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Reference:
Muylle Merel, Bernolet Sarah, Hartsuiker Robert J..- On the limits of shared syntactic representations : when word order variation blocks priming between an artificial language and Dutch
Journal of experimental psychology: learning, memory, and cognition - ISSN 1939-1285 - 47:9(2021), p. 1471-1493
Full text (Publisher's DOI): https://doi.org/10.1037/XLM0000997
To cite this reference: https://hdl.handle.net/10067/1831800151162165141

On the limits of shared syntactic representations: When word order variation blocks priming between an artificial language and Dutch

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Funding

This research was funded by a grant (G049416N) from the Research Foundation – Flanders (FWO).

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Abstract

Several studies used artificial language (AL) learning paradigms to investigate structural priming between languages in early phases of learning. The presence of such priming would indicate that these languages share syntactic representations. Muylle, Bernolet, and Hartsuiker (2020a) found similar priming of transitives and ditransitives between Dutch (SVO order) and an AL with either SVO or SOV order. However, it is unclear whether such sharing would occur if the AL allows both the same and different word order as the L1. Indeed, the presence of a (easy to share) similar structure might block (i.e., impede) sharing of a less similar structure. Here, we report two experiments that each tested 48 Dutch native speakers on an AL that allowed both SVO and SOV order in transitive and ditransitive sentences. We assessed both within-AL and AL-Dutch priming. We predicted a) priming of both structure and word order within the AL, and b) weaker AL-Dutch priming from SOV vs. SVO sentences due to the presence of SVO sentences in the AL. Indeed, cross-linguistic priming was significantly weaker in SOV vs. SVO conditions, but the blocking hypothesis was only supported by the transitive results. Unexpectedly, in the absence of a condition with verb overlap between prime and target sentences, no priming was found in AL and Dutch target conditions without verb overlap (Experiment 1), but priming emerged when a verb overlap condition was added (Experiment 2). This finding suggests that lexical repetition across sentences is crucial to establish abstract syntactic representations during early L2 acquisition.

Keywords: structural priming, artificial language learning, sentence production

A fundamental question in bilingualism is how people who know two or more languages represent syntactic information in their mind. Are there specific syntactic representations for each language or are they integrated in a more abstract representational network? Existing theories run the gamut from those arguing for a separate syntactic network for each language (e.g., Amaral & Roeper, 2014; de Bot, 1992) to those that state that syntactic structures can be shared across languages as long as they are similar enough (e.g., Hartsuiker & Bernolet, 2017; Hartsuiker, Pickering, & Veltkamp, 2004).

The idea that some structures might be shared across languages is supported by findings with the *structural priming* paradigm (Bock, 1986). Structural priming refers to the observation that recent exposure to a certain sentence structure facilitates the processing of a new sentence with this structure. For instance, hearing a passive structure (e.g., "the dog is being chased by the mailman") will increase the chance that you will use a passive structure as well in your own utterances. It is generally assumed that structural priming indicates that prime and target structure share a common underlying representation. Interestingly, reliable priming effects have been found regardless of whether there was lexical overlap between prime and target (although the effects tend to be larger when there is overlap; the so-called *lexical boost* effect, Pickering & Branigan, 1998), and even across languages (e.g., Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016; Hartsuiker et al., 2004; Kantola & van Gompel, 2011; Loebell & Bock, 2003; Salamoura & Williams, 2006; Schoonbaert, Hartsuiker, & Pickering, 2007; see Mahowald, James, Futrell, & Gibson, 2016, for a meta-analysis). Structural priming between languages has been widely observed, with several language pairs and with various syntactic constructions (see Van Gompel & Arai, 2018, for a review), for instance English-Mandarin transitives (Chen, Jia, Wang, Dunlap, & Shin, 2013), Mandarin-Cantonese ditransitives (Cai, Pickering, Yan, & Branigan, 2011), and English-

Dutch genitives (Bernolet, Hartsuiker, & Pickering, 2012; 2013). This raises the question how similar structures have to be across two languages in order to establish sharing.

The role of word order

Several studies found priming between languages that are very different in morphological realization (e.g., overt vs. covert case markers on nouns, Fleischer, Pickering, & McLean, 2012; Muylle, Bernolet, et al., 2020a; Salamoura & Williams, 2007), which indicates that the shared syntactic representations are abstracted over such morphosyntactic differences. In contrast, studies investigating priming of a structure that varies in word order between languages yield mixed results. For instance, priming was found in comprehension (Weber & Indefrey, 2009), but not in production (Loebell & Bock, 2003) between English verb-medial (e.g., "The floors <u>are cleaned</u> daily by the janitor") and German verb-final passives (e.g., "Die Böden <u>werden</u> täglich von dem Hausmeister <u>gereinigt</u>"), although this latter study also did not find priming within German. In contrast, other production studies found priming between an analogous pair of language structures, namely English verb-medial and Dutch verb-final passives (e.g., "De vloeren <u>worden</u> dagelijks door de conciërge <u>schoongemaakt</u>", see Bernolet, Hartsuiker, & Pickering, 2009). Furthermore, several studies investigating German-English and Dutch-English prime-target pairs found no priming for subordinate or relative clauses that have subject-verb-object (SVO) word order in English, but subject-object-verb (SOV) order in German and Dutch (Bernolet, Hartsuiker, & Pickering, 2007; Jacob, Katsika, Family, & Allen, 2017; Kidd, Tennant, & Nitschke, 2015), whereas other studies found cross-linguistic priming between structures with different word orders (Desmet & Declercq, 2006; Hartsuiker et al., 2016). Finally, for language pairs that are typologically more distant (e.g., English-Korean, English-Mandarin), cross-linguistic priming was found despite word order differences (Chen et al., 2013; Hwang, Shin, & Hartsuiker, 2018; Shin & Christianson, 2009; Song & Do, 2018). In their review paper, van Gompel and Arai (2018) suggest that representations of structures that differ in word order across languages are connected, but not fully shared, in contrast to identical structures. If this is true, priming effects should be stronger for structures that have the same word order than for structures that have a different word order across languages.

In a recent study, Muylle, Bernolet, et al. (2020a) aimed to isolate the role of word order in structural priming, using an artificial language (AL) learning paradigm. Participants acquired the AL by means of pictures and action movie clips (from the normed set of Muylle, Wegner, Bernolet, & Hartsuiker, 2020). More concretely, priming was assessed between the native language (L1), in this case Dutch (that has SVO order in the main clause, but see below for a more detailed discussion of Dutch word order) and an AL version that had either SVO (e.g., "dettus zwifsi fuipam" [clown kisses cook]) or SOV word order (e.g., "dettus fuipam zwifsi" [clown cook kisses]) in the main clause (there was also a third AL version that had SVO order and case marking, which we will not further discuss here). This manipulation allowed for a direct comparison between priming effects elicited by constructions with different word orders, while all other factors that might play a role in priming were eliminated. Interestingly, no significant differences in priming were found between the different AL versions; for transitives (actives vs. passives), priming was similar for both AL groups a) within the AL, b) within Dutch, c) from Dutch to the AL, and d) from the AL to Dutch. Within the AL, the priming effect was 21% in the SVO version and 30% in the SOV version. Importantly, transitive priming from the AL to Dutch was 26% for the SVO version and 25% for the SOV version.[1] For the ditransitives (double-object datives or DO vs.

[1] The data for the within-Dutch and Dutch-to-AL condition are not further mentioned here because they are less relevant for the current paper.

prepositional-object datives or PO), the priming effect within the AL was 35% in the SVO version and 22% in the SOV version, but there was no cross-linguistic priming. Regarding the latter, a similar finding was obtained by Muylle, Bernolet, and Hartsuiker (2019), who investigated priming by means of the same AL paradigm in a multiple session design. Also there, cross-linguistic priming effects were reliably found in transitive sentence pairs during the first session, but not in ditransitive pairs (which were only observed from the second session onwards). This suggests that ditransitive structures need more time to become shared across languages.

Muylle, Bernolet, et al.'s (2020a) findings with the AL learning paradigm suggest that differences in word order (but similarity on other dimensions such as voice, information structure, and constituent structure) between languages do not affect the emergence of shared syntactic representations in late second language (L2) learners. In other words, the representations of structures that differed in word order were shared to the same extent as those with identical word order (e.g., active SVO structures were shared to the same extent with active SVO and active SOV structures in the other language). It has to be noted, however, that main clauses in Dutch have mainly SVO order (although there is subject-verb inversion, hence VSO order, for questions and for sentences that do not start with the subject), whereas subordinate clauses have SOV word order. For this reason, linguistic theories often consider Dutch as an SOV language (see Koster, 1975). Nevertheless, the Dutch syntax does not allow SOV word order in the type of sentences that were used in Muylle, Bernolet, et al.'s (2020a) study (i.e., simple transitive and ditransitive main clauses). Hence, L1 speakers of Dutch should have more difficulties to integrate SOV compared to SVO AL representations with their L1 representations. However, Muylle, Bernolet, et al. (2020a) found no differences in priming between Dutch and an AL with SVO vs. SOV order when participants learned only one of both word orders, which indicates that word order does not affect the sharing of syntax during AL acquisition.

Structural priming studies show that syntactic representations can be very abstract in nature, given that there is evidence for sharing across languages despite clear differences in the realization of constituent structure (see also Hartsuiker & Bernolet, 2017). However, it is not clear whether the sharing of syntax would also emerge for an L2 structure that is quite different from L1 *when the L2 has an alternative structure that is more similar to L1*. According to behavioral learning theory (see Rescorla & Wagner, 1972; Stout & Miller, 2007), the learning of an association between a conditioned stimulus and an unconditioned stimulus is impaired when the conditioned stimulus is presented together with another conditioned stimulus that was already associated with the unconditioned stimulus (Kamin, 1969). For instance, when Pavlov's dog would be presented with a flashing light (a new conditioned stimulus) during the ringing of the bell (conditioned stimulus) that has been associated with food (i.e., unconditioned stimulus), he would have great difficulties with learning the association between the flashing light and the food, because the bell has already been associated with the food. As a result, the dog will not produce saliva when presented with the flashing light alone, even though it actually predicts the presentation of the food in 100% of the cases. This is referred to as the Kamin blocking effect. Although we do not claim that classical conditioning mechanisms underlie L2 learning, it is conceivable that in an L2 learning situation, a similar blocking mechanism could come into play in the sense that the sharing of the similar L2 structure (that is more easily integrated with the L1 structure in comparison with the less similar structure) might interfere with the sharing of the less similar L2 structure with its L1 counterpart. In other words, if an L2 would allow both SVO and SOV word order for sentence structures that can only have SVO in the L1, the sharing of the L2 SOV representations with L1 SVO representations may be blocked because the L2 SVO representations are shared with L1 SVO representations. This sharing is measured by means of structural priming in terms of the alternation between actives and passives (for transitives) and PO and DO (for ditransitives), so apart from the specific word order the tested structures share features on another level as well (e.g., information structure, voice). The focus will be on this type of priming and not on word order priming (SVO vs. SOV, although we also report data on word order priming). Hence, structural priming from L2 SVO to L1 should be stronger than from L2 SOV to L1 when both orders exist in the L2 (but not in isolation as was shown by Muylle, Bernolet, et al., 2020a). The current study aims to test this hypothesis by investigating how the presence of both a structure with the same and a different word order in L2 influences the integration of their representations across L1 and L2, using the AL learning paradigm (Muylle et al., 2019; Muylle, Bernolet, et al., 2020a).

The artificial language learning paradigm

There are several advantages to the use of ALs from both learning and linguistic perspectives. In terms of learning, an AL learning paradigm allows the experimenter to investigate how participants learn a new language in the earliest stages of acquisition, while maintaining full control of the participant's exposure to that language (e.g., there is no contact outside the lab, the experimenter can decide how many times a certain word is presented in a certain structure, and knows exactly how many times a stimulus was presented at a given timepoint during the experiment). From a linguistic perspective, researchers can freely adjust features of the AL in order to manipulate the similarity with natural languages that are known by the participant.

Nevertheless, there are also some limitations inherent to AL experiments. First, for practical reasons, the AL usually consists of a very limited set of vocabulary and syntactic structures (for that reason, they are sometimes referred to as 'miniature' or 'toy' languages, e.g., Wonnacott, Newport, & Tanenhaus, 2008). In addition, the motivation of a participant to study a non-existing language might be different from people studying a natural language that serves a communicative purpose in life.

Despite these limitations, AL learning paradigms have proven to be a promising tool in second language acquisition research (e.g., Muylle et al., 2019; Weber, Christiansen, Indefrey, & Hagoort, 2019; Wonnacott et al., 2008) and seem to replicate processes and phenomena that are also observed in natural language learning situations. For instance, Muylle and colleagues (2019) studied structural priming in a five session AL learning design and found priming within the AL during all sessions, and a lexical boost effect, comparable to what has been found in natural language experiments. In addition, they found priming between the AL and the participants' L1 in both directions. Cross-linguistic priming was stronger when there was meaning overlap (in the form of translation equivalents) between prime and target verb. This so-called translation equivalent boost has also been observed in priming between L1 and L2 (Schoonbaert et al., 2007). This indicates that the sharing of syntactic information within and between languages can emerge in very early stages of L2 learning. In sum, AL learning paradigms seem to be an adequate tool to study shared syntactic representations in L2 learning.

The goal of the present study is to investigate whether the presence of an L2 structure that is similar to L1 blocks the sharing of an L2 structure that is less similar to L1 in early phases of L2 acquisition. Specifically, we tested how the presence of both SVO and SOV word order in L2 influences structural priming of transitive and ditransitive sentences from L2 to an L1 that allows SVO, but not SOV word order in main clauses. We therefore created an AL that had both SVO and SOV word order for each structure (i.e., active, passive, PO, and DO). Participants with Dutch as L1 came to the lab to learn the AL. We hypothesized that there would be more priming of transitives and ditransitives from SVO to SVO compared to SOV to SVO sentences, because the existence of the SVO structure in the AL would block the integration of the AL SOV structure with Dutch syntax. We tested these predictions in two experiments, reported below. Experiment 1 presented only conditions with different verbs between prime and target, but Experiment 2 added a condition with related verbs.

Experiment 1

Methods

Participants

Forty-eight university students (14 males, 34 females) participated in this experiment. They were between 18 and 34 years old (*M*= 19.5; *SD*= 2.92) and received course credits and a payment of 10 Euros in exchange for participation. All of them had exclusively Dutch as L1, had normal or corrected-to-normal hearing and vision, and did not suffer from any learning or language disorder. Students who were interested in participating received a questionnaire about their language background. If they met the criteria, an authorization code was sent which was necessary to sign up for the experiment.

Materials and design

The materials were nearly identical to those used in the SVO and SOV conditions in Muylle, Bernolet, et al.'s (2020a) study, who made adapted versions of *PP02*, an AL that was originally created by Muylle et al. (2019; see Table 1 for examples of PP02 sentences). In total, the AL consisted of twelve nouns, of which ten designated human figures and two designated objects. Each participant learned nine verbs (three intransitives, three transitives, and three ditransitives)[2].

The PP02 learning tasks consisted of five blocks: a) a vocabulary learning block in which participants learned to associate pictures with their PP02 names; each picture of human figures or objects appeared eight times (96 trials in total), b) a sentence exposure block (60 trials) in which participants watched short movie clips of 3 s, depicting either an intransitive, transitive, or ditransitive action, after which they repeated a PP02 sentence that described the movie, c) a matching block (90 trials), in which participants matched PP02 sentences with the appropriate movie, receiving feedback afterwards, d) a sentence production block (24 trials), where participants described movies with a PP02 sentence and received feedback on their utterances, and e) a priming block (120 trials), in which participants first decided whether the prime sentence matched the prime movie, after which they described the target movie in either Dutch or PP02[3]. Throughout the blocks, the participants received an equal number of SVO and SOV stimuli, which were equally divided across the different blocks, syntactic structures and across verbs. Hence, each participant was presented with, for instance, an equal number of active SVO sentences with the verb "zwif" and passive SOV sentences with the verb "firp".

[2] This is different from Muylle et al.'s (2020a) study, where each participant learned only two verbs per type, instead of three. This was done in order to avoid that participants could predict which verb would appear in the target condition, given that we did not include any verb overlap (i.e., related) condition in the current experiment. Indeed, if there were only two verbs for each type, this would mean that the appearance of one verb as prime verb would constrain the target verb to be the other verb.

[3] The increase in the number of verbs that needed to be learned, together with the fact that each movie clip could be described with four instead of two different sentence structures (e.g., for transitives: active SVO, active SOV, passive SVO, passive SOV), led to the decision to augment the number of trials in comparison with Muylle, Bernolet et al.'s (2020a) study.

Table 1. Examples of each structure for both word orders in PP02.

	SVO	SOV	Dutch
Intransitive	Dettus jaltsi	Dettus jaltsi	De clown zwaait
	Clown waves	*Clown waves*	*The clown is waving*
Active	Dettus zwifsi fuipam	Dettus fuipam zwifsi	De clown kust de kok
	Clown kisses cook	*Clown cook kisses*	*The clown is kissing the cook*
Passive	Fuipam nast zwifo ka dettus	Fuipam ka dettus nast zwifo	De kok wordt gekust door de clown
	Cook is kissed by clown	*Cook by clown is kissed*	*The cook is being kissed by the clown*
DO-dative	Dettus heufsi fuipam sifuul	Dettus fuipam sifuul heufsi	De clown geeft de kok de hoed
	Clown gives cook hat	*Clown cook hat gives*	*The clown is giving the cook the hat*
PO-dative	Dettus heufsi sifuul bo fuipam	Dettus sifuul bo fuipam heufsi	De clown geeft de hoed aan de kok
	Clown gives hat to cook	*Clown hat to cook gives*	*The clown is giving the hat to the cook.*

Procedure

The experiment had a duration between 1.5 and 2 hours. After signing the informed consent, the participants sat in front of a 24-inch computer screen, where they started with the online version of LexTALE Dutch (www.lextale.com; Lemhöfer & Broersma, 2012). Next, the experimenter administered the forward and backward digit span (WAIS-IV subtests; Wechsler, 2008). The LexTALE and digit span tests were done to provide control measures of vocabulary knowledge and working memory capacity (this allows for comparison with other studies using the same paradigm in which these tests were done as well). When these were completed, the participants received a Sennheiser HD 215 headphone and were told that they would learn an AL by means of pictures and short action movie clips after which they went sequentially through the five AL learning blocks. This part of the experiment was recorded in Audacity® (Audacity Team, 2018). All stimuli appeared on a grey background and both pictures and movies appeared in the center of the screen (except for the matching block). The text was always in black (font type: Courier, bold; height: 62 px) and PP02 textual stimuli were always accompanied by an oral presentation through the headphones. Each block was preceded by a screen with instructions.

During the vocabulary learning block, each trial started with a picture of a human figure or object. When the picture was encountered for the first time, the PP02 name appeared below the picture and participants were asked to repeat the name aloud and press the spacebar to continue to the next trial. The next time the same picture was presented, no name was given and participants had to try to produce the noun themselves. After this, they could press the spacebar to access the correct answer.

In the sentence exposure block, the trial started with a PP02 verb that was presented centrally on the screen. Then, an action movie played, accompanied by a PP02 sentence that described the action depicted in the movie using the presented verb. Here, the participants were simply asked to repeat the sentence aloud and press the spacebar to go to the next trial.

Next, in the matching block, two movie stills appeared on the left and right hand side of the screen. First, the left movie played, and, once finished, the right movie started to play. After this, a fixation cross appeared in the middle of the screen and a PP02 sentence appeared underneath. The participants were instructed to indicate which of the movies matched the sentence, by pressing either Q for the left movie or M for the right movie. Once a response was given, the correct movie played again and the sentence was repeated through the headphones. The participants repeated the sentence aloud and pressed the spacebar to continue with the next trial.

During the sentence production block, participants watched a movie and were asked to describe the action in PP02. For this, they could use cheat sheets on which the pictures and their names from the vocabulary block were given. The experimenter gave feedback on their utterances using a Cedrus RB-730 response box to present the correct response that most closely resembled the utterance (based on the categorization described in the *Coding of responses* section). In total, there were five buttons: a) active/DO SVO, b) active/DO SOV, c) a button that randomly picks one of the other responses (in case of *other* productions, see below), d) passive/PO SOV, and e) passive/PO SVO. For intransitive sentences all buttons activated the same response. The response was presented underneath the movie and after the audio stopped playing, a new trial started.

Finally, in the priming block, a movie appeared at the start of each trial with underneath a sentence of which the participants were asked to indicate whether the movie matched the sentence (by pressing Q) or not (by pressing M). After this, a new movie appeared and participants were instructed to describe the action in either PP02 or Dutch, depending on a cue ('AT'= PP02, 'NL'= Dutch). Also here, participants were allowed to use the vocabulary cheat sheets. When finished, they pressed the spacebar to continue to the next trial.

When all tasks were completed, the participants were asked to write down what they thought the goal of the experiment could be. Next, they read the debriefing and answered some final questions in which they were asked a) whether they noticed during the experiment that they were influenced by the prime sentence (yes/no), and b) if so, whether they formulated another structure than the one that came into their mind (never-seldom-sometimes-often-always). At the end of the questionnaire, some space was provided for comments. When these documents were completed, the experiment ended.

Coding of responses

Transitive and ditransitive responses in the sentence production and priming blocks were scored on two dimensions: constituent structure (i.e., *active*, *passive*, or *other* for transitives, and *DO*, *PO*, or other for ditransitives), and word order (i.e., *SVO*, *SOV*, or *other*, only for PP02 targets). Erroneous responses that contained all constituents (e.g., vocabulary errors or preposition errors) were also scored based on a fixed set of rules.

For the transitives, responses were coded as *active* when the structure that was used in the sentence was active (i.e., when there was no auxiliary and preposition). For instance, if someone said "fuipam firpsi hapolkt" (*cook shoots pirate*) instead of "hapolkt firpsi fuipam" (*pirate shoots cook*), the response was coded as *active*, because the syntactic structure was that of an active. A similar rule was applied for passives. Switches in thematic roles had no impact on the scoring of ditransitives as DO or PO (e.g., switch of agent and indirect object in sentences with the verb 'dwok' [*sell*], which was sometimes erroneously interpreted as *buy*). Ditransitive sentences in which a preposition was used were always scored as *PO* and the sentences without preposition as *DO*, regardless of the order in which theme and indirect object appeared.

PP02 sentences in which the verb appeared in the second position of the sentence were coded as *SVO*. Any verb movement toward the end of the sentence was coded as *SOV* (for instance, if in a PO sentence, the verb appeared in between the theme and indirect object, it was coded as *SOV*, e.g., 'dettus sifuul <u>heufsi</u> bo fuipam' [clown hat gives to cook]). Dutch sentences that contained another verb than the intended one were still scored as long as the sentence structure belonged to one of the target categories (i.e., *active* or *passive* for transitives, and *DO* or *PO* for ditransitives). For instance, if the participants used the verb *kriebelen* instead of *kietelen* (Dutch synonyms for *tickle*), the response was categorized, but if they used the construction "geeft een kus aan" [*gives a kiss to*] instead of "kust" [*kisses*], this was scored as *other* response. Finally, responses formulated in the wrong target language, were also coded as *other*. All *other* responses were discarded from analysis (485 in total, 9% of the responses).

Results

The data and scripts can be found on the Open Science Framework (link: https://osf.io/ncdfa).

Control tasks and accuracy. The mean LexTALE score was 86.20 (*SD* = 7.31), the mean forward digit span was 5.98 (*SD* = 0.86), and the mean backward digit span was 4.75 (*SD* = 1.08). PP02 accuracy was calculated by adding accuracy scores of a) the eighth presentation of each item in the vocabulary block (in order to grasp the vocabulary knowledge at the end of the vocabulary learning block), b) the matching block, c) the production block, and d) PP02 target trials in the priming block (responses were only coded as correct when both vocabulary and sentence structure were entirely correct), divided by the total number of observations. The mean accuracy was 78% (*SD* = 12%). An overview of the accuracy for the different blocks (except for the sentence exposure block, where no accuracy was measured) can be found in Table 2. For the vocabulary learning block the mean accuracy was 64% (*SD* = 28%). In order to find out whether there was a difference in learning for both word orders, we built generalized linear mixed effects models with Accuracy (0 vs. 1) as outcome variable using the lme4 (Bates, Mächler, Bolker, & Walker, 2015) and afex (Singmann et al., 2016) packages in R. The fixed effects model consisted of Word Order (SVO vs. SOV) and the random effects model was kept maximal (i.e., Word Order | Subject), in accordance with the guidelines provided by Barr, Levy, Scheepers, and Tily (2013). In case of a singular fit (i.e., the effect of the random slope was 0), the slope of Word Order was removed (see osf.io/ncdfa for the model output). The results of these analyses indicate that initially, there is a small difference for comprehension (as measured in the matching block) in the sense that the participants show higher accuracy for the SVO sentences. However, this difference disappeared in the sentence production and priming blocks.

Table 2. Accuracy scores for SVO and SOV sentences in each block (Experiment 1).

	SVO *M* (*SD*)	SOV *M* (*SD*)	*Wald's Z*	*p*-value
Matching block	0.86 (0.48)	0.84 (0.51)	2.04	<.05
Sentence production block	0.56 (0.62)	0.52 (0.64)	0.63	.53
Priming block	0.72 (0.57)	0.68 (0.49)	1.10	.27

Structural preferences. The response distribution of PP02 targets in the sentence production block and priming block can be found in Table 3 and 4, respectively. As can be derived from the tables, the distribution was very similar in both blocks. In the priming block, transitive utterances showed a strong preference for the active structure in both SVO (97%) and SOV sentences (98%). For the ditransitives, there was a preference for PO responses in PP02 SVO (59%), but this preference was inverted in the PP02 SOV utterances (29%). For the Dutch responses in the priming block, active responses were strongly preferred over passive responses (99%) and the PO responses were preferred over the DO responses (89%).

Table 3. Response distribution in the sentence production block (Experiment 1).

	transitives			Ditransitives		
	active	passive	*total*	DO	PO	*total*
SOV	0.25	<0.01	*0.25*	0.22	0.10	*0.32*
SVO	0.73	0.02	*0.75*	0.30	0.38	*0.68*
total	*0.98*	*0.02*	*1.00*	*0.51*	*0.49*	*1.00*

Table 4. Response distribution in the priming block (Experiment 1).

	transitives			Ditransitives		
	active	passive	*total*	DO	PO	*total*
SOV	0.21	<0.01	*0.22*	0.21	0.08	*0.29*
SVO	0.76	0.02	*0.78*	0.29	0.42	*0.71*
total	*0.97*	*0.03*	*1.00*	*0.50*	*0.50*	*1.00*

Structural priming. In the context of the current study, structural priming is conceptualized as the proportion of active/PO responses after an active/PO prime minus the proportion of active/PO responses after a passive/DO prime. The observed priming effect for each condition can be found in Figures 1 and 2 (see Appendix A.1 for a distribution of responses combining structure and word order). Priming effects were assessed separately for transitives and ditransitives with generalized linear mixed effects models.

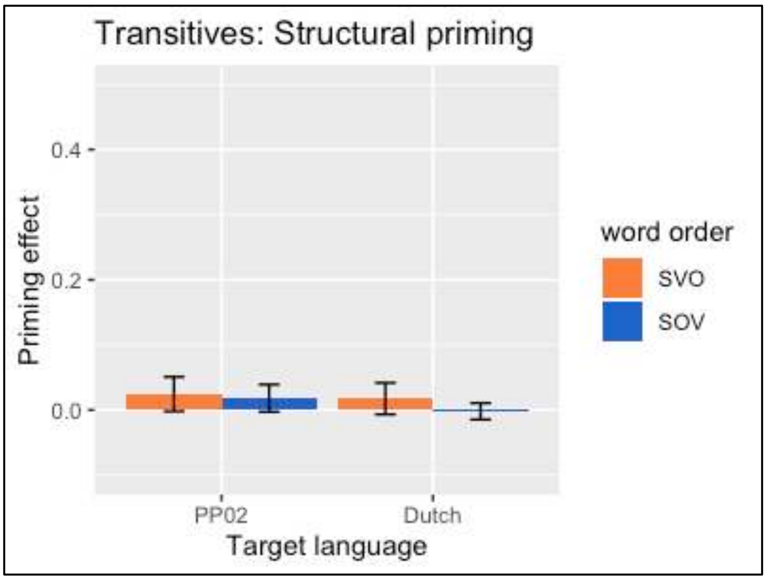

Figure 1. Structural priming in transitives (Experiment 1).

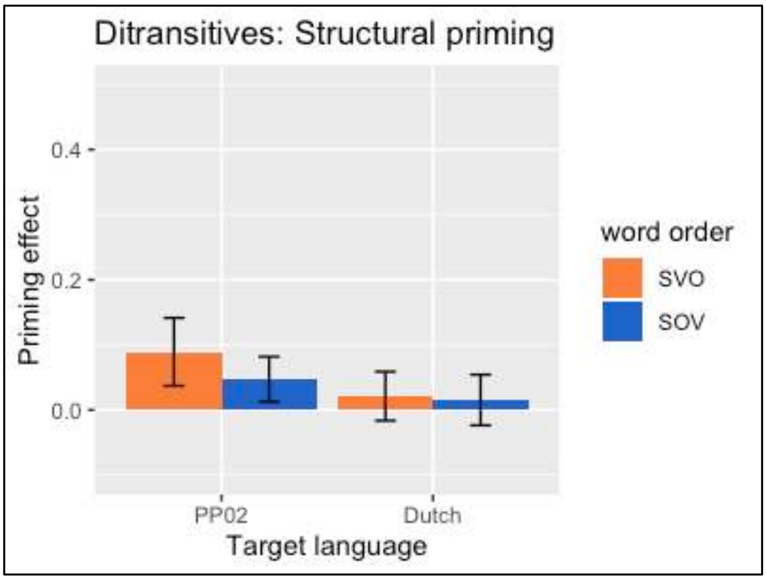

Figure 2. Structural priming in ditransitives (Experiment 1).

Transitives. The fixed effects structure of the transitive model (binomial outcome: *Active answer*) consisted of a three-way interaction *Prime structure * Prime order * Target language*. Because the maximal random effects structure (Barr et al., 2013) did not converge, it was simplified until convergence (Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). Hence, the random effects structure consisted of a random intercept for *Subject* and an uncorrelated random slope of *Target language* over *Subjects* (the output of the model can be found in Appendix B.1). Overall, there was only weak evidence for priming ($Z = 1.79$, $p = .07$) and this did not differ across prime word orders and target languages (all *p*'s > .1).

Ditransitives. The ditransitive model had the same fixed effects structure as the transitive one (outcome variable: *PO answer*). Also here, the random effects structure was simplified due to convergence issues. The random effects consisted of a random intercept for *Subject* and uncorrelated random slopes of *Prime structure* and *Target language* over *Subjects* (the model output is presented in Appendix B.2). There was an overall significant priming effect ($Z = -3.57$, $p < .001$), but post hoc pairwise comparisons using the phia package (De Rosario-Martinez, 2013) showed that this effect was only present in the PP02 targets ($\chi^2(1) = 14.44$, $p < .001$), whereas there was no significant cross-linguistic priming

($\chi^2(1) = 2.52$, $p = .11$). In addition, there was a significant main effect of *Target language* ($Z = 4.94$, $p < .001$), which indicates that there were more PO responses in Dutch than in PP02.

Word order priming. Here, word order priming is defined as the proportion of SVO responses after an SVO prime minus the proportion of SVO responses after an SOV prime (see Figure 3, for word order priming for each prime structure). Similar to the structural priming analyses, separate mixed effects models were built for transitives and ditransitives. Analyses of word order priming only included responses in PP02 (given that only SVO order is possible in Dutch main clauses).

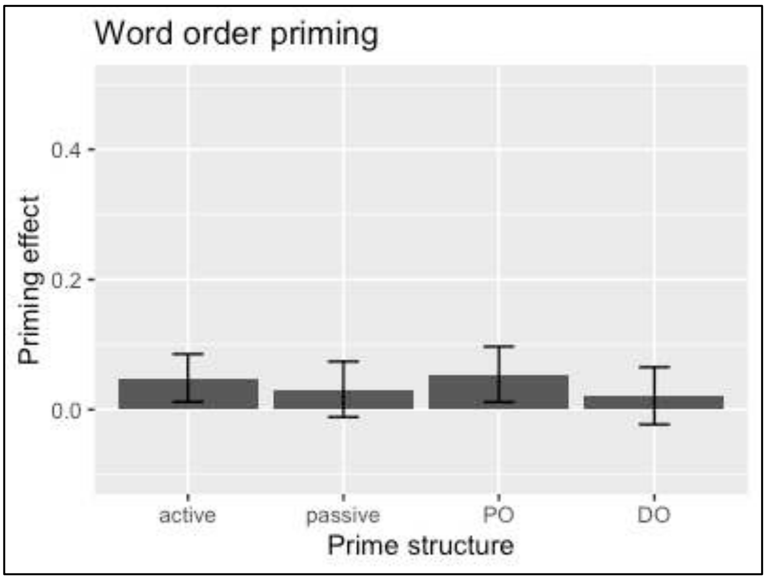

Figure 3. Word order priming in transitives and ditransitives (Experiment 1).

Transitives. The outcome variable was *SVO answer* (binomial) and the fixed effects consisted of the interaction *Prime structure* * *Prime order*, while the random effects structure contained a random intercept for *Participant* and an uncorrelated random slope of *Prime order* over *Participants* (see Appendix B.3 for the model output). There was a significant word order priming effect ($Z = -2.29$, $p = .02$), which did not differ across prime structures ($Z = -0.61$, $p = .54$).

Ditransitives. A similar model was fitted for the ditransitives as for the transitives. Here, the random effects structure consisted of a random intercept for *Participant*. The model (see Appendix B.4) also shows a main effect of word order priming here (Z = -2.50, p = .01), but no interaction with *Prime Structure* (Z = 1.14, p = .25).

Discussion

The current study aimed to find out whether the presence of an AL structure that is similar to L1 would block the sharing of a less similar AL structure with L1. We therefore compared structural priming from AL structures with SVO word order with priming from AL structures with SOV word order to Dutch SVO structures. If there is a blocking effect, there should be more priming from AL SVO than from AL SOV primes to Dutch. However, in the transitive sentence pairs, there was only a very weak priming effect for either word order condition. Also within the AL, there was no clear evidence for structural priming (i.e., actives vs. passives) for transitives (although there was word order priming). This is surprising, given that Muylle, Bernolet, et al. (2020a) did find evidence for within AL and AL-Dutch priming in transitives with both SVO and SOV versions of the AL. Relatedly, only very few passive responses were observed (i.e., less than 2% of the responses) in contrast to previous experiments using the AL learning paradigm (Muylle et al., 2019; Muylle, Bernolet, et al., 2020a). For the ditransitives, there was also no cross-linguistic priming, but there was structural priming and word order priming within the AL (although the difference between within and between-language priming was not statistically significant). Furthermore, participants had a preference for the PO structure when producing an SVO AL sentence or a Dutch sentence, but when producing an SOV AL sentence, this preference shifted toward the DO structure. The DO bias in SOV sentences replicates Muylle, Bernolet, et al.'s (2020a) finding that people in the SOV condition preferred the DO structure over the PO structure, whereas people in the SVO conditions preferred the PO structure.

The overall absence of cross-linguistic priming in this study is remarkable and merits some further investigation. Given that there are only two changes in the experimental design with respect to our previous study (Muylle, Bernolet, et al., 2020a), it is very likely that one of these is responsible for the disappearance of the priming effects in the current study. First, participants were exposed to both SVO and SOV versions of the sentences, instead of either the SVO or SOV version. We hypothesized that the presence of both structures in the AL would block the sharing between SOV structural representations and Dutch representations, whereas SVO representations would become shared with Dutch representations in an unimpeded way. However, the presence of both structures might also have more severe consequences for the sharing. Perhaps, the inconsistency of word order in the AL caused confusion for the participants, who were not able to form abstract structural representations in the AL, and hence could not integrate these with existing L1 representations. If such representations are not formed during the learning process, priming will also not occur within the AL.

Second, there was no verb overlap condition in this experiment, in contrast to the previous studies using the AL learning paradigm (Muylle et al., 2019; Muylle, Bernolet, et al., 2020a). Arguably, the boost in priming for verb overlap conditions also influences priming in conditions without verb overlap, especially in early stages of L2 acquisition. Indeed, lexical overlap between prime and target lowers the threshold of producing the less favored structure given that less effort is needed to copy and edit the prime structure. Once the learner has some experience with actively producing this structure, it becomes easier to produce this structure in other situations as well. This idea is in line with Hartsuiker and Bernolet's (2017) account that states that learners develop item-specific before abstract representations during L2 acquisition. Hence, when the item-specific representations do not get the chance to develop because they are not practiced well (i.e., the learner is not encouraged to produce the less favored structure), this will also hinder the development of more abstract representations.

For the ditransitives, there is another possible explanation for the absence of cross-linguistic priming, given that previous studies with this paradigm (Muylle et al., 2019; Muylle, Bernolet, et al., 2020a) also did not find evidence of AL-Dutch priming in ditransitives after only one training session. Indeed, in our multiple-session study, cross-linguistic priming effects in ditransitives only emerged from the second day of training (Muylle et al., 2019). Furthermore, the presence of structural priming within the AL indicates that other mechanisms are responsible for the absence of cross-linguistic priming than in transitives. Given that there are several possible explanations for the observed results, we decided to conduct a second experiment in which these were further investigated.

Experiment 2

The goal of the second experiment was twofold. On the one hand, we aimed to discriminate between the different explanations for the absence of priming between languages in Experiment 1 by testing them in a systematic way. On the other hand, we wanted to investigate further whether there are blocking effects in cross-linguistic priming. First, if the absence of priming is caused by the absence of a verb overlap condition, introducing this condition in the experiment will result in the emergence of priming effects within the AL and between the AL and Dutch (or at least for SVO primes according to the initial blocking hypothesis). In contrast, if the presence of both SVO and SOV word order in the AL blocks the development of abstract representations in general, the results should be similar to those obtained in Experiment 1. Second, if priming between languages does not emerge before the second session of priming in ditransitives, adding a second session can inform us whether such priming is indeed present on the second day of training. Hence, in Experiment 2, participants were tested in a two-session design and received prime-target pairs with and without verb overlap.

Methods

Participants

We tested 48 students (7 males, 41 females) with the same selection criteria as in Experiment 1. Their ages ranged between 18 and 34 years old (*M*= 22.6, *SD*= 3.8). They either received a financial compensation of 35 Euro or a course credit and 25 Euro.

Materials and design

For the first session of Experiment 2, the vocabulary learning block, sentence exposure block, matching block, and sentence production block were exactly the same as in Experiment 1. The priming block had again 120 trials, but now half of them had verb overlap. The vocabulary in the second session of Experiment 2 was the same as in the first session. Hence, the purpose of the vocabulary learning block in the second session was simply to refresh the memory of the participants. Therefore, each picture was presented four instead of eight times (48 trials in total). For the same reason, the sentence exposure block (30 trials) and the matching block (45 trials) were shorter than in the first session. The design of the sentence production block (24 trials) and the priming block (120 trials) was identical to the first session.

Procedure

The course of the experiment was almost identical to that of Experiment 1, except that there were two sessions (with one week in between) instead of one. Both the LexTALE and digit spans were administered during the first session, which took 1.5 – 2 hours. The second session was shorter (about 1 – 1.5 hour), given that the vocabulary learning, sentence exposure, and matching blocks consisted of fewer trials.

Coding of responses

The same coding scheme was applied as in Experiment 1. Here, 749 *other* responses were discarded (i.e., 6.5% of the responses).

Results

Control tasks & accuracy. In this experiment, the mean LexTALE score was 89.74 (SD = 5.49), the mean forward digit span 6.54 (SD = 1.15), and the mean backward digit span 4.96 (SD = 1.13). Accuracy scores were computed in the same way as in Experiment 1 (except for the vocabulary block on Day 2, in which the fourth presentation was taken), but were split up per day. On Day 1, the mean accuracy was 82% (SD = 10%) and on Day 2 this increased to 93% (SD = 5%). An overview of the accuracy scores per day and block can be found in Table 5. The mean accuracy in the vocabulary learning block was 71% (*SD* = 24%)

on Day 1 and 96% (*SD* = 8%) on Day 2. Similar to Experiment 1, we built generalized linear mixed effects models to assess whether learning was different for SVO vs. SOV word order throughout the blocks. The results indicate that participants had a similar accuracy for both structures in all blocks on both Day 1 and 2.

Table 5. Accuracy scores for each block (Experiment 2).

		SVO *M* (*SD*)	SOV *M* (*SD*)	*Wald's Z*	*p*-value
Day 1	Matching block	0.88 (0.37)	0.87 (0.39)	1.45	.15
	Sentence production block	0.64 (0.50)	0.59 (0.53)	1.57	.12
	Priming block	0.77 (0.45)	0.75 (0.45)	1.12	.26
Day 2	Matching block	0.94 (0.26)	0.92 (0.30)	1.57	.12
	Sentence production block	0.87 (0.38)	0.85 (0.34)	0.02	.98
	Priming block	0.92 (0.31)	0.89 (0.36)	0.88	.38

Structural preferences. The response distribution for the PP02 productions in the sentence production block and the priming block can be found in Table 6 and 7, respectively. Again, the pattern was very similar in both blocks. In the priming block, the active structure was preferred over the passive one in PP02 SVO sentences (87%), PP02 SOV sentences (79%), and Dutch sentences (89%). This tendency did not differ across days for Dutch (90% vs. 89%) and PP02 SVO (88% vs. 87%), but decreased slightly for PP02 SOV (82% vs. 76%). For ditransitive sentences, the PO structure was preferred over the DO structure in PP02 SVO sentences (74%) and Dutch sentences (95%), but not in PP02 SOV sentences (38% PO responses). The preference for the PO structure increased in the second session (Dutch: 93% vs. 96%; PP02 SVO: 67% vs. 81%; PP02 SOV: 37% vs. 40%). The output of the model that investigated structural priming (see below) indicates that the increase in the proportion of PO responses was significant (i.e., there was a main effect of Day: $Z = -3.09$, $p = .002$). When producing in PP02, SVO word order was preferred over SOV word order on both days in transitives (Day 1: 78%; Day 2: 83%) and ditransitives (Day 1: 73%; Day 2: 77%). The output of the word order models (see below) indicates that there was a significant increase in the preference for SVO word order in transitives ($Z = -3.35$, $p < .001$) and a marginally significant increase in ditransitives ($Z = -X$, $p = .08$) during PP02 sentence formulation. This tendency to more closely approximate the L1 order or preference may suggest that, over time, learners try to align the AL representations with existing L1 representations, which supports the idea of sharing.

Table 6. Response distribution in the sentence production block (Experiment 2).

		Transitives			ditransitives		
		active	Passive	*total*	DO	PO	*total*
Day 1	SOV	0.16	0.02	*0.18*	0.20	0.06	*0.25*
	SVO	0.79	0.03	*0.82*	0.27	0.48	*0.75*
	total	*0.95*	*0.05*	*1.00*	*0.47*	*0.53*	*1.00*
Day 2	SOV	0.12	<0.01	*0.12*	0.16	0.07	*0.23*
	SVO	0.81	0.07	*0.88*	0.12	0.66	*0.77*
	total	*0.93*	*0.07*	*1.00*	*0.27*	*0.73*	*1.00*

Table 7. Response distribution in the priming block (Experiment 2).

		Transitives			ditransitives		
		active	Passive	*total*	DO	PO	*total*
Day 1	SOV	0.18	0.04	*0.22*	0.17	0.10	*0.27*
	SVO	0.69	0.09	*0.78*	0.24	0.49	*0.73*
	total	*0.87*	*0.13*	*1.00*	*0.41*	*0.59*	*1.00*
Day 2	SOV	0.13	0.04	*0.17*	0.14	0.09	*0.23*
	SVO	0.72	0.11	*0.83*	0.14	0.63	*0.77*
	total	*0.85*	*0.15*	*1.00*	*0.28*	*0.72*	*1.00*

Structural priming. The priming effect for each priming condition can be found in Figure 4 for transitives and Figure 5 for ditransitives (see Appendix A.2 for the distribution of responses combining structure with word order and Appendix D for the priming results, split up by day). Structural priming effects were assessed using the same methods as in Experiment 1.

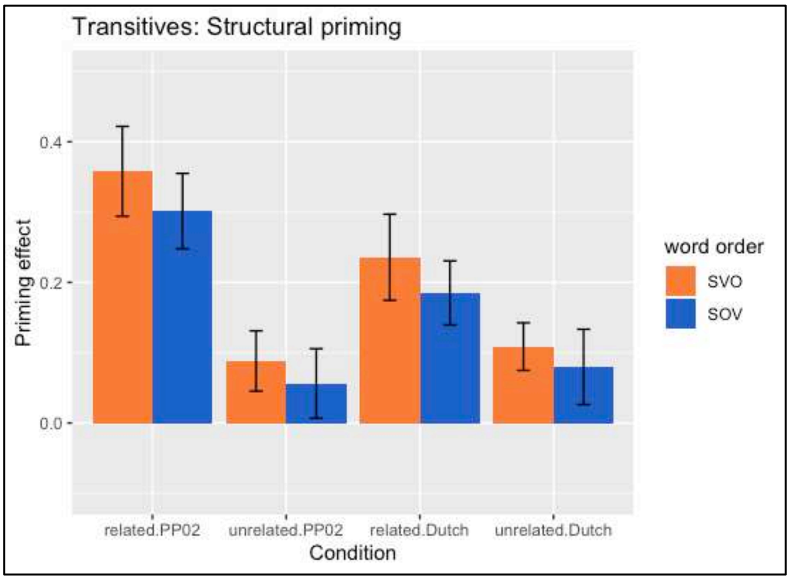

Figure 4. Structural priming in transitives, collapsed over days (Experiment 2).

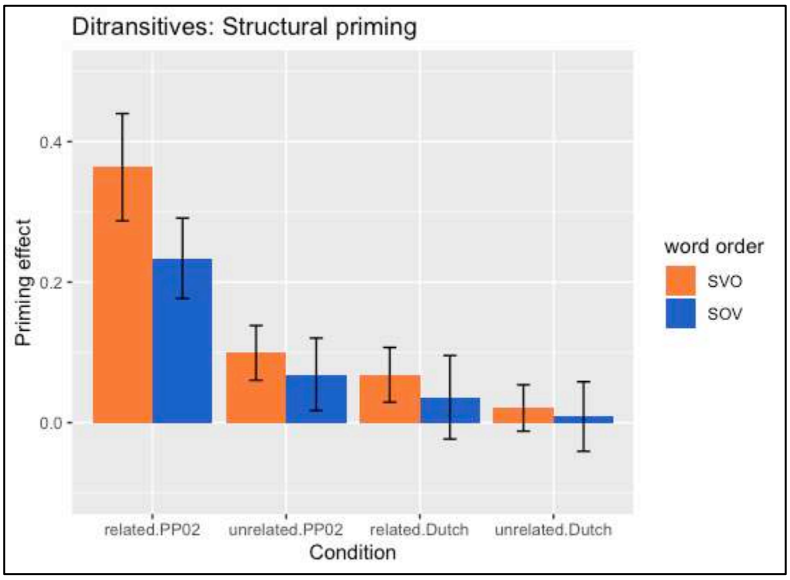

Figure 5. Structural priming in ditransitives, collapsed over days (Experiment 2).

Transitives. In Experiment 2, generalized linear mixed effects models contained the same variables as in Experiment 1, but now *Relatedness* (i.e., verb overlap vs. no verb overlap) and *Day* were added. The model with the interaction *Prime structure* * *Prime order* * *Target Language* * *Relatedness* * *Day* did not converge (not even when only a random intercept for *Subject* was included) and given that there was descriptively no difference between Day 1 and Day 2 in the priming pattern, we decided to discard *Day* as predictor. In the final model, the random effects structure consisted of a random intercept for *Subject*, whereas the fixed effects contained the interaction *Prime structure* * *Prime order* * *Target Language* * *Relatedness* (the output of this model can be found in Appendix C.1). Pairwise comparison showed that there was significant structural priming in all priming conditions (all *p*'s <.01). In addition, there was a significant interaction between *Prime structure, Target Language*, and *Relatedness* ($Z = -3.70$, $p < .001$) in the sense that a) priming effects were larger within PP02 than from PP02 to Dutch for both related ($\chi^2(1) = 7.91$, $p < .01$) and unrelated conditions ($\chi^2(1) = 5.82$, $p = .01$), and b) there was a lexical boost effect within PP02 ($\chi^2(1) = 63.87$, $p < .001$) and a translation equivalent boost in Dutch ($\chi^2(1) = 6.05$, $p = .01$), but the boost was significantly larger within PP02. Importantly, there was a significant interaction between *Prime structure* and *Prime order* ($Z = -2.53$, $p = .01$) in the sense that the priming effects were larger for the SVO than for SOV primes. Still, there was significant structural priming for both word orders (SVO: $M = .20$; $\chi^2(1) = 153.46$, $p < .001$; SOV: $M = .16$; $\chi^2(1) = 128.81$, $p < .001$).

Ditransitives. The ditransitive model did converge with *Day* in the interaction (i.e., *Prime structure* * *Prime order* * *Target Language* * *Relatedness* * *Day*) and the random effects consisted of a random intercept for Subject and a random slope for Day over Subjects (the output of this model is reported in Appendix C.2). Because *Day* did not interact with *Prime structure*, data from both days were taken together to study priming effects in each prime condition. Pairwise comparisons showed that there was significant structural priming for all within-PP02 conditions (related SVO: $\chi^2(1) = 141.89$, $p < .001$; unrelated SVO: $\chi^2(1) = 13.8701$ $p = .001$; related SOV: $\chi^2(1) = 65.32$, $p < .001$), except for the unrelated SOV condition, where there was only a marginally significant effect ($\chi^2(1) = 5.85$, $p = .06$). For PP02-Dutch priming, there was a significant effect in the related SVO condition ($\chi^2(1) = 8.67$, $p = .01$), but not in the other conditions (all p's > .60). Similar to the transitives, there was a significant interaction between *Prime structure*, *Target Language*, and *Relatedness* ($Z = 2.38$, $p = .02$) and between *Prime structure* and *Prime order* ($Z = 2.99$, $p = .003$). Within-PP02 priming was larger than PP02-Dutch priming for the related condition ($\chi^2(1) = 22.57$, $p < .001$), but not for the unrelated condition ($\chi^2(1) = 1.85$, $p = .17$). In addition, there was a lexical boost effect in PP02 ($\chi^2(1) = 57.17$, $p < .001$), but no translation equivalent boost for Dutch targets ($\chi^2(1) = 2.18$, $p = .14$). Importantly, priming effects were larger for SVO than SOV primes in both PP02 ($M_{SVO} = .23$, $M_{SOV} = .15$; $\chi^2(1) = 9.36$, $p = .004$) and Dutch (although this was only marginally significant, $M_{SVO} = .04$, $M_{SOV} = .01$; $\chi^2(1) = 3.06$, $p = .08$).

Word order priming. As in Experiment 1, separate models were built to test word order priming. The observed word order priming for each prime structure can be found in Figure 6 (see Appendix D for the results, split up by day).

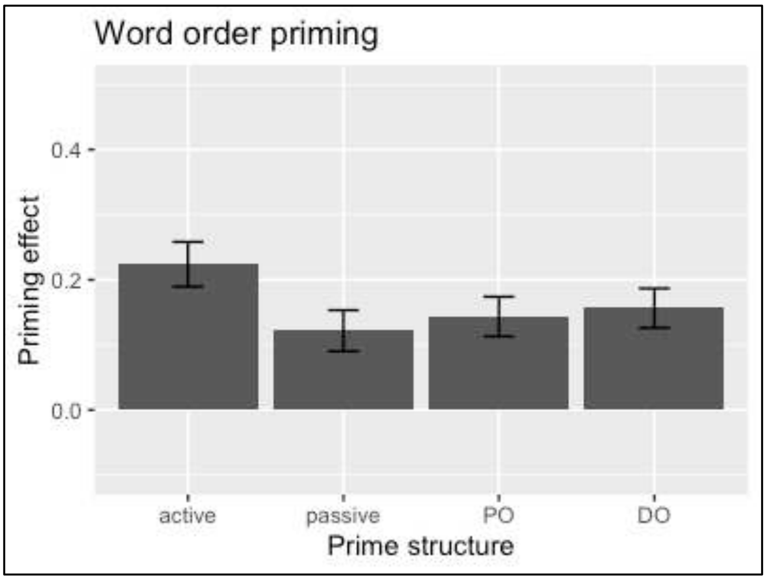

Figure 6. Word order priming in transitives and ditransitives, collapsed over days (Experiment 2).

Transitives. The fixed effects structure of the model consisted of the interaction *Prime structure* * *Prime order* * *Day*, with a random intercept for *Subject* and a slope of *Day* over subjects as random effects (see Appendix C.3 for the model output). There was significant word order priming for both prime structures on both days (all *p*'s < .001). Moreover, there was a significant interaction between *Prime structure* and *Prime order* (Z = -3.18, p = .001), which did not differ across days (Z = -1.09, p = .28). Pairwise tests revealed that there was stronger word order priming with active ($\chi^2(1)$ = 122.89, p < .001) compared to passive primes ($\chi^2(1)$ = 53.02, p < .001).

Ditransitives. The ditransitive model contained the same fixed effect structure as the transitive model, but here the random effects were a random intercept for *Subject* and an uncorrelated random slope for *Day* over *Subjects* (see Appendix C.4 for the model output). Here, there was a main effect of *Prime order* (Z = -11.12, p < .001), but this did not interact with *Prime structure* or *Day* (all *p*'s > .20). In addition, there was a main effect of Prime Structure (Z = -2.33, p = .02), in the sense that fewer SVO responses were produced after a DO than after a PO prime.

Discussion

The goal of the second experiment was to disentangle the different explanations for the absence of structural priming in Experiment 1 and to further investigate whether there were blocking effects in the sharing of AL SOV structures with Dutch.

Transitives. For transitives, the absence of priming could be either due to the absence of a verb overlap condition or to confusion caused by the presence of both SVO and SOV word orders in the AL, which prevented the formation of abstract structural representations. Experiment 2 shows that the inclusion of a verb overlap condition resulted in significant priming both within the AL and from the AL to Dutch for SVO and SOV conditions. Importantly, priming effects were larger for SVO conditions compared to SOV conditions for both target languages. This finding contrasts with the findings of Muylle, Bernolet, et al.'s (2020a) study, in which no differences in priming were found between the SVO and SOV version of the AL in a between-subjects design. The finding that priming is stronger for SVO than SOV word order in a within-subjects design can be explained by mechanisms similar to Kamin's (1969) blocking hypothesis (i.e., the presence of SVO sentences in the AL blocks the development of shared syntactic representations for SOV sentences), although such blocking is not strong enough to completely prevent the actual sharing of AL SOV structures with Dutch SVO structures (i.e., we did find priming from AL SOV to Dutch).

The finding that structural priming was also stronger for SVO compared to SOV structures within the AL suggests that blocking effects were already present during the formation of AL structural representations; learners were faster in forming representations for SVO structures that are similar to the L1 and this blocked the formation of representations for less similar SOV structures. The smaller priming for SOVs within the AL can only be explained by the presence of the SVO (i.e., a blocking effect), given that there was no difference in priming when only one of both word orders is taught (see Muylle, Bernolet, et al., 2020a). Indeed, L2 acquisition research indicates that learners transfer their L1 expectations to the L2 in early phases of learning (Ellis, 2002; MacWhinney, 2008; Montero-Melis & Jaeger, 2019; Muylle, Bernolet, & Hartsuiker, 2020b; Pajak, Fine, Kleinschmidt, & Jaeger, 2016). As such, the participants in our experiment might have stronger abstract representations for SVO compared to SOV structures in the AL and this seems to have consequences for the sharing of these structures across languages. Importantly, this implies that the blocking effects in the sharing of syntax across languages might originate in the formation of weaker abstract representations for SOV structures in the AL. In sum, it seems that structural representations are formed more easily for L2 structures that are similar to L1 structures than for less similar structures, but only when there is such a similar structure present in the L2.

Ditransitives. For ditransitives, the absence of cross-linguistic priming in Experiment 1 could be due to a) the absence of a verb overlap condition, b) confusion because both word orders are present, which prevents the formation of representations, or c) more time needed to share structural representations across languages (in line with our previous PP02 studies). The inclusion of a verb overlap condition in the current experiment resulted in structural priming effects in the AL and from the AL to Dutch. However, cross-linguistic priming was only found for SVO, but not for SOV conditions (although the difference between the SVO and SOV condition was only marginally significant). Priming within the AL was also stronger for SVO structures, similar to the transitives. The priming pattern was the same on both days, except for an overall increase in the preference for the PO structure on Day 2, which was also attested in the multiple-session study (Muylle et al., 2019). Hence, it seems that cross-linguistic priming in ditransitives was boosted by the presence of the verb overlap condition. The finding that there was cross-linguistic priming in ditransitives on the first day contrasts with some of the previous findings with this paradigm, especially because these studies had conditions with verb overlap as well (Muylle et al., 2019; Muylle, Bernolet, et al., 2020a). However, in Experiment 2 from Muylle et al. (2019), there was also significant priming from the AL to Dutch in the verb overlap condition on Day 1. Arguably, cross-linguistic priming effects for ditransitive structures in early phases of AL learning might be weak in general (and certainly weaker than for transitives), which results in effects that sometimes emerge descriptively, but only seldom reach significance. Similar to Experiment 1, significant word order priming was found for both transitives and ditransitives.

When taking together the findings of Experiment 2, it is possible that the absence of priming from AL SOV ditransitive structures to Dutch is the result of the overall weak cross-linguistic priming in ditransitives. Indeed, the priming effects for the SVO structures were already very weak and only reached significance in the verb overlap condition (this may also explain why the difference between SVO and SOV structures was only marginally significant). Thus, if SOV priming was weaker compared to SVO priming, it is not surprising that the structural priming effect disappeared for SOV sentences. In fact, both the within- and between-language priming patterns for the ditransitives are very similar to those observed by Muylle, Bernolet, et al. (2020a). An omnibus analysis of the latter data (comparing not only the SVO and SOV version of PP02, but a SVO case marking version as well) showed that there was no difference in priming between the different versions of the AL, but if we perform pairwise contrasts comparing SVO with SOV data only, there is weaker priming for SOVs vs. SVOs in that dataset as well (SVO-SOV in PP02 targets: $\chi^2(1) = 11.98$, $p = .001$; SVO-SOV in Dutch targets: $\chi^2(1) = 2.93$, $p = .09$). Hence, it is clear that within the AL there is weaker priming for SOV vs. SVO structures in both studies. These findings are different from those obtained with transitives and suggest that it may be harder to form AL representations of the ditransitive structures with SOV word order for L1 speakers of Dutch, regardless of whether the more similar SVO order exists within the AL as well. It has to be noted, however, that despite the fact that the participants in the current study had a strong preference for the SVO word order, they did not show weaker learning for the SOV vs. SVO word order: the accuracy data of the different learning blocks showed no lower accuracy for SOV sentences and this was also the case for the priming block, although the preference for SVO word order persisted. As such, it seems unlikely that the weaker cross-linguistic priming for SOV vs. SVO structures is due to poorer learning of the SOV structures. Regarding priming across languages for ditransitives, the weakness or even absence of an effect makes it very hard to identify whether priming is weaker for SVO vs. SOV structures in both studies.

One possible explanation for the weaker cross-linguistic priming in ditransitives vs. transitives may be related to differences in constituent structure (i.e., there are more phrasal constituents in ditransitives than transitives, which may result in slower sharing) and differences in information structure (see Fleischer et al., 2012). Indeed, actives and passives differ in sentence head (i.e., agent in actives vs. patient in passives), whereas PO and DO datives share the same sentence head (i.e. the agent). As a result, transitives may receive priming from both constituent and information structure, but ditransitives mainly from constituent structure (see also Muylle et al., 2019; Muylle, Bernolet, et al., 2020a), which results in slower sharing of ditransitives across languages.

Finally, the results of Experiment 2 clearly show that the absence of structural priming in Experiment 1 can be explained by the absence of a verb overlap condition in the experimental design. The theoretical implications of this finding will be discussed further in the General Discussion.

General Discussion

In the current study, we aimed to investigate whether the sharing of structural representations across languages is blocked for L2 structures with different word order (compared to the L1), when a structure with the same word order is also possible in the L2. In order to manipulate this in a controlled way, we used the AL learning paradigm that was developed by Muylle et al. (2019), which allows to investigate the sharing of structural representations in early phases of L2 acquisition. Participants were exposed to both SVO and SOV versions of transitive (i.e., actives and passives) and ditransitive structures (i.e., POs and DOs) during acquisition of the AL, after which priming was assessed both within the AL and from the AL to L1 Dutch for each structure and word order. Surprisingly, no reliable structural priming effects were found in the first experiment, apart from within-AL priming for ditransitives. To rule out different explanations for this absence of priming and to study further whether there was blocking of the sharing of SOV representations, we conducted a second experiment, in which we added a verb overlap condition and a second session to the design. Here, structural priming of transitives and ditransitives was found for both SVO and SOV word order primes across the two sessions, but this was weaker for SOV primes than for SVO primes and even absent in AL-Dutch priming of SOV ditransitives.

Taken together, the current study yielded two important results. First, for transitive structures, there are blocking effects from the presence of SVO structures in the AL to the formation of SOV structural representations within the AL and therefore also to the sharing of such representations with Dutch SVO representations. However, the blocking effects are not strong enough to fully prevent the formation of such representations. Indeed, priming emerged from both AL SVO and AL SOV primes to Dutch, but was stronger for AL SVO sentences. The blocking effects are analogous to the Kamin blocking effect, which has been implemented in behavioral learning theories. Similar to our findings, the Kamin blocking effect does not entail that there is no learning at all, but rather that it is impaired. If such an effect also applies to natural L2 learning situations, then – for languages that have a similar and less similar translation equivalent of L1 structures – the learning of the less similar L2 structure will be impaired. Another explanation for the weaker priming in SOV structures was provided by van Gompel and Arai (2018), who proposed that the inconsistent findings for cross-linguistic priming between structures that differ in word order may indicate that the representations for these structures are not fully shared between the languages, but rather connected. However, the finding that there was no difference in the magnitude of cross-linguistic priming between an AL version with the same vs. a different word order compared to Dutch (Muylle, Bernolet, et al., 2020a) cannot be reconciliated with this hypothesis. As such, this explanation seems to be less likely in the current context.

In fact, the blocking effect might explain why Bernolet et al. (2007) did not find priming between L1 Dutch and L2 English relative clauses. In Dutch, relative clauses with a predicate adjective have verb-final word order (e.g., "de baby die rood is"), whereas such clauses have verb-medial word order in English (e.g., "the baby that is red"). Based on the finding that there was priming with L2 German relative clauses (that are verb-final), but not with L2 English relative clauses, Bernolet and colleagues (2007) concluded that differences in word order prevented the sharing of syntax between L1 and L2. However, this idea cannot be easily reconciled with the ample evidence from other studies that did find priming between languages that differ in word order (see Introduction). An alternative explanation for their finding might be provided by the blocking hypothesis. In fact, there is another type of relative clause in Dutch that closely resembles the one with the predicate adjective (e.g., "de baby die rood is" [the baby that is red]), namely the (passive) present perfect relative clause (e.g., "de baby die gewassen is" [the baby that has been washed]). Interestingly, this type of relative clause can be both finite verb-final and finite verb-medial (e.g., "de baby die is gewassen"). Given that the distinction between adjectives and past participle is not always that clear, L1 Dutch speakers might represent the two relative clause types as the same structure. In that case, they will easily integrate the English verb-medial relative clause with the Dutch verb-medial one, while blocking the association of the Dutch verb-final relative clause with the English verb-medial one. As a result, priming effects between the latter structures can be very weak or even non-existent.

In a recent study, Maier, Pickering, and Hartsuiker (2017) investigated the role of structural priming during translation between English and German ditransitives. Crucially, in German there is a third possible way to formulate a ditransitive, apart from the standard DO (e.g., "Der kleine Junge schrieb dem Nachbarn den Brief" [The little boy wrote the neighbor the letter]) and PO (e.g., "Der kleine Junge schrieb den Brief an den Nachbarn" [The little boy wrote the letter to the neighbor]) that also exist in English, namely the shifted DO (e.g., "Der kleine Junge schrieb den Brief dem Nachbarn" [*The little boy wrote the letter the neighbor]). Maier et al. (2017) found that German DO sentences primed English DO sentences, whereas shifted DO sentences primed English PO sentences (that have the same order of thematic roles). Interestingly, priming effects were larger in English-German compared to German-English bilinguals. This finding is also in line with the blocking hypothesis, given that during L2 learning, L1 German speakers have two concurrent dative structures to map onto L2 English POs (i.e., the very similar PO and the less similar shifted DO), whereas L1 English speakers initially map L1 English POs onto L2 German POs, which become associated with the German shifted DO later on (note that the shifted DO is very infrequent and therefore rarely known by non-native speakers of German, see Maier et al., 2017, for a discussion). Because simultaneity of the competing alternatives is one of the conditions of the Kamin blocking effect, priming between the German shifted DO and the

English PO is blocked in German L1 speakers, but not in English L1 speakers.[4] In sum, there seems to be evidence for the blocking hypothesis in both AL and natural L2 learning. Future research might aim to find out whether this hypothesis can also explain other instances in which priming was expected, but not found or was weaker for less similar structures.

The second important finding of this study is that priming only emerged in prime-target pairs without verb overlap when there was also a verb overlap condition in the experiment. This suggest that the presence of a verb overlap condition in the experimental design plays a key role in establishing abstract structural representations during L2 acquisition in the lab. A similar result was obtained by Coumel, Ushioda, and Messenger (in preparation), who tested priming in L1 speakers of English at different stages of L2 French acquisition. Hence, when we transpose this to real life L2 learning situations, it is conceivable that repeating the structure of previous utterances that share words with the current utterance could be beneficial or even critical in the development of abstract syntactic representations. This idea is in line with the developmental theory of shared syntax (Hartsuiker & Bernolet, 2017) that states that item-specific representations are established before more abstract ones (see also the discussion of Experiment 1). Our findings show that establishing item-specific representations might be even *necessary* in order to develop more abstract ones.

More concretely, a learner may start with item-specific representations for the preferred structure (e.g., PO), but not for the less preferred structure (e.g., DO). When presented with a prime in the lexical overlap condition, the threshold to produce the less preferred structure becomes much lower, causing an increased probability that the learner will choose this structure during formulation of the target sentence. Thereby, the learner will develop item-specific representations for the less preferred structure as well. Experience with

[4] A future study could test this assumption of simultaneity by investigating blocking to priming in a group that learns PP02 with both word orders on Day 1 and 2, and a group that learns one of the word orders on the first day and the other on the second day. Blocking effects should be present in the former, but not in the latter group, because the two word orders were not simultaneously associated with the Dutch structures.

the active production of this structure (in contrast to passive repetition) will then increase the probability of reusing this structure in future sentences as well, through mechanisms of cumulative priming (see Jaeger & Snider, 2013; Kaschak, 2007) and this will enhance the development of more abstract syntactic representations. Such explanation is in line with activation-based accounts of structural priming (e.g.,Hartsuiker & Bernolet, 2017; Hartsuiker et al., 2004; Pickering & Branigan, 1998; Reitter, Keller, & Moore, 2011), but contrasts with the error-based learning account (Chang, Dell, & Bock, 2006), that does not predict priming based on the speaker's own productions (see also Jacobs, Cho, & Watson, 2019).

Please note that the importance of having a lexical overlap condition in the experiment only applies to situations in which a new language is acquired. There is ample evidence for structural priming in experiments that do not include verb overlap conditions (see Mahowald et al., 2016), but these studies tested participants in languages that they already learned before. In such cases, the participants already know the different structures of the languages in which they are tested, and the abstract structural representations of these structures are already established before the experiment. At this point, it is not clear whether the presence of lexical overlap conditions also boosts priming in more abstract priming conditions for languages that are already known by the participant. However, it is often found in studies investigating priming within L1 that when one of the alternative structures is largely dispreferred, this structure is often produced for the first time in a lexical overlap condition (although this has not been formally tested). In other words, the use of the structure can be triggered by lexical overlap between prime and target. Hence, when there is a large difference in preference between the alternatives, lexical overlap might play a more important role in priming. This topic merits some further investigation. Future studies may reveal whether the magnitude of priming effects in the conditions without lexical overlap differs when a lexical overlap condition is present or absent.

Finally, despite the clear advantage of choosing the SVO order to formulate sentences in the AL, an SOV structure was picked in almost 25% of the cases. Interestingly, this was also the case when no prime was presented, given that in the production block 23% of the utterances had SOV order (see osf.io/ncdfa for all data from the PP02 learning blocks). Related to this, when the SOV word order was chosen, the DO structure was clearly preferred over the PO structure. In Muylle, Bernolet, et al.'s (2020a) study, participants in the SOV condition also preferred the DO over the PO to describe ditransitive actions. We provided two explanations in that paper. First, Dutch speakers might prefer to have the direct object adjacent to the ditransitive verb. In SVO sentences, this is the case for the PO structure (e.g., "the cook gives the hat to the clown"), but not for the DO structure (e.g., "the cook gives the clown the hat"), whereas in SOV sentences, the direct object is adjacent to the verb in DO sentences (e.g., "the cook the clown the hat gives"), but not in PO sentences (e.g., "the cook the hat to the clown gives"). Another possible explanation might be that for Dutch subordinate clauses with a ditransitive verb, which have SOV word order, there are three possible structures: a) DO (e.g., "… dat de kok de clown de hoed geeft" [literally: … that the cook the clown the hat gives]), b) pre-verbal PO (e.g., "… dat de kok de hoed aan de clown geeft" [literally: … that the cook the hat to the clown gives]), c) post-verbal PO (e.g., "… dat de kok de hoed geeft aan de clown" [literally: … that the cook the hat gives to the clown]). The fact that the Dutch SVO ditransitive structures in the main clause map onto three subordinate SOV structures might shift the preference from PO toward DO for SOV subordinates. If this is the case, then Dutch speakers should prefer the DO in subordinate clauses. Further studies are needed to test these hypotheses.

Conclusions

In this study, we found evidence for a blocking effect in the acquisition of AL structures with a word order that differs from their L1 counterparts because of the presence of AL structures with the same word order as L1. Evidence for this hypothesis stems mainly from transitive priming, whereas for ditransitives, the results are less conclusive. In addition, the presence of a verb overlap condition in the experimental design was necessary to establish shared syntactic representations. Furthermore, we replicated Muylle, Bernolet, et al.'s (2020a) finding that the preference for the PO structure in ditransitives disappeared in the formulation of sentences with SOV word order, which further confirms the idea that DOs are preferred with this order.

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Appendix A: Distribution of different responses

A.1 Proportion of responses for each priming condition of Experiment 1.

Prime	Target PP02				Target Dutch	
Transitive	Active SVO	Active SOV	Passive SVO	Passive SOV	Active	Passive
Active SVO	0.79	0.20	0.01	-	0.99	0.01
Active SOV	0.74	0.24	0.01	<0.01	0.99	0.01
Passive SVO	0.77	0.19	0.03	<0.01	0.97	0.03
Passive SOV	0.74	0.22	0.02	0.01	0.99	0.01
Ditransitive	PO SVO	PO SOV	DO SVO	DO SOV	PO	DO
PO SVO	0.47	0.07	0.27	0.19	0.91	0.09
PO SOV	0.42	0.11	0.27	0.20	0.90	0.10
DO SVO	0.38	0.07	0.34	0.21	0.88	0.12
DO SOV	0.41	0.08	0.29	0.22	0.87	0.13

A.2 Proportion of responses for each priming condition in Experiment 2, split up by day.

	Prime	Target PP02								Target Dutch			
	Transitive	Act SVO		Act SOV		Pass SVO		Pass SOV		Active		Passive	
	Day	1	2	1	2	1	2	1	2	1	2	1	2
related	Act SVO	0.91	0.90	0.09	0.08	-	0.02	-	-	0.99	0.96	0.01	0.04
	Act SOV	0.48	0.57	0.51	0.39	0.01	0.03	-	0.01	0.98	0.97	0.02	0.03
	Pass SVO	0.54	0.56	0.09	0.07	0.34	0.34	0.04	0.03	0.75	0.71	0.25	0.29
	Pass SOV	0.59	0.59	0.10	0.08	0.11	0.10	0.21	0.23	0.78	0.78	0.22	0.22
unrelated	Act SVO	0.82	0.85	0.13	0.09	0.04	0.06	0.01	0.01	0.99	0.98	0.01	0.02
	Act SOV	0.74	0.75	0.22	0.16	0.04	0.08	0.01	0.01	0.96	0.97	0.04	0.03
	Pass SVO	0.74	0.76	0.13	0.08	0.12	0.15	0.01	0.01	0.88	0.86	0.12	0.14
	Pass SOV	0.73	0.78	0.15	0.09	0.07	0.09	0.05	0.04	0.86	0.89	0.14	0.11
	Ditransitive	PO SVO		PO SOV		DO SVO		DO SOV		PO		DO	
	Day	1	2	1	2	1	2	1	2	1	2	1	2
related	PO SVO	0.70	0.83	0.06	0.06	0.17	0.08	0.06	0.04	0.98	0.97	0.02	0.03
	PO SOV	0.42	0.59	0.27	0.22	0.15	0.09	0.15	0.10	0.95	0.95	0.05	0.05
	DO SVO	0.33	0.48	0.05	0.06	0.51	0.38	0.11	0.08	0.90	0.92	0.10	0.08
	DO SOV	0.37	0.52	0.08	0.08	0.20	0.10	0.36	0.29	0.91	0.95	0.09	0.05
unrelated	PO SVO	0.60	0.70	0.09	0.07	0.19	0.09	0.12	0.14	0.93	0.98	0.07	0.02
	PO SOV	0.53	0.65	0.11	0.09	0.21	0.13	0.15	0.13	0.92	0.98	0.08	0.02
	DO SVO	0.49	0.64	0.07	0.06	0.28	0.16	0.16	0.15	0.92	0.95	0.08	0.05
	DO SOV	0.48	0.62	0.06	0.09	0.22	0.13	0.23	0.17	0.94	0.97	0.06	0.03

Appendix B: Output of the fixed effects models in Experiment 1

B.1 Transitive model output of structural priming in Experiment 1.

Summary of the fixed effects in the multilevel logit model (*N* = 2080; log-likelihood = -156.6)				
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	7.94	(1.652)	4.80	< .001
Prime structure	0.37	(0.207)	1.79	.074
Prime order	0.18	(0.207)	0.87	.39
Target language	0.59	(0.501)	1.17	.24
Prime structure * Prime order	-0.20	(0.208)	-0.96	.34
Prime structure * Target language	-0.15	(0.207)	-0.73	.47
Prime order * Target language	0.22	(0.207)	1.05	.30
Prime structure * Prime order * Target language	-0.10	(0.207)	-0.49	.63

B.2 Ditransitive model output of structural priming in Experiment 1.

Summary of the fixed effects in the multilevel logit model (*N* = 2073; log-likelihood = -548.1)				
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	2.80	(0.560)	4.99	< .001
Prime structure	-0.35	(0.097)	-3.57	< .001
Prime order	0.00	(0.089)	-0.04	.97
Target language	3.07	(0.622)	4.94	< .001
Prime structure * Prime order	0.11	(0.089)	1.19	.23
Prime structure * Target language	0.12	(0.093)	1.25	.21
Prime order * Target language	-0.07	(0.089)	-0.83	.41
Prime structure * Prime order * Target language	-0.03	(0.089)	-0.29	.77

B.3 Transitive model output of word order priming in Experiment 1.

Summary of the fixed effects in the multilevel logit model (*N* = 1139; log-likelihood = -249.6)				
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	9.05	(1.422)	6.37	< .001
Prime structure	-0.08	(0.131)	-0.61	.54
Prime order	-0.40	(0.177)	-2.29	<.05
Prime structure * Prime order	-0.08	(0.131)	-0.61	.54

B.4 Ditransitive model output of word order priming in Experiment 1.

Summary of the fixed effects in the multilevel logit model (*N* = 1124; log-likelihood = -280.6)				
Fixed effect	β	*SE*	Wald's *Z*	p-value
(Intercept)	7.89	(1.944)	4.06	< .001
Prime structure	-0.03	(0.122)	-0.24	.81
Prime order	-0.31	(0.125)	-2.50	<.05
Prime structure * Prime order	0.14	(0.123)	1.14	.25

Appendix C: Output of the fixed effects models in Experiment 2

C.1 Transitive model output of structural priming in Experiment 2.

Summary of the fixed effects in the multilevel logit model (*N* = 4258; log-likelihood = -928.7)				
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	4.27	(0.428)	9.98	<.001
Prime structure	1.46	(0.091)	16.11	<.001
Prime order	-0.07	(0.083)	-0.87	.39
Target language	0.23	(0.084)	2.76	<.01
Relatedness	-0.18	(0.084)	-2.18	<.05
Prime structure * Prime order	-0.21	(0.083)	-2.53	<.05
Prime structure * Target language	-0.05	(0.084)	-0.55	.58
Prime order * Target language	0.01	(0.083)	0.07	.95
Prime structure * Relatedness	0.61	(0.085)	7.22	<.001
Prime order * Relatedness	0.03	(0.083)	0.42	.68
Target Language * Relatedness	-0.09	(0.084)	-1.06	.29
Prime structure * Prime order * Target language	0.02	(0.083)	0.18	.86
Prime structure * Prime order * Relatedness	-0.03	(0.083)	-0.39	.69
Prime structure * Target language * Relatedness	-0.31	(0.084)	-3.70	<.001
Prime order * Target language * Relatedness	0.09	(0.083)	1.12	.26
Prime structure * Prime order * Target language * Relatedness	0.06	(0.083)	0.71	.48

C.2 Ditransitive model output of structural priming in Experiment 2.

Summary of the fixed effects in the multilevel logit model (*N* = 4233; log-likelihood = -1214.6)				
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	3.08	(0.346)	8.90	<.001
Prime structure	-0.57	(0.067)	-8.51	<.001
Prime order	-0.03	(0.066)	-0.53	.60
Target language	1.64	(0.075)	21.98	<.001
Relatedness	-0.09	(0.066)	-1.38	.17
Day	-0.56	(0.182)	-3.09	<.01
Prime structure * Prime order	0.20	(0.066)	2.99	<.01
Prime structure * Target language	0.29	(0.067)	4.27	<.001
Prime order * Target language	0.03	(0.066)	0.51	.61
Prime structure * Relatedness	-0.33	(0.066)	-4.96	<.001
Prime order * Relatedness	-0.02	(0.066)	-0.32	.75
Target Language * Relatedness	0.00	(0.066)	0.06	.95
Prime structure * Day	-0.02	(0.067)	-0.36	.72
Prime order * Day	-0.04	(0.066)	-0.66	.51
Target language * Day	0.05	(0.075)	0.65	.52

Relatedness * Day	0.08	(0.066)	1.17	.24
Prime structure * Prime order * Target language	0.01	(0.066)	0.08	.93
Prime structure * Prime order * Relatedness	0.08	(0.066)	1.18	.24
Prime structure * Target language * Relatedness	0.16	(0.066)	2.38	<.05
Prime order * Target language * Relatedness	-0.04	(0.066)	-0.56	.57
Prime structure * Prime order * Day	-0.01	(0.066)	-0.22	.83
Prime structure * Target language * Day	0.02	(0.067)	0.35	.73
Prime order * Target language * Day	-0.04	(0.066)	-0.56	.58
Prime structure * Relatedness * Day	-0.07	(0.066)	-1.08	.28
Prime order * Relatedness * Day	0.00	(0.066)	-0.07	.95
Target language * Relatedness * Day	0.12	(0.066)	1.79	.073
Prime structure * Prime order * Target language * Relatedness	-0.04	(0.066)	-0.60	.55
Prime structure * Prime order * Target language * Day	0.00	(0.066)	0.05	.96
Prime structure * Prime order * Relatedness * Day	-0.02	(0.066)	-0.35	.73
Prime structure * Target language * Relatedness * Day	-0.10	(0.066)	-1.44	.15
Prime order * Target language * Relatedness * Day	-0.04	(0.066)	-0.54	.59
Prime structure * Prime order * Target language * Relatedness * Day	-0.01	(0.066)	-0.18	.85

C.3 Transitive model output of word order priming in Experiment 2.

Summary of the fixed effects in the multilevel logit model (*N* = 2283; log-likelihood = -655.1)

Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	2.86	(0.427)	6.70	<.001
Prime structure	-0.15	(0.084)	-1.75	.08
Prime order	-1.15	(0.092)	-12.48	<.001
Day	-0.17	(0.185)	-0.94	.35
Prime structure * Prime order	-0.27	(0.084)	-3.18	<.01
Prime structure * Day	-0.01	(0.084)	-0.18	.86
Prime order * Day	0.00	(0.092)	0.03	.97
Prime structure * Prime order * Day	-0.09	(0.084)	-1.09	.28

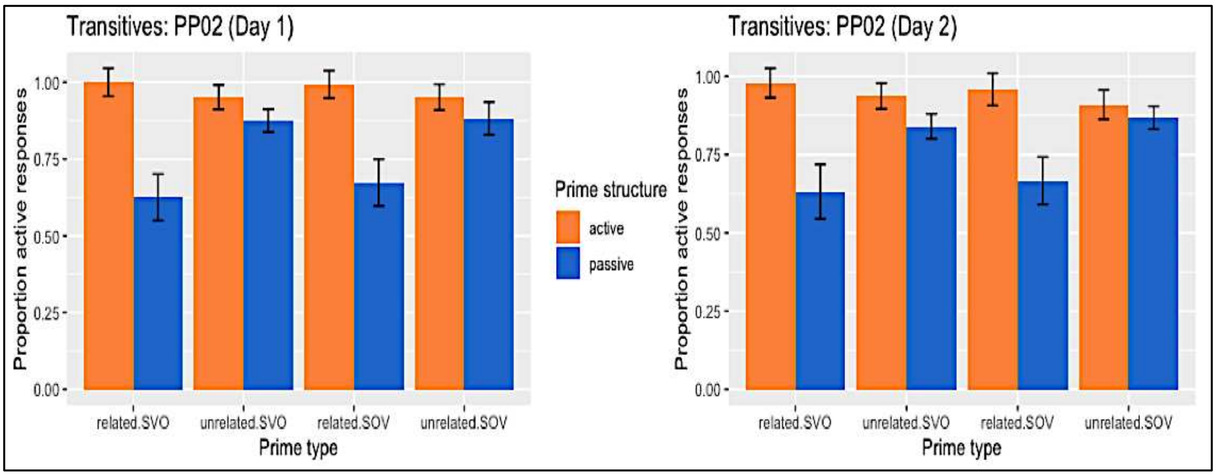
C.4 Ditransitive model output of word order priming in Experiment 2.

Summary of the fixed effects in the multilevel logit model (*N* = 2267; log-likelihood = -646.5)

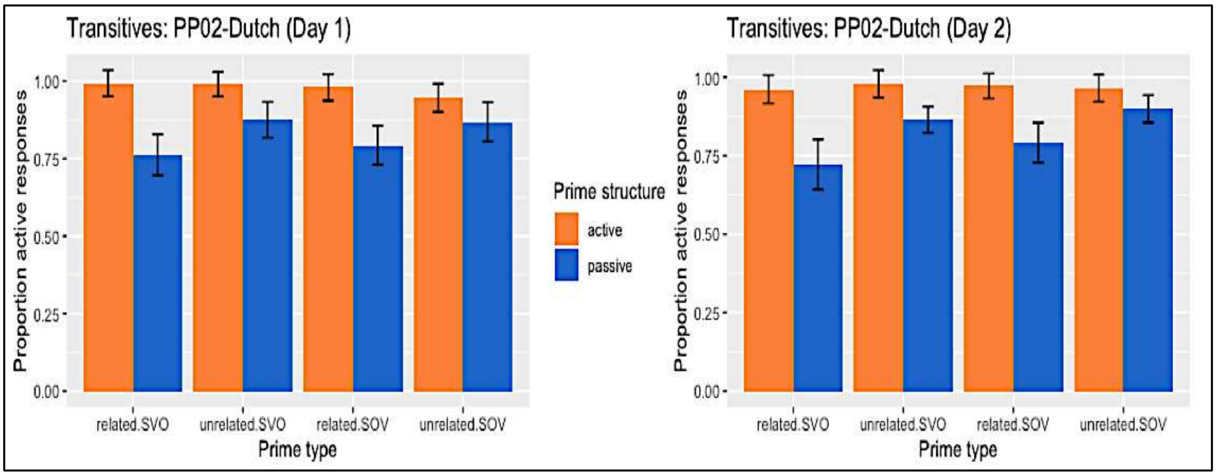
Fixed effect	*β*	*SE*	Wald's *Z*	p-value
(Intercept)	2.85	(0.542)	5.26	<.001
Prime structure	-0.18	(0.079)	-2.33	<.05
Prime order	-1.02	(0.092)	-11.12	<.001

Day	-0.43	(0.246)	-1.77	.077
Prime structure * Prime order	-0.03	(0.079)	-0.33	.75
Prime structure * Day	0.01	(0.079)	0.18	.86
Prime order * Day	-0.10	(0.089)	-1.08	.28
Prime structure * Prime order * Day	0.03	(0.079)	0.39	.70

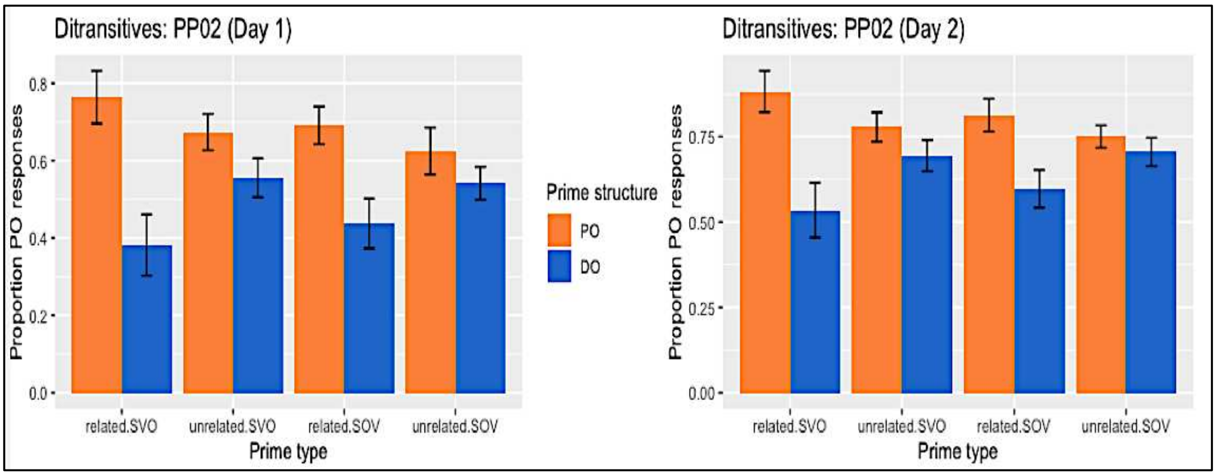
Appendix D: Priming results of Experiment 2, split up by day



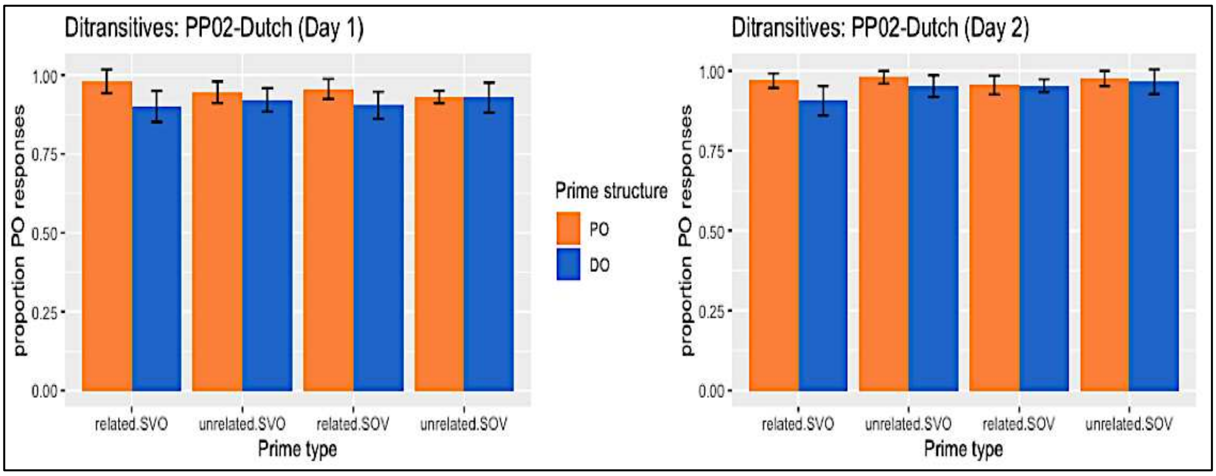
D.1. Structural priming within PP02 for transitives, split up by day (Experiment 2).



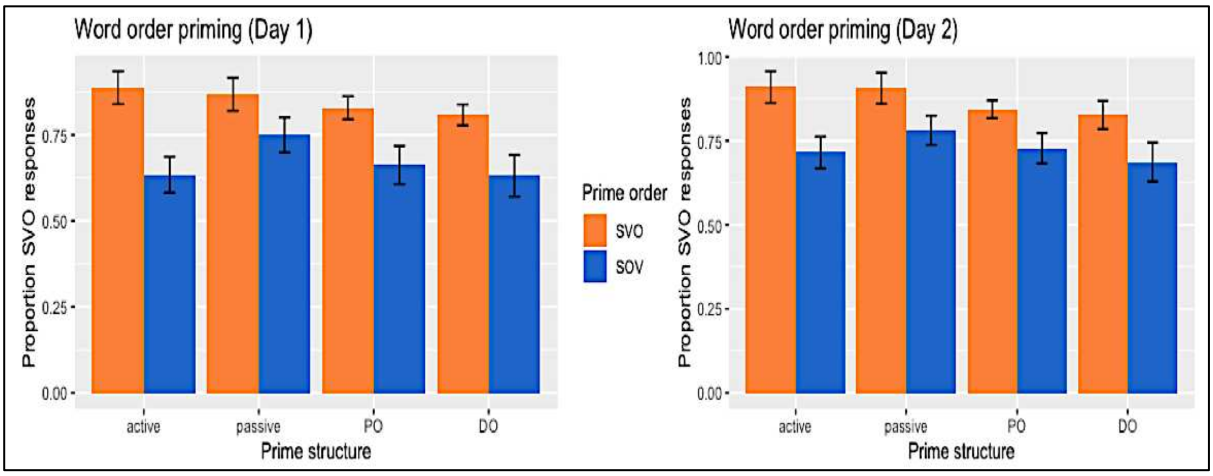
D.2. Structural priming from PP02 to Dutch for transitives, split up by day (Experiment 2).



D.3. Structural priming within PP02 for ditransitives, split up by day (Experiment 2).



D.4. Structural priming from PP02 to Dutch for ditransitives, split up by day (Experiment 2).



D. 5. Word order priming in transitives and ditransitives, split up by day (Experiment 2).