Are Bilingual Logical Representations Shared?: Priming scopally ambiguous sentences in English, Estonian, and Dutch

Sentences with multiple scope-bearing operators, such as “All apples are not in the boxes”, are scopally ambiguous. One interpretation is that none of the apples are in the boxes (*universal-wide* interpretation: *all* takes wide scope over *not*), whereas the sentence could also mean that not all apples are in the boxes (*negation-wide* interpretation: *not* takes wide scope over *all*). The interpretations of a scopally ambiguous sentence are represented at a level know as logical representations, which can be primed in language comprehension (Raffray & Pickering, 2010; Feiman & Snedeker, 2016). In the present study, we tested whether bilingual logical representations are shared across languages or separate between languages, by measuring effects of logical representation priming between languages in language comprehension. This is an important question, as the construction of logical representations can be influenced by language-specific biases. For instance, in English and Dutch, the universal-wide interpretation of an *all...not* sentence is preferred, whereas the negation-wide interpretation of such a sentence is preferred in Estonian. By focusing on the interpretation of *all...not* sentences in English, Estonian, and Dutch, we also explored cross-linguistic transfer in bilingual logical representations.

We conducted five sentence-picture matching experiments to measure logical representation priming within and between languages (Figure 1). In the prime trials, participants were forced to assign one possible reading to an *all...not* sentence. In the subsequent target trials, they could choose between the two possible interpretations of such a sentence. In Experiment 1, we tested priming within the L1 in native speakers of English (Exp 1a; n = 113), Estonian (Exp 1b; n = 153), and Dutch (Exp 1c; n = 136) respectively. In Experiment 2, we tested priming from the L1 onto the L2 in Estonian-English (Exp 2a; n = 123) and Dutch-English (Exp 2b; n = 98) bilinguals. In Experiment 3, we tested priming from the L2 onto the L1 in Estonian-English bilinguals (n = 95). Finally, we also tested effects of priming within the L2 in Estonian-English bilinguals (Experiment 4; n = 99).

The results are shown in Figure 2. Logit mixed-effect model comparisons showed a main effect of priming in most of our (sub)experiments (Exp1a: $\chi^2(1) = 8.34$, $p = 0.008$; Exp1b: $\chi^2(1) = 10.99$, $p = 0.027$; Exp2a: $\chi^2(1) = 12.23$, $p < 0.001$; Exp3: $\chi^2(1) = 12.74$, $p < 0.001$; $\chi^2(1) = 22.27$, $p < 0.001$). The only exceptions were Experiment 1c ($\chi^2(1) = 3.47$, $p = 0.062$) and Experiment 2b ($\chi^2(1) = 2.29$, $p = 0.130$), which were the sub-experiments that involved speakers of Dutch. Here, the preference for the universal-wide reading seemed so strong that it hindered any effects of priming. Moreover, cross-experimental analyses showed that the effects of priming were comparable across all our experiments ($\chi^2(6) = 4.17$, $p = 0.654$).

One may posit an alternative explanation of these results in terms of visual priming, rather than in terms of logical representation priming. We tested this explanation in an English sentence-picture matching task in Experiment 5 (participants: n = 151). Here, the prime sentences were replaced by unambiguous sentences (Figure 1). Importantly, the prime trials were designed in such a way that the participants were still forced to select the same response picture as they would have in Experiments 1-4. The results of this experiment did not show an effect of visual priming ($\chi^2(1) = 0.53$, $p = 0.468$), and thus, the alternative explanation of visual priming does not bear out (which was further confirmed by cross-experimental analyses).

Finally, Experiments 1-4 also showed that Estonian-English bilinguals encounter transfer from the non-selected language in interpreting *all…not* sentences. Moreover, this cross-linguistic influence was induced when the prime trials were given in another language than the target trials (from the L1 onto the L2 and vice versa).

Altogether, the effects of priming observed in this study indicate that bilingual logical representations are shared between the languages a bilingual knows. Moreover, the cross-linguistic influence in the construction of logical representations suggests that not only short-term logical representations are shared, but more implicit knowledge and biases in the construction of logical representations are shared between languages as well (Van Gompel & Arai, 2018).

References
Feiman, R., & Snedeker, J. (2016). The logic in language: How all quantifiers are alike, but each quantifier is different. *Cognitive Psychology*, 87, 29–52. Raffray, C. N., & Pickering, M. J. (2010). How Do People Construct Logical Form During Language Comprehension? *Psychological Science*, 21, 1090–1097. Van Gompel, R. P., & Arai, M. (2018). Structural priming in bilinguals. *Bilingualism: Language and Cognition*, *21*(3), 448-455.

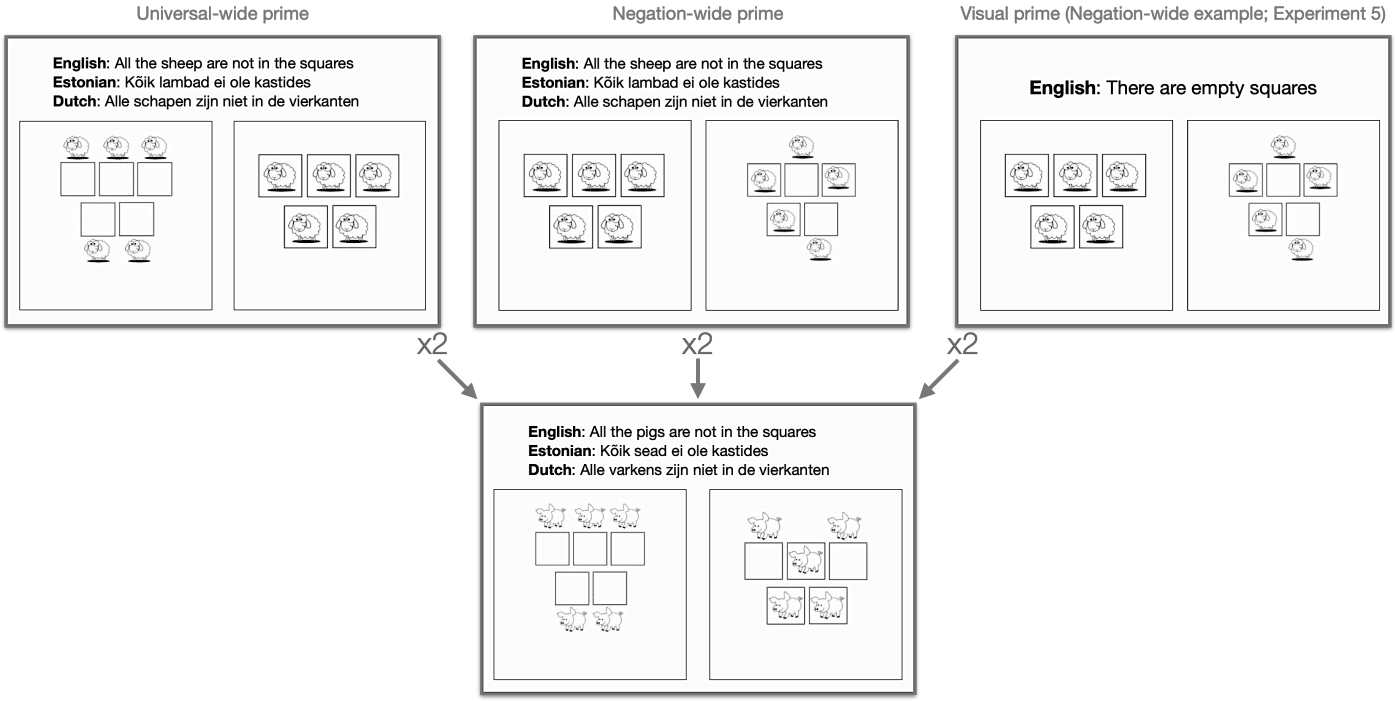

Figure 1. Procedure of the sentence-picture matching task used in all experiments. The participants were instructed to match the sentence with one of the two pictures. Each target trial was preceded by two prime trials. Both prime conditions (universal-wide vs negation-wide) were shown to each participant.

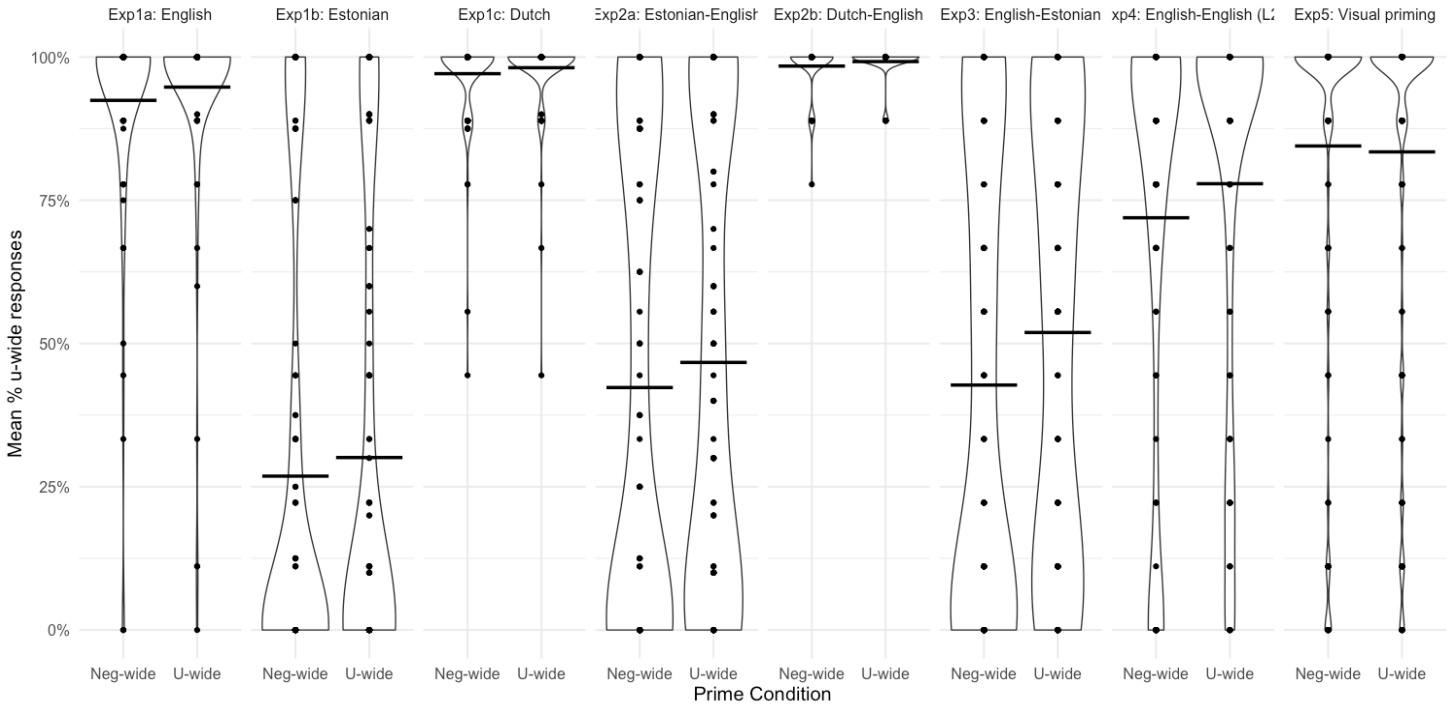

Figure 2. The participants' mean percentage of universal-wide responses on the target trials the two prime conditions in Experiments 1-5. The dots in this graph denote the mean response rate of the individual participants, and the vertical lines denote the mean response rate. The outlines of the violin plots indicate the distribution of the data.