youngest participants to make them suitable for their age.

Table 1. Average self-reported proficiency for Dutch and French in the different bilingual age groups (and standard deviation, in parentheses).

	Dutch	French
5-year olds	6.76 (0.56)	5.94 (1.39)
8-year olds	6.14 (1.25)	5.18 (1.59)
10-year olds	5.69 (1.07)	5.19 (1.27)
12-year olds	5.73 (1.33)	5.27 (1.03)
14-year olds	6.19 (0.94)	5.46 (0.99)
Adults	6.50 (0.74)	5.70 (0.64)

Procedure

Participants performed the naming task at home, at school, or in a test room at the university. Although the setting varied, testing was always in a quiet room where their performance could not be disturbed. Adults signed an informed consent form; parents signed on behalf of children. The picture set was presented on the screen of a laptop computer.

The participants were first asked to look through the picture set to familiarize themselves with the varied objects. Then they went through the pictures one by one and named each object. Instructions were given in the language in which the task was performed: Dutch for the Dutch-speaking monolinguals and for the bilinguals when doing Dutch naming, French for the French-speaking monolinguals and for the bilinguals when doing French naming. The instructions were translations of those given in the naming task by Malt et al. (1999): participants were asked to give the most natural or best name for the pictured container using one word or more than one. It was emphasized that the participant should name the container, not the contents, and that there were not correct or incorrect answers. Monolinguals performed the naming task only once. Bilinguals named all the stimuli twice, once in Dutch and once in French, with the order of the two languages randomized (with the restriction that half of the bilingual participants performed the Dutch naming task first and the other half performed the French task first). The order of the stimuli within the set was also randomized, and for bilinguals, the stimuli were shuffled again before the second presentation. A 10-minute break was given to bilinguals between their two language sessions.

The monolingual and bilingual adult participants (described in Ameel et al. 2005) and the Dutch-speaking monolingual children (described in Ameel et al. 2008) performed the naming task for two different stimulus sets: the "bottles set" described above and a similar set with pictured plates, bowls, cups, etc. The presentation order of the two sets was counterbalanced. Only the data gathered for the bottles set were used in the current study. This set shows larger divergences for adult monolinguals of the two languages (Ameel et al. 2005) and so can more clearly reveal cross-language influences in bilingual development.

Results

Bilingual development in each language individually

We investigate whether the bilingual children show a similar developmental trajectory in each of their two languages to that observed in the Dutch-speaking monolingual children

by Ameel et al. (2008) and the French-speaking monolingual children tested in the current study. First, we calculate the average number of different names produced by individual bilinguals and monolinguals at different ages. This measure provides one indication of the vocabulary size of participants. However, this measure does not capture where name consensus lies for a group. Even if members of a given age group provide on average, say, 10 names apiece across the stimulus set, it does not reveal to what extent individuals share the same 10 names or whether these names are used in a consistent way across participants. Therefore, we also compare the number of dominant (most frequently given) names in every age group in the monolinguals and the bilinguals. Next, we compare patterns of overextensions and underextensions in monolinguals and bilinguals. Last, we investigate whether the bilinguals' naming pattern evolves over as lengthy a period as monolinguals by comparing the complete naming patterns of the different age groups.

Average number of different names produced

Like the Dutch monolinguals reported in Ameel et al. (2008), and replicated here for the French monolinguals, the bilinguals show an increasing vocabulary across age groups, and this is true for both of their languages. The average number of different names produced by individuals (across all stimuli) in Dutch and French is shown in Table 2. Both series of averages rank correlate perfectly with the age of the participant groups, $\rho = 1$, $p < .01$.

A 2 (speaker group: bilinguals versus monolinguals) by 6 (age groups) factorial design analysis of variance (ANOVA; Kirk 1982) revealed that, on average, the monolingual values differ from the bilingual values, $F(1, 543) = 24.7$, $p < .01$, and that the number of different names differs across ages, $F(5, 543) = 179.6$, $p < .01$. As Table 2 shows, the speaker group effect reflects a tendency toward lower values for bilinguals; the age effect increases with age. However, the interaction between these variables is also significant, $F(5, 543) = 6.8$, $p < .01$. A posteriori *t*-tests show that the vocabulary size of the bilinguals is significantly smaller than that of the monolinguals in the 5-, 8-, and 10-year olds, but that the difference no longer reaches significance for the 12- and 14-year olds. For adults, the number of different names used by bilinguals even slightly (although not significantly) exceeds that of monolinguals. Thus, despite lesser language exposure to each of their two languages, which seems to especially affect their early vocabulary, the adult bilinguals succeed in building up lexicons that are as rich in both languages as those of the monolinguals in each.

Table 2. Average number of different names produced by individuals across all stimuli.

	5-year olds	8-year olds	10-year olds	12-year olds	14-year olds	Adults
Bilinguals						
Dutch	4.6	5.1	6.9	8.1	10.6	14.2
French	4.4	4.9	6.5	8.3	10.3	15.7
Monolinguals						
Dutch	5.7	7.6	8.4	8.6	10.1	13.6
French	7.1	8.0	8.4	10.3	10.7	14.9

Dominant names

Tables 3 and 4 show the set of names that emerge as dominant (i.e. are produced as the most frequent name for at least one stimulus within an age group) and the number of stimuli to which they apply in each of the age groups, for Dutch and French bilingual and monolingual naming. As for the Dutch (Ameel et al. 2008) and French monolinguals, an increase with age in the number of different words occurring as dominant names can be seen for both bilinguals' Dutch and their French naming. This is confirmed in a 2 (speaker group: bilinguals versus monolinguals) by 6 (age groups) factorial design ANOVA that yields a significant effect for age, $F(5, 12) = 7.2$, $p < .01$, while the two speaker groups do not differ significantly, $F(1, 12) = 0.012$. Furthermore, the interaction was not significant, $F(5, 12) = 1.7$. In other words, in contrast to the number of different words produced by individual participants, the number of dominant names is not smaller for bilinguals at early ages than that for monolinguals.

Patterns of overextension and underextension

Closer inspection of the dominant names reveals further evidence for a similar extended learning trajectory in bilingual naming as in monolingual naming (Ameel et al. 2008). In the Dutch naming task for all bilingual age groups, *fles* and *pot* are the most frequently occurring dominant names, consistent with the naming data from the Dutch monolinguals. Also in line with the findings from the Dutch monolinguals, the Dutch dominant names of the bilinguals show clear overextension for *fles*, as can be seen in Table 3: *Fles* is the dominant name for at least 40 stimuli in all age groups of the bilingual children, while it is the dominant name for only 30 stimuli in the adult bilinguals. Overextension can also be seen, but to a somewhat lesser extent, for *pot*. A remarkable difference in the naming of the bilinguals and the monolinguals in Dutch, however, is the use of *bus.* The number of stimuli for which *bus* is the dominant name grows gradually in the monolinguals, showing less underextension over time, while the bilinguals persistently severely underextend the category, as that name does not show up in the naming of the bilinguals before adulthood. The bilinguals' Dutch, then, shows a similar extended evolution in most respects to that of monolinguals, although it differs in some details of what words are used when.

In the French naming of all bilinguals, as well as all monolingual age groups, *bouteille*, *pot,* and *boîte* appear most frequently as the dominant names. Similar to the Dutch naming of the monolinguals and bilinguals, the percentage of stimuli for which the (three) most important names are dominant decreases with age. In line with naming for the monolingual French speakers, the use of *bouteille* decreases over time for bilinguals, showing a textbook example of early overextension. Early underextension is found for *tube*, *spray*, and *flacon*, similar to that for the monolingual French speakers.

Evolution of the name distributions in the bilinguals

The dominant names alone do not tell the whole story of correspondence in naming patterns across ages because they do not take into account other names used for an object. Objects are rarely named identically by all participants in an age group. For instance, only 3 of the 73 stimulus objects receive the same name from all 14-year-old bilingual participants in Dutch. Intragroup variability can be taken into account by looking at the complete name distribution of an age group for each object; that is, the frequency with which every possible name is given by that age group to a particular stimulus (Malt et al. 1999).

Table 3. Dominant names of the different age groups and their frequencies in the Dutch naming of monolinguals (1L) and bilinguals (2L).

5-year olds	1L	2L	8-year olds	1L	2L	10-year olds	1L	2L	12-year olds	1L	2L	14-year olds	1L	2L	Adults	1L	2L
fles	46	42	*fles*	34	49	*fles*	30	48	*fles*	28	41	*fles*	26	41	*fles*	25	30
pot	17	15	*pot*	21	9	*pot*	19	11	*pot*	*18*	15	*pot*	13	12	*pot*	13	11
fles/pot	0	5	*doos*	7	8	*doos*	4	7	*doos*	*4*	6	*doos*	6	10	*doos*	4	7
glas	0	4	*fles/pot*	2	4	*blik*	2	2	*tube*	4	4	*tube*	2	4	*tube*	4	6
doos	7	3	*blik*	2	1	*brik*	5	2	*blik*	2	2	*blik*	2	2	*bus*	16	4
fles/glas	0	2	*doos/pot*	0	1	*brik/doos*	0	1	*brik*	5	2	*spray*	0	2	*spray*	0	4
fles/glas/pot	0	1	*mand*	1	1	*fles/pot*	3	1	*brik/doos*	0	1	*spray/fles*	0	1	*blik*	2	3
mand	1	1	*bus*	2	0	*mand*	1	1	*fles/pot*	0	1	*mand*	1	1	*brik*	4	2
blik	1	0	*tube*	2	0	*bus*	5	0	*mand*	1	1	*bus*	14	0	*bidon*	0	1
fles/doos	1	0	*brik*	1	0	*doos/pot*	1	0	*bus*	8	0	*brik*	2	0	*emmer*	0	1
			fles/bus	1	0	*fles/doos*	1	0	*fles/bus*	2	0	*fles/bus*	2	0	*mand*	1	1
						tube	1	0	*pot/vat*	1	0	*fles/roller*	1	0	*molen*	1	1
												pot/doos	1	0	*roller*	1	1
												vat	1	0	*vat*	1	1
															stick	1	0
Total number of different dominant names used	6	8		10	7		11	8		10	9		12	8		12	14

Note: Whenever two or more names occurred with an equal frequency and that frequency was the maximum frequency, all these names were considered dominant and they are presented in combination, e.g. *fles/pot*.

Table 4. Dominant names of the different age groups and their frequencies in the French naming task of monolinguals (1L) and bilinguals (2L).

5-year olds	1L	2L	8-year olds	1L	2L	10-year olds	1L	2L	12-year olds	1L	2L	14-year olds	1L	2L	Adults	1L	2L
bouteille	60	44	*bouteille*	55	46	*bouteille*	44	41	*bouteille*	43	40	*bouteille*	30	34	*bouteille*	16	22
pot	0	13	*boîte*	6	19	*pot*	9	13	*pot*	16	12	*pot*	14	13	*pot*	10	13
bouteille/pot	0	5	*boîte/bouteille*	0	3	*boîte*	8	10	*boîte*	7	7	*tube*	4	7	*boîte*	6	9
boîte/pot	0	3	*boîte/ bouteille/pot*	0	1	*tube*	2	3	*tube*	0	3	*boîte*	6	5	*spray*	5	8
boîte	0	2	*boîte/verr*	0	1	*biberon*	1	1	*bouteille/ flacon*	0	2	*spray*	2	5	*flacon*	16	6
boîte/ bouteille/pot	0	2	*bouteille/ carton*	0	1	*boîte/bouteille*	0	1	*bocal/pot*	0	1	*carton*	0	4	*tube*	6	6
biberon	1	1	*bouteille/pot*	0	1	*boîte/ bouteille/pot*	0	1	*bouteille/pot*	0	1	*biberon*	1	1	*carton*	0	2
bouteille/verre	0	1	*verre*	0	1	*bouteille/pot*	1	1	*brique*	0	1	*bidon*	0	1	*biberon*	1	1
panier	1	1	*pot*	7	0	*canette*	1	1	*canette*	1	1	*boîte/pot*	0	1	*bidon*	2	1
verre	0	1	*biberon*	1	0	*panier*	1	1	*flacon*	2	1	*canette*	1	1	*canette*	1	1
canette	1	0	*bol*	1	0	*carton*	3	0	*flacon/pot*	0	1	*panier*	1	1	*moulin*	0	1
			berlingo	1	0	*bouteille/ flacon*	2	0	*flacon/tube*	0	1	*flacon*	1	0	*panier*	1	1
			canette	1	0	*bouteille/tube*	1	0	*panier*	1	1	*jus*	1	0	*rolleur*	0	1
			panier	1	0				*pot/tube*	0	1				*salière*	1	1
									biberon	1	0				*berlingo*	2	0
									carton	1	0				*brique*	2	0
									spray	1	0				*bidon/ bouteille*	1	0
															boîte/brique	1	0
															bombe	1	0
															poivrier	1	0
Total number of different dominant names used	4	10		8	8		11	10		9	14		10	11		17	14

Note: Whenever two or more names occurred with an equal frequency and that frequency was the maximum frequency, all these names were considered dominant and they are presented in combination, e.g. *bouteille/pot*.

We investigate whether the naming distributions of the bilingual children more closely resemble those of the bilingual adults in each language as they grow older. To do so, we first correlate the distributions of all possible pairs among the 73 stimuli, yielding a lower triangular similarity matrix of 2628 (= 73 × 72/2) correlations for every age group. The matrices can then be correlated to yield measures that indicate how well the entire naming patterns of two age groups (or of two different languages) resemble each other (Malt et al. 1999).

Table 5 shows the correlations between the name distribution similarities of the bilinguals in the six age groups for the Dutch naming task (upper panel) and for the French naming task (lower panel). The last column of each table shows the correspondence in naming between adults and each age group. The similarity to the name pattern of the adults increases with age, with rank correlations between age and the correlation with the adult name distribution significant for both Dutch and French ($\rho = 1$, $p < .01$, and $\rho = .90$, $p < .05$, respectively). (There is one exception to this trend: the correlation of 10-year olds with adults is significantly higher for French than that of the 12-year olds, $t(2625) = -7.19$, $p < .01$.) In general, the correlations increase as the ages of the participant groups being correlated differ less. Thus, these correlations indicate again that bilinguals show the same extended development trajectory, extending from age 5 to 14, that characterizes Dutch-speaking monolinguals (Ameel et al. 2008). A similar pattern is observed for the French monolinguals. Due to space limitations, we do not present the detailed correlations here.

Similarity in naming of the monolingual groups as a function of age

We now examine the developmental trajectory of similarities in naming between the two monolingual speaker groups to determine whether the imperfect correspondence between adult monolinguals observed by Ameel et al. (2005) is present from age 5 onward or whether agreement starts high and decreases over time. We investigate the similarities in the name distributions of the Dutch and the French monolingual groups as a function of age by correlating the matrices containing the 2628 correlations of pairwise name

Table 5. Correlations between the name distributions of the different age groups for the bilinguals in Dutch (upper panel) and in French (lower panel).

Age group	5-year olds	8-year olds	10-year olds	12-year olds	14-year olds	Adults
Dutch data						
5-year olds	–	0.74	0.60	0.55	0.47	0.36
8-year olds		–	0.71	0.64	0.59	0.48
10-year olds			–	0.89	0.85	0.69
12-year olds				–	0.86	0.75
14-year olds					–	0.85
Adults						–
French data						
5-year olds	–	0.68	0.56	0.51	0.41	0.33
8-year olds		–	0.66	0.62	0.52	0.39
10-year olds			–	0.83	0.77	0.64
12-year olds				–	0.78	0.58
14-year olds					–	0.82
Adults						–

distributions. These correlations are shown in Figure 3 above the top line of the squares for every age group. To give a better overview of the evolution of these correlations with age, the dashed line in Figure 4 shows these correlations graphically. The correlations between the matrices of the Dutch and the French monolingual children increase from the 5-year olds to the 10-year olds, indicating increasing correspondence of naming patterns. Then the correlation decreases to a more or less stable level from age 12 onward. This outcome is compatible with the hypothesis that children start out with shared similarity-based assumptions about word meanings and this similarity principle increasingly dominates their naming until the age of 10. Only then do they start to reshape their lexical categories to be more adult-like and language-specific, causing the naming patterns in the two languages to diverge.

Similarity in the two languages of bilinguals as a function of age

To investigate how the convergence in bilingual naming (Ameel et al. 2005) takes shape, the correlations between matrices for the two languages of the bilinguals (shown in Figure 3 below the bottom line of the square of every age group) are compared to the corresponding correlations for the two monolingual groups (shown above the top line of the squares for every age group). The correlation patterns of the monolinguals and the bilinguals are graphically displayed in Figure 4. The correspondence displayed by the bilinguals between the age of 5 and 10 is greater than that shown by the monolinguals described in the previous section, as can be seen in the (significantly) higher correlations in the bilingual group. Moreover, the bilinguals' correlations are significantly higher than the monolinguals' for every single age group, $p < .01$, demonstrating that the convergence in the bilinguals described in Ameel et al. (2005) is already present at early ages.

Because the reliability of the naming data, estimated with the split-half technique, differs in the age and language groups between 0.81 and 0.96, the correlations displayed in Figure 3 can be affected by these reliability differences. An estimate of the error-free correlation r^* between two variables X and Y, with reliabilities of, respectively, r_{XX} and r_{YY}, and an empirically obtained (error perturbed) correlation r_{XY} is given by $r* = r_{XY}/\sqrt{r_{XX}r_{YY}}$ (Lord and Novick 1968). The correlations between the name distributions of the two languages from the bilinguals, corrected for unreliability, are still significantly larger than those from the monolinguals at each age, $p < .01$. This finding unambiguously shows there is convergence in the naming of the bilinguals.

To determine how the convergence takes place, we can examine the values of the correlation between the matrices of the bilinguals as a function of age. The solid line in Figure 4 shows that the correspondence between the name distributions of the Dutch and the French bilinguals increases from the age of 5 to 14, but then decreases for the adults. The difference between the bilingual and the monolingual correlations is relatively small for ages 5–10 because of the increasing correlations for the monolinguals in this age range, as discussed previously. Because the correlation between naming in the two languages keeps on increasing through age 14 in the bilinguals while it declines in the monolinguals after age 10, the difference between the two language groups becomes substantially larger after age 10. The increasing correlations of the bilinguals through age 14 is in line with the increasing convergence hypothesis that bilingual children early on treat their two languages as distinct and only later on, as their knowledge increases and cross-connections in their lexical network become denser, reshape their naming patterns

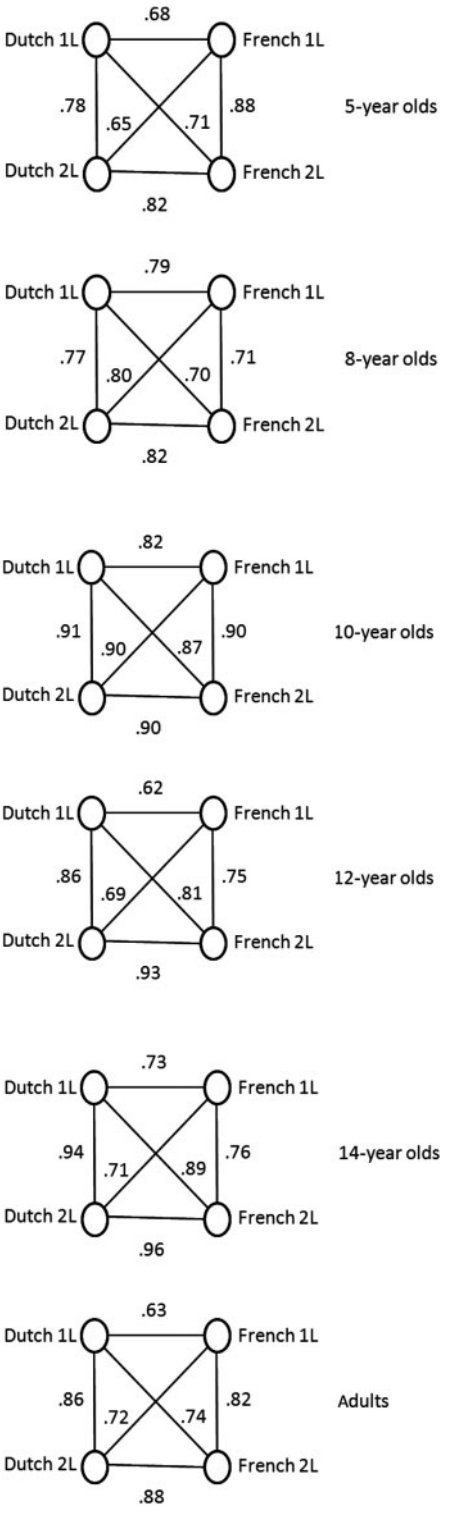

Figure 3. Patterns of correlations between the name similarity matrices of the language groups in the six age groups.

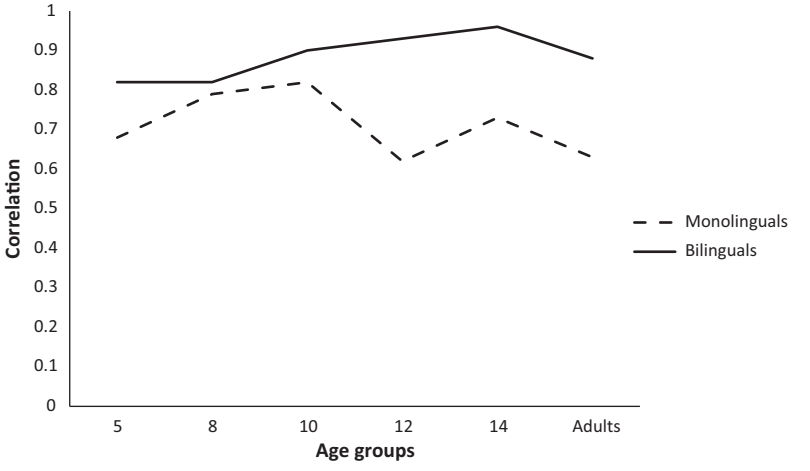

Figure 4. Evolution of the correlations between Dutch and the French name similarity matrices for monolingual and bilingual children.

to make them more alike in their two languages. Furthermore, the results show that this increasing convergence goes on at least until the age of 14.

Discussion

Developmental trajectory of naming common objects in monolinguals and bilingual children

Several researchers have called learning the meaning of common nouns an easy process (Gentner 1982) or even uninteresting (Bloom 2001). Nevertheless, as previously shown for monolingual Dutch speakers (Ameel et al. 2008), in the present study we found that in bilingual children, the vocabulary that refers to familiar household objects increases well beyond the early years of language learning. The bilinguals' growth in total vocabulary and in dominant names in both languages resembles the trajectory of monolinguals closely: Both monolinguals and bilinguals show an increasing number of different words used in the naming task and an increasing number of dominant names. Furthermore, bilinguals' use of these words evolves considerably after the nouns first appear in a child's vocabulary. Largely the same words are initially over- or underextended as for monolinguals, and just as in monolinguals, the naming pattern of the bilingual children takes at least until the age of 14 to become adult-like.

The highly similar vocabulary growth and refinement of meaning in bilinguals as in monolinguals is surprising, because the bilinguals have to learn adult-like naming in two languages that are not fully equivalent (Ameel et al. 2005, 2009), and must do so with roughly only half of the input for each language. Evidence that diminished input may hinder language learning comes from Gollan et al. (2005), who found that bilinguals name pictures in their dominant language more slowly and with more errors than did monolinguals, suggesting that the reduced practice bilinguals have in each language results in weaker mappings between semantic and lexical representations in each language. The results of studies with bilingual children, focusing on vocabulary size, are more equivocal, with some authors reporting a smaller vocabulary in bilingual children (e.g. Bialystok et al. 2010) and others reporting no difference between

monolinguals and bilinguals (e.g. De Houwer, Bornstein, and Putnick 2014). Nevertheless, our results show that they succeed rather well in their challenging task at least for the words for common household objects, which may be relatively frequently encountered. The bilingual children do initially lag behind in terms of the size of their lexicon, but they catch up by the time they are 12 years old. They also adjust their word meanings over time to use words in a more adult-like fashion.

Development of convergence in the bilingual lexicon

Two alternative hypotheses were put forward regarding the development of convergence in word use for the bilinguals. The decreasing convergence hypothesis stated that these children treat the two languages as the same initially, but later, as their knowledge increases, they learn the differences between the naming patterns in the languages. The increasing convergence hypothesis stated that the bilingual children treat the languages as distinct initially and that only later on cross-activation from words in one language to words in the other language reshapes their naming patterns to make them more alike in their two languages. Our finding of steadily increasing correlations up till the age of 14 in the bilinguals is clearly inconsistent with the hypothesis that the bilinguals start off with a single set of categories that gets labeled with two names, one for each language, and then learn to treat the languages differently. It is more in line with the increasing convergence hypothesis, which states that convergence becomes stronger as the children get older.

Several authors have shown cross-language influences at very early ages in bilinguals, which might be seen as contrasting with our results. However, this evidence comes from other domains, such as the use of pronouns (e.g. Serratrice, Sorace, and Paoli 2004) or the ordering of elements in compound nouns (e.g. Nicoladis 2002) and it does not provide inferences about possible crosslinguistic influences at the level of word meanings. Moreover, these projects have not traced the developmental trajectory of such influences. The increasing convergence that we found should not be interpreted as meaning that the bilinguals treat their languages initially as completely distinct, at least not in the age span investigated in this paper. In our 5-year olds, the naming distributions of the bilinguals' two languages correlate more strongly than do the name distributions of the monolingual groups. This finding does not reveal, however, how the correspondence in naming of bilingual children younger than 5 relates to the correspondence for equally young monolingual children. Using the current methodology to test younger children is not feasible, so it may be impossible to determine whether the earliest vocabulary is treated as more similar or more distinct across languages.

Similarity-based naming in Dutch/French monolingual and bilingual children

Correlating the name similarity matrices of the current study showed that naming patterns in monolingual Dutch and French speakers become more similar as children get older until the age of 10. This similarity in naming by the monolinguals does not increase further for 12- and 14-year olds and adults. For bilinguals, however, the similarity in naming in their two languages, which is already larger than for monolinguals in the young children, keeps on increasing until the age of 14 but decreases again in adults. How can the upward slope followed by a decline be explained, and why is there a difference between the two groups?

The increasing correlations with age for young children can be explained by an augmented sensitivity for similarity among potential referents of words. Young children

pick up names of individual objects very quickly from the adults they are interacting with, a process called fast mapping (Carey 1978). However, to learn the full conventional meaning of these words requires generalizing far beyond the initial fast mapping. Our data suggest that children's reliance on the similarity-driven nature of the extension of words increases with age as they generalize the use of the word beyond the initial experience. Eventually, however, they become more sensitive to the fact that similarity does not tell the whole story. This is the point when they learn to pay attention to language specificities in which relatively dissimilar objects may belong to the same lexical category or relatively similar objects may go into different ones in a given language. An important question, then, is why similarity as the binding principle of a lexical category is held onto longer in bilinguals than in monolinguals.

We can suggest at least one reason for this difference: The set of stimuli that are all labeled with the same name in a given language, as a whole, are usually fairly homogeneous. In other words, the similarity principle that the children discover gradually applies rather well for the majority of stimuli they are confronted with; the language-specific "exceptions" form a minority. Hence, the success of similarity-based categorization models like the prototype model (Rosch and Mervis 1975; Smith and Minda 2000), exemplar models (Medin and Schaffer 1978; Nosofsky 1988), varying abstraction models (Love, Medin, and Gureckis 2004; Vanpaemel and Storms 2008), and decision-bound models (Ashby and Maddox 1992). It seems plausible that the children first have to master similarity-based naming and feel certain about the general carving up process that divides the world into lexical categories before they start paying attention to the exceptions.

The situation, however, is somewhat different for the bilinguals. Not only do they have to learn (nonoverlapping) language-specific exceptions in two languages – a task they never fully succeed in (Ameel et al. 2005) – but, in early learning, they are much more occupied with mastering the basics of the approximately twice as large vocabulary set. Because the similarity principle serves them well in their double task of learning to name in their two languages, combined with the need to master a vocabulary twice the size of that of monolinguals, they may be tempted (or even forced) to lean longer on a general principle that allows them to get the right name for an object "mostly", but not always.

Though this hypothesis begs for further investigation, some evidence from our study can be given. Ameel et al. (2009) found that even adult bilinguals deviate from native-like naming in that they form simpler categories, which obey linear separability more, a finding that is consistent with the idea that bilinguals hold on longer to similarity as a categorization principle. Further investigation of early adherence to the similarity principle in naming in monolingual and bilingual children and of the increasing sensitivity to language-specific deviations of the principle may lead to increased understanding of the word learning process in general.

Acknowledgements

We thank Marieke Buffel, Jochem Raats, and Ellen Seys for their help in gathering the data and Farah Djalal, Loes Stukken, and Steven Verheyen for their help in some of the analyses. Any opinions, findings, and conclusions or recommendations expressed in this material are ours and do not necessarily reflect the views of the National Science Foundation.

Funding

This research was partly supported by the Leuven University Research Council [grant number OT/10/024], awarded to Gert Storms, and by National Science Foundation [grant number 1057885] to Barbara Malt and Ping Li.

Note

1. The rated proficiency of the bilingual children in both languages is analyzed with a bifactorial ANOVA, including age (5-, 8-, 10-, 12-, and 14-year olds) and language (Dutch and French). The analysis revealed that, on average, the children are more proficient in Dutch than in French, $F(1, 202) = 17.72$, $p < .01$, and that the language groups differ in proficiency, averaged over the two languages, $F(4, 202) = 3.60$, $p < .01$. The interaction of age and language is not significant, $F(4, 202) = 0.32$. Tukey's testing further revealed that the proficiency ratings of the 5-year olds are significantly larger than those of the 10- and the 12-year olds, but that no other pairwise comparisons among the age groups yield significance.

References

Ameel, E., B. Malt, and G. Storms. 2008. "Object Naming and Later Lexical Development: From Baby Bottle to Beer Bottle." *Journal of Memory and Language* 58 (2): 262–285. doi:10.1016/j.jml.2007.01.006.

Ameel, E., B. C. Malt, and G. Storms. 2014. "Steps along a Continuum of Word Knowledge: Later Lexical Development through the Lens of Receptive Judgments." *Language Learning and Development* 10 (3): 234–262. doi:10.1080/15475441.2013.840485.

Ameel, E., B. C. Malt, G. Storms, and F. Van Assche. 2009. "Semantic Convergence in the Bilingual Lexicon." *Journal of Memory and Language* 60 (2): 270–290. doi:10.1016/j.jml.2008.10.001.

Ameel, E., G. Storms, B. C. Malt, and S. A. Sloman. 2005. "How Bilinguals Solve the Naming Problem." *Journal of Memory and Language* 53 (1): 60–80. doi:10.1016/j.jml.2005.02.004.

Ashby, F. G., and W. T. Maddox. 1992. "Complex Decision Rules in Categorization: Contrasting Novice and Experienced Performance." *Journal of Experimental Psychology: Human Perception and Performance* 18 (1): 50–71. doi:10.1037/0096-1523.18.1.50.

Bialystok, E., F. I. M. Craik, D. W. Green, and T. H. Gollan. 2009. "Bilingual Minds." *Psychological Science in the Public Interest* 10 (3): 89–129. doi:10.1177/1529100610387084.

Bialystok, E., G. Luk, K. F. Peets, and S. Yang. 2010. "Receptive Vocabulary Differences in Monolingual and Bilingual Children." *Bilingualism: Language and Cognition* 13: 525–531. doi:10.1017/S1366728909990423.

Bloom, P. 2001. "Precis of 'How Children Learn the Meaning of Words'." *Behavioral and Brain Sciences* 24: 1095–1103.

Bowerman, M., and S. Choi. 2001. "Shaping Meanings for Language Universals and Language-specific in the Acquisition of Spatial Semantic Categories." In *Language Acquisition and Conceptual Development*, edited by M. Bowerman and S. C. Levinson, 475–511. Cambridge: Cambridge University Press.

Bowerman, M., and S. Choi. 2003. "Space under Construction: Language-specific Categorization in First Language Acquisition" In *Language in Mind*, edited by D. Gentner and S. Goldin-Meadow, 387–427. Boston: MIT Press.

Carey, S. 1978. "The Child as Word Learner." In *Linguistic Theory and Psychological Reality*, edited by M. Halle, J. Bresnan, and G. A. Miller, 264–293. Cambridge, MA: MIT Press.

Clark, E. V. 1993. *The Lexicon in Acquisition*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511554377.

De Houwer, A., M. H. Bornstein, and D. L. Putnick. 2014. "A Bilingual–monolingual Comparison of Young Children's Vocabulary Size: Evidence from Comprehension and Production." *Applied Psycholinguistics* 35: 1189–1211. doi:10.1017/S0142716412000744.

Dufour, R., and J. F. Kroll. 1995. "Matching Words to Concepts in Two Languages: A Test of the Concept Mediation Model of Bilingual Representation." *Memory and Cognition* 23 (2): 166–180. doi:10.3758/BF03197219.

Genesee, F. 1989. "Early Bilingual Development: One Language or Two?" *Journal of Child Language* 16: 161–179.

Genesee, F., E. Nicoladis, and J. Paradis. 1995. "Language Differentiation in Early Bilingual Development." *Journal of Child Language* 22: 611–631. doi:10.1017/S0305000900009971.

Gentner, D. 1982. "Why Nouns Are Learned before Verbs: Linguistic Relativity versus Natural Partitioning." In *Language Development, Thought and Culture*, Volume 2, edited by S. Kuczaj, 301–334. Hillsdale, NJ: Lawrence Erlbaum.

Gollan, T. H., R. I. Montoya, C. Fennema-Notestine, and S. K. Morris. 2005. "Bilingualism Affects Picture Naming but not Picture Classification." *Memory and Cognition* 33: 1220–1234. doi:10.3758/BF03193224.

Kirk, R. E. 1982. *Experimental Design: Procedures for the Behavioral Sciences*. Monterey, CA: Brooks/Cole.

Kroll, J., E. Michael, N. Tokowicz, and R. Dufour. 2002. "The Development of Lexical Fluency in a Second Language." *Second Language Research* 18 (2): 137–171. doi:10.1191/0267658302sr201oa.

Lord, F. M., and M. R. Novick. 1968. *Statistical Theories of Mental Test Scores*. Reading: Addison-Wesley.

Love, B. C., D. L. Medin, and T. M. Gureckis. 2004. "SUSTAIN: A Network Model of Category Learning." *Psychological Review* 111 (2): 309–332.doi:10.1037/0033-295X.111.2.309.

Malt, B. C., and S. A. Sloman. 2003. "Linguistic Diversity and Object Naming by Non-native Speakers of English."*Bilingualism: Language and Cognition* 6 (1): 47–67. doi:10.1017/S1366728903001020.

Malt, B. C., S. A. Sloman, S. Gennari, M. Shi, and Y. Wang. 1999. "Knowing versus Naming: Similarity and the Linguistic Categorization of Artifacts." *Journal of Memory and Language* 40 (2): 230–262. doi:10.1006/jmla.1998.2593.

Medin, D. L., and M. M. Schaffer. 1978. "Context Theory of Classification Learning." *Psychological Review* 85 (3): 207–238. doi:10.1037/0033-295X.85.3.207.

Nicoladis, E. 2002. "What's the Difference between 'Toilet Paper' and 'Paper Toilet'? French-English Bilingual Children's Crosslinguistic Transfer in Compound Nouns." *Journal of Child Language* 29: 843–863. doi:10.1017/S0305000902005366.

Nosofsky, R. M. 1988. "Exemplar-based Accounts of Relations between Classification, Recognition, and Typicality." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14: 700–708. doi:10.1037/0278-7393.14.4.700.

Rosch, E., and C. B. Mervis. 1975. "Family Resemblances: Studies in the Internal Structure of Categories." *Cognitive Psychology* 7 (4): 573–605. doi:10.1016/0010-0285(75)90024-9.

Serratrice, L., A. Sorace, and S. Paoli. 2004. "Crosslinguistic Influence at the Syntax–pragmatics Interface: Subjects and Objects in English–Italian Bilingual and Monolingual Acquisition." *Bilingualism: Language and Cognition* 7 (3): 183–205.doi:10.1017/S1366728904001610.

Smith, D. J., and J. P. Minda. 2000. "Thirty Categorization Results in Search of a Model." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 26 (1): 3–27. doi:10.1037/0278-7393.26.1.3.

Vanpaemel, W., and G. Storms. 2008. "In Search of Abstraction: The Varying Abstraction Model of Categorization." *Psychonomic Bulletin and Review* 15: 732–749. doi:10.3758/PBR.15.4.732.