Spring 5-1-2015

Cognitive Influences on Constituent Order: Priming Evidence

Lee Prunier
University of Connecticut - Storrs, prunierlee@gmail.com

Cognitive Influences on Constituent Order: Priming Evidence

Lee Prunier

University of Connecticut

Abstract

In spoken as well as signed language, a shift over time from the use of Subject-Object-Verb (SOV) word order to Subject-Verb-Object (SVO) word order has been observed. The use of pantomimed gesture and priming can help determine the extent to which this shift comes from pressures specific to language, as opposed to existing as a more broad feature of communication. Participants took turns matching images to videos showing gestured event descriptions primed in SVO or SOV order, and gesturing event descriptions to a camera. Results show a strong preference for orders consistent with SVO across prime types, and an increase in these orders over rounds. These results suggest that the shift to SVO word order arises partially from experience in comprehending communication from others, and occurs even if that communication uses SOV order, not SVO.

Acknowledgments

I would like to thank Matthew L. Hall for his support through the process of research and writing for this thesis paper. His enthusiasm and knowledge about not just his own research but my contributions as well have greatly enhanced my learning and enjoyment during this year-long project.

I would also like to thank Professor William Snyder for his advice and for supporting my academic choices through my full four years at the University of Connecticut, and Professor Diane Lillo-Martin for enthusiastically supporting my decision to pursue a thesis related to sign languages and for her help making sure that everything would work out on paper.

Cognitive Influences on Constituent Order: Priming Evidence

While many languages currently use Subject-Object-Verb (SOV) word order, there is evidence that some of the world's languages began with SOV order and later shifted to using Subject-Verb-Object (SVO) word order (Givón, 1979). The shift from SOV to SVO is a long and gradual process, but once it occurs, it does not reverse itself (Gell-Mann & Ruhlen, 2011). A shift from SOV word order to SVO word order has also been observed in American Sign Language (Fischer, 1975). In addition, a study of the grammar of an emerging sign language found that how the three major constituents (S, O, and V) are organized in a language is seemingly initially fixed at an early stage of the language's development, with SOV order arising first - though it could gradually change to another order later on (Sandler, Meir, Padden, & Aronoff, 2005).

Interestingly, the word order in established sign languages does sometimes vary in a very specific pattern. In established sign languages, while the major word order may be SOV, SVO order is used for a certain type of event. In most sentences, ("girl kicks ball"), the agent and the patient are not plausibly interchangeable. In other words, the converse ("ball kicks girl") would describe an event that is extremely unlikely in the real world. In some sentences, though, the agent and patient are both possible agents ("girl pushes boy", "boy pushes girl"). The events in these sentences are considered *reversible events* because of this interchangeability of the agent and patient. SVO word order is prevalently used in reversible events (Hall, Mayberry, & Ferreira, 2013). This might be due to the fact that this order separates the agent from the patient as much as possible, compared to other orders such as SOV where the agent and patient are adjacent to each other.

A survey of 42 sign languages has reported that SOV order is grammatical in all sign languages, but also that in reversible sentences with plain verbs, sign languages tend to favor SVO order (Napoli & Sutton-Spence, 2014). The researchers considered two possible accounts to explain their findings - one modal, the other amodal. The modal account states that sign order patterns are due to modality and are determined by what makes visual sense, whereas the amodal account states that the patterns are due to universal pressures on language. Something similar, though, has also been seen in spoken languages, making the modal explanation less likely.

A phenomenon known as word order freezing shows up in some spoken languages, especially those with more variation in what word orders are allowed. In word order freezing, a certain word order becomes fixed in certain situations – those where features of the words cannot distinguish which word holds which syntactic place in the sentence (Sells, 2001). This sort of situation is similar to that seen in reversible events. Interestingly, many languages with word order freezing are overall SOV-ordered languages such as Hindi and Korean and typically move to OSV word order in freezing – presumably in order to preserve verb-final speech. While SVO order does not have dominance in known word order freezing situations, it is clear that SOV order is at a disadvantage for ambiguous situations.

With word order freezing as a uniquely different case, it is still clear that in both signed and spoken languages, there is a tendency to move towards SVO word orders – not just for reversible events, but for all event types. There are different possible explanations for this change which fit into two broad categories –formal and functional. Formal explanations for the SVO shift posit that the change in word order is due to the human cognitive system of grammar, which influences human language (Kayne, 1994, Langus & Nespor, 2010). Conversely, functional explanations broadly explain the SVO shift as related to how language is used in communicative

context and therefore which word order "functions" better for language users (Dryer, 2006). From a formal approach, choice in word order is influenced by grammar-specific properties so changes such as the shift to SVO order should not be seen outside of developed language. From a functional approach, word order choices are due to principles that are not related to grammar and therefore should be seen in less structured communication such as gestured pantomime.

Defending the formal explanation of shift to SVO, one study began by replicating a previous experiment in which participants performed a communicative task using only gesture, and then added a portion where participants comprehended gestures instead of producing them (Langus & Nespor, 2010). Participants viewed videos of a person gesturing and then chose an image matching the gestured description.

In gesture studies, terms such as SOV and SVO can be used metaphorically in relation to constituent orders. While the gestures involved are non-linguistic, the referent of each gesture is an agent or action in the scene which corresponds to the linguistics ideas of subject, object, verb, and others. In this study, regardless of their native language's word order, participants produced most of their gesture strings in SOV order and were also fastest at comprehending SOV-ordered videos (Langus & Nespor, 2010). Participants were also, in a different portion of the study, asked to comprehend artificially synthesized strings of words in their native language. In this portion, participants were unsurprisingly best at comprehending their own native order (Langus & Nespor, 2010). Because language seems to eventually prefer SVO orders and the gesturing in the study did not tend towards SVO, the experimenters concluded that SOV order's prevalence in gesture reflects only human sensory-motor systems, while human language also makes use of systems that govern grammar.

For functional explanations of the shift to SVO, there are a few different classifications. Broadly, functional theories are about what makes communication easier – either for the producer, for the comprehender, or both. As previously noted, functional explanations of the shift to SVO word order base the shift not on grammatical principles, but on communicative pressures that are not specific to language.

The study of pantomime can be useful in order to tease apart the formal and functional explanations for word order variation. When individuals are gesturing, the influence on them from their native language's rules is much lessened. Because pantomime is not a structured language, formal accounts of word order change would not predict constituent orders in pantomime to share similar patterns with word order in language. Conversely, by functional accounts, word order choices are related to more general cognitive constraints and would be seen in pantomime as well as language.

One functional explanation puts the reasoning for the observed shift to SVO solely on the producer – in other words, the person who is initiating the communication as opposed to receiving it (Hall et al., 2013). Hall et al. discussed the idea of role conflict in gesture, defining it by example. If a participant were describing a reversible event, they might use a body-as-agent strategy, acting out the agent and the patient by impersonating each. If the participant began with gesturing the agent, then gestured the patient, they would experience role conflict when gesturing the patient followed by the action, as occurs in SOV constituent order. This is because it is the agent who performs the action, not the patient, and the participant would currently be in the patient role. Hall et al.'s participants described videos of simple scenes and then described them in English in half of the trials, and in the other half by using gesture only. In the gesture descriptions, for non-reversible events participants produced mostly SOV constituent order, but

for reversible events they produced mostly SVO order and, notably, SOV order became less frequent (Hall et al., 2013). The researchers did note that role conflict in this form may be unique to the manual modality.

Another functional theory credits the comprehender – the person who is receiving the communication through listening or through watching – with initiating the shift to SVO word order. The researchers had participants produce gestures to match a series of images, and found different results for trials using reversible events than those using non-reversible events. Reversible events were generally gestured with SOV order, whereas SVO was typically used for non-reversible events (Gibson, Piantadosi, Brink, Bergen, Lim, & Saxe 2013). The researchers proposed an explanation called the noisy-channel hypothesis. It is rooted in communicative pressures affecting the comprehender's understanding - not cognitive constraints on the producer as in the role conflict explanation, or a general function of grammar as in formal accounts.

The noisy-channel hypothesis posits that language users are sensitive to the potential of noise corrupting the signal, and is applied here to explain that the language users would switch from SOV order to SVO order in order to diminish potential ambiguity about which entity – the actual agent or the actual patient – is the agent in a given sentence (Gibson et al., 2013). Exploration of reversible events, in which this potential ambiguity is present, can lend possible support to the noisy-channel hypothesis.

A following study made a different distinction, separating two types of verbs but still using a similar experimental paradigm to those thus far, where participants used gesture to describe images of scenes to a communicative partner. Schouwstra and de Swart (2014) tested extensional verbs (those where possible objects are fairly interchangeable - usually motion-related verbs such as "throw" or "carry") as opposed to intensional verbs (those where the

object's meaning is integral to the phrase's meaning, such as "think" or "hear"). The researchers found that SVO was the most common order for intensional events, and SOV was the most common for extensional events. They concluded that SOV word order simply appeared so prevalently in other studies because of the semantics of the particular verbs and events used there (Schouwstra & de Swart, 2014). The researchers also noted that participants' choices of constituent order were functionally based - independent of language - and stated that either communicative pressures from the comprehender (e.g. Gibson et al., 2013) or cognitive constraints on the producer (e.g. Hall et al., 2013), or both, are what leads a language to SVO constituent order.

Considering the possible influence of communicative pressures, Hall and Ferreira (in prep) designed an experiment that covered some of the shortcomings of previous work. Despite theoretical discussion of communicative pressures and the effect of communicators trying to make themselves understood, some of the preceding research did not involve an interlocutor being present – or, the researchers had themselves played the part of a passive interlocutor, which may have influenced results. In Hall and Ferreira's study, there were two conditions - interactive, and solitary. Interactive participants took turns gesturing descriptions of images, and watching their partner gesture while themselves choosing which image matched the description. Solitary participants followed the same procedure but gestured to a video camera and instead of watching a partner gesture, they watched a live-action video of each same event.

Some events in Hall and Ferreira's experimental stimuli were reversible - those with both the agent and patient being possible agents - and the rest were non-reversible events. If the shift to SVO order was seen in the interactive condition and not seen in the solitary condition, that would have meant that some aspect of interactive communication was driving the shift. For

reversible events, the researchers found that the use of SOV order for reversible events was rare across rounds and conditions, and the use of SVO order in either event type (reversible or non-reversible) increased over rounds in both conditions but with a more marked increase in the interactive condition – consistent with the hypothesis that SVO constituent order emerges at least partially because of dynamic interaction between the communicator's needs and the comprehender's needs (Hall and Ferreira, in prep).

This interactive explanation has two possibilities within it. One prospect is that as producers receive direct feedback from their interlocutor, they are alerted to a comprehension advantage for SVO orders, and begin to use more of them. Alternatively, when producers become comprehenders and experience what it is like to receive a message, they may then notice a relative ease in comprehending SVO orders over other orders. This would lead to the use of more SVO orders when it is their turn at production again.

Despite these past experiments, there is still uncertainty over what causes communicators to begin to use SVO constituent order when describing non-reversible events – whether the explanation is formal or functional, and if it is functional, whether it is based on the producer's needs, the comprehender's needs, or some combination thereof. From past research, it is apparent that SVO orders may be easier to comprehend (Hall et al., 2013; Langus & Nespor, 2014). But, this does not mean that ease of comprehension is the reason that SVO orders start to be used more frequently – the ease of comprehension could simply be a side effect.

Both classes of explanation for the shift to SVO word order – formal and functional – are plausible. In traditional language studies, it is difficult to de-confound the two broad possibilities. This can be partially cleared up by observing participants who are using gestured pantomime to

communicate, and therefore not being influenced by their native language's rules, as noted above.

While studies focusing on developed languages have attempted to prime word order through constructs such as grammatical roles (subject, object, and verb), gesture studies cannot. This is because in untrained gesture, there is no such thing as grammatical roles because spontaneous gesture communication is not governed by the rich syntax which is characteristic of and influences word order choices in natural languages. In gesture, the order of thematic roles such as agent, patient, and action can be primed instead. There is a rough correlation between the thematic agent (the initiator of an event) with a subject, of the thematic action with a verb, and of the thematic patient (that which an action is carried out on) with an object. Thematic roles can be primed just as well as grammatical categories have been and may in fact be what is being primed when some word order priming is observed (Pappert & Pechmann, 2014). Priming in gesture may be possible too, drawing from the methodology of previous gesture-based experiments (Gibson et al., 2013; Hall et al., 2013) but instead of having pairs of participants, using just one participant at a time. Each solo participant would view videos of a confederate producing gestures in pre-determined orders corresponding to a prime type – either SOV-ordered videos or SVO-ordered videos. Participants would gesture their own utterances not to a fellow participant, but to a video camera.

If no bias towards SVO constituent order is seen at any priming level, even when participants are primed with SVO-ordered videos, the formal explanation of the shift to SVO will be indirectly supported. This is because the formal explanation is based firmly in developed language only, and pantomimed gesture is not a language. Therefore, a lack of SVO bias would be consistent with a formal explanation.

One functionally-based hypothesis, as discussed above, is that SVO use increases in non-reversible events solely due to cognitive constraints on the producer. If this is so, there would be no priming effect – the same behavior would be expected across all priming conditions. If there are interactions involved indicating a more nuanced effect, though, this hypothesis will not be supported.

A different functional answer is possible. Because participants do not interact with a communicative partner during the experiment, if real-time feedback from the comprehender is responsible for the shift to SVO order, no shift would not be observed whatsoever. Participants would be expected to be influenced mostly by priming effects, or no differences between groups would be expected at all.

Alternatively, regardless of priming group, participants may use more SVO constituent orders over time. That is, even SOV-primed participants would gesture more SVO orders in later rounds. This observation would support the hypothesis that participants are learning from their own experience as comprehenders and using constituent orders that they think would be easiest to comprehend.

Method

Participants

32 undergraduate students enrolled in introductory linguistics or psychology courses at the University of California, San Diego (n = 16) or at the University of Connecticut (n = 16) participated in this experiment for course credit. All participants gave their consent to participate and to be videotaped as part of the study.

Data from 10 participants were excluded for various reasons. These consisted of proficiency in a SOV language (6) and experimenter or technical error (4). Participants also

would have been excluded if they had had sign language or mime experience, but this did not occur. All exclusion decisions were made blind to the performance of the participant in question. Ultimately, 16 individuals in the equal-prime condition, 8 individuals in the SOV-prime condition and 8 individuals in the SVO-prime condition constituted the final dataset.

Materials

Stimuli were primarily a series of hand-drawn images depicting cartoon figures participating in transitive events. There were in total 24 unique events. Of these, 16 were non-reversible events, those involving a human agent and a non-human patient. The other 8 events were reversible events - involving both a human agent and a human patient. This labeling of events follows Hall, Mayberry, and Ferreira (2013). The agents were always either a man or a woman, depicted as a stick figure. The actions depicted (all of which were transitive) were kissing, lifting, petting, and pushing, with arrows indicating the action's direction. The patient of the action was either non-human (a ball, a box, a car, or a dog) or human (a man or a woman - whichever differed from the agent).

There was a second set of stimuli consisting of videos showing an individual using gesture to describe the events pictured in the hand-drawn scenes, just like the participants would be doing themselves. There were two full sets of videos of the individual describing events using gesture. In one set, the individual was pictured using Subject-Object-Verb order, and in the other set, Subject-Verb-Object order was pictured. These videos, as well as the hand-drawn images, were drawn from stimuli used in Hall and Ferreira (in prep). The individual in the videos was introduced to participants as a previous participant, but was in fact a confederate. This minor deception was explained to participants during post-experimental debriefing.

Design

Participants alternated between blocks of describing event images, and blocks of matching event images with video clips of an individual describing the images. Half of the participants described first, and half matched first.

Word order prime condition was manipulated between subjects. Half (n = 16) of the participants were in the equal-prime condition, where there was no priming of a specific word order attempted. These participants saw equal amounts of videos with Subject-Object-Verb (SOV) order and videos with Subject-Verb-Object (SVO) order in every round, and for both reversible and non-reversible events. For the remaining participants (n = 16), half were assigned to the SOV-prime condition and half were assigned to the SVO-prime condition, yielding 8 participants per prime type. Prime condition was distributed evenly between participants in the describing-first and matching-first groups such that there were four participants in each of the four possible combinations of the two conditions.

Items were arranged in a pseudo-random order following Hall and Ferreira (in prep), such that for each participant in the equal-prime condition there was a participant in either the SOV-prime or SVO-prime condition who had experienced the same order of both image and video stimuli.

Reversibility was manipulated within subjects. Out of the set of 24 possible items (events), each participant had the chance to describe each image twice over the course of the study, and each participant saw a video of each event (corresponding to their priming condition) twice as well.

Out of the 24 total items, 12 were involved in each round. Each round always consisted of 4 reversible events and 8 non-reversible events. For rounds where the participant was

describing images, the design was as follows. For the first round, four reversible and eight non-reversible events were selected out of the set of 24 possible items and ordered randomly. For the second round of describing images, the remaining 12 items were presented in random order. For the third describing round, the same images were presented as during the first describing round, and the fourth round similarly corresponded to the second round. Overall, each participant described each item twice during their participation in the experiment.

For rounds where the participant was matching images with video clips, the design for the four matching rounds proceeded the same way as that for the describing rounds (explained above) with one additional constraint. As the participant alternated between rounds of describing and matching, in each adjacent round (of the opposite type), there were six items in common and six items different. For example, for participants who described images first, their first describing round naturally had 12 images the participant had not seen before. In the first matching round, six items were taken from those already seen during the first describing round, and six items were taken from those not already seen. In the second describing round, the participants described those images that they had not described yet: six that had already been matched, and six that had not. In this way, each item was overall described twice and matched twice.

For the practice trial, each participant had the chance to describe one image and match one video to an image. The matching video was a description of the same item for every participant (“woman pets ball”) with a correct gesture order for the participant’s prime condition. The item to be described was different for each participant and was chosen randomly out of the set of sixteen possible non-reversible events.

Procedure

Participants were told that they would be taking turns describing and matching simple images. When they described images it would be to a video camera and they must use only gesture - no speech, mouthing, or sound effects - to describe each image. When they matched images they would watch a video of an individual describing each image in gesture, and for each video they would have to choose the correct image from a set of possible matches. Participants were told that they would alternate between the two tasks with four rounds of each task total, and that there would be twelve items in each round.

Before beginning the experiment block, participants had the opportunity to practice each of the two tasks, describing and matching. For describing, each participant viewed an array of four images. These four images consisted of the target image to be described as well as three foil images. Each foil image differed from the target image in one element. If a participant's gestured description omitted any of these three elements, the experimenter encouraged them to produce their description again but to make sure to describe all three elements of the scene. When encouraging participants, experimenters were very careful to avoid any wording that suggested a communicative partner trying to understand the gestures, as well as to avoid any wording that mentioned terms such as "subject", "object", or "verb". Most often the experimenter would simply point to one of the foil images that would have been consistent with the participant's description and ask, "How would you show how that picture is different from this one?" No feedback was given in relation to the order in which the parts of the image were described. Participants then had the opportunity to try describing the target image again.

For their practice round at matching, each participant viewed an array of a different four images. The target image was not marked, but each of the other three images in the array differed

from the target in one element only. The participant watched a video of a gestured description of one of the images and had to guess, by pointing at it, which image was being described. When each participant had finished both practice trials, the experimenter gave an opportunity for any last questions before the experiment would begin.

During each describing round, participants were given a sheet with an array of twelve images. They were instructed to describe the images to a video camera one by one (left to right and top to bottom on the sheet) and to let the experimenter know when they had finished describing all twelve images.

During each matching round, the participant advanced through a series of twelve videos shown on a screen. After watching each of the twelve videos, the participant selected which image they thought was being described, out of a set of all 24 possible images, and placed a card displaying that image on a sheet that was marked with a space for each item 1 through 12. Then, the participant would move on to watch the next video and make their next selection. After all 12 images had been matched and the participant indicated that they were done, the experimenter announced the participant's total number wrong out of 12 for that round. No feedback was given about which particular items were correct or incorrect.

After the participant had completed four rounds of description and four rounds of matching, alternating between the two, the experiment was over. During all rounds of the experiment, the experimenter remained in the room but did not interact with the participant other than to provide the participant with materials necessary for the start of each round, and to score accuracy after each matching round.

Coding

Responses were coded by two trained coders who identified each gesture's referent as subject (S), verb (V), or object (O). If a coder could not determine the referent of a gesture, the trial was coded as "ambiguous". If a gesture appeared to refer to more than one referent at the same time with neither reference clearly occurring first, the trial was coded as "simultaneous" (for example, stroking down their hair to indicate "woman" with one hand at the same time as the other hand moved outward to indicate the action "push"). Every gesture that the participant produced was counted as part of a single utterance until the participant moved on to the next item.

Trials were classified as (S)OV, (S)VO, or Other. Trials were classified in the "Other" category if they did not follow strictly SOV, OV, SVO, or VO word order. "Other"-classified trials included those with repetition (e.g. "SOVO" or "SOSV") and those with omission (e.g. "V"). The only way for a trial to be classified as (S)OV or (S)VO was if the participant had either followed exactly SOV, OV, SVO, or VO order, respectively, with no other constituents produced for that image during that round. The classifications of (S)VO and (S)OV were used instead of strict SVO and SOV because some participants seemed to have a null or missing subject, in that they would include the subject when the subject was female, but skip the S and produce only OV or VO if the subject was male. A very small number of trials followed OV or VO order – 19 out of 1536 (1.24%) and 2 out of 1536 (0.13%) respectively.

While aware of the experimental manipulations, coders were blind to each other's ratings. Coders agreed on 1460 of the 1536 utterances (95.05%). Cases of disagreement were excluded from analyses. The agreement of the two raters was measured using Cohen's kappa coefficient and resulted in a kappa value of 0.93, indicating excellent agreement.

Results

To examine the impact of thematic role priming, event reversibility, current experience with task (round number), and starting role on the prevalence of produced constituent orders, manually coded data were transformed into a new measure - the absolute prevalence of (S)VO constituent orders. While the prevalence of (S)VO, (S)OV, and Other orders are interdependent, the three sets of values cannot be compared to each other meaningfully. Results that are theoretically significant can be computed using (S)VO prevalence as the main variable of interest. The overall proportions of (S)VO constituent orders in each condition were submitted to a 4 x 2 x 3 x 2 ANOVA. Within-subjects factors were round (1-4) and reversibility (non-reversible vs. reversible). Between-subjects factors were prime type (equal-prime, SOV-prime, or SVO-prime) and the participant's starting role (describing pictures vs. matching pictures).

Occurrence of Syntactic Priming

There was a significant main effect of prime type on gesture order ($F(2,26) = 3.90$, $p = .033$, $MSe = 2.58$, $\eta^2 = .23$). A series of post hoc t-tests revealed that (S)VO descriptions were significantly more common in the SVO-prime condition ($M = .82$, $SD = .21$) than in the SOV-prime ($M = .42$, $SD = .30$) condition: ($t(14) = 3.06$, $p = .008$). There was a marginally significant difference between SVO-prime and equal-prime ($M = .59$, $SD = .31$) conditions ($t(22) = 1.84$, $p = .080$), but no significant difference between SOV-prime and equal-prime conditions ($t(22) = 1.32$, $p = .200$) (see Figure 1). This indicates that SVO priming was marginally more effective than SOV priming.

Additionally, a significant interaction was found between prime type, reversibility, and round ($F(6,78) = 3.70$, $p = .003$, $MSe = 0.08$, $\eta^2 = .22$). While (S)VO percentage increased over rounds in all priming conditions for reversible events, (S)VO percentage did not increase as

much in non-reversible events in the SOV-prime and equal-prime conditions compared to in the SVO-prime condition. The percent of (S)VO orders generated, collapsing across priming conditions, did not have a significant increase over rounds ($F(3,78) = 1.01$, $p = .426$, $MSe = 0.03$, $\eta^2 = .07$), and no other effects involving prime type reached significance (All Fs < 1.63, all $p > .05$).

Effect of Reversibility on Word Order

The main effect of reversibility on constituent order was significant ($F(1,26) = 32.55$, $p < .001$, $MSe = 4.16$, $\eta^2 = .56$), with greater amounts of (S)VO orders being produced for reversible events as opposed to non-reversible events. There was also a significant interaction (see Figure 2) between reversibility and round ($F(3,78) = 5.99$, $p < .001$, $MSe = 0.13$, $\eta^2 = .19$). Reversible events were described using (S)VO word orders more often in later rounds than earlier rounds. Aside from further interactions involving reversibility and starting role (see below), no other effects involving reversibility reached significance (All Fs < 1.63, all $p > .21$).

Other Factors

There was no significant difference between those whose starting role was describing images and those whose starting role was matching images ($F = 0.87$, $p > .05$). The main effect of round on constituent order was, however, significant ($F(3,78) = 33.41$, $p < .001$, $MSe = 0.87$, $\eta^2 = .56$). There was a significant interaction between round and starting role ($F(3,78) = 17.20$, $p < .001$, $MSe = 0.45$, $\eta^2 = .40$) and between reversibility and starting role ($F(1,26) = 9.03$, $p = .006$, $MSe = 0.21$, $\eta^2 = .30$) as well as a significant three-way interaction between those same three variables - starting role, round, and reversibility ($F(3,78) = 3.24$, $p = .027$, $MSe = 0.07$, $\eta^2 = .11$). There were no other significant interactions involving round or starting role (All Fs < 1.44, all $p > .21$).

As mentioned above, two-way interactions between each pair of factors out of participant starting role, round, and event reversibility were present. While reaching significance, the interaction between starting role and round is simply due to the particular dependent measure used - (S)VO order prevalence. The form of the interaction is such that each round has similar data to all other rounds with the exception of round one for those who described images first (as opposed to matching). This significant difference is because of the large amount of "Other" orders produced in these participants' first rounds. During their first round, likely due to inexperience with the task, participants produced fewer (S)VO orders not due to an increase in (S)OV orders, but because of having far more omissions (e.g. "V", "SO") and duplications (e.g. "SVOV", "SOVO") at first.

The interaction between starting role and reversibility is similarly explained. Participants who described first produced less (S)VO orders for non-reversible events than were produced by participants who matched first. This effect can be attributed to describer-first participants becoming set in some of their constituent order tendencies before they had a chance to view or be primed by videos of another person's gestures. Another explanation is that – similarly to the above – describing-first participants produced more "Other" orders.

Discussion

Participants in this study used pantomimed gesture to describe reversible and non-reversible events with no interactive interlocutor. Unlike previous pantomime studies with no interactive partners for participants, these participants did experience both being gesture comprehenders and gesture producers. They comprehended gestures produced by a videotaped confederate in either SVO order only, SOV order only, or an equal mix of both SOV and SVO orders.

Results show a strong (S)VO preference across prime types, in both event types. Importantly, there was an increase in (S)VO orders over time, through each round of the experiment. Analyses of the data determined that in reversible events especially, there is a strong preference for (S)VO constituent orders over any other type of constituent order. This finding replicates previous results from Hall and Ferreira (in prep). The (S)VO preference was seen at all priming levels – even when participants viewed only SOV-prime videos.

Looking closer at the overall differences between the three priming conditions, there was a significant difference between the amount of (S)VO orders produced by SVO-prime participants as opposed to SOV-prime participants. This difference indicates that some constituent order choices may have simply been due to exposure to that constituent order. There was also, however, a marginal difference between SVO-prime and equal-prime participants but no significant difference between SOV-prime and equal-prime participants. This pattern suggests that there may be differential overall strength between SVO and SOV priming – regardless of reversibility – though further exploration would be needed to make such a conclusion. If SVO priming were truly more effective than SOV priming, that result could support an overall cognitive advantage for SVO order itself, over SOV.

A skeptic's explanation of the observed priming effects might be that participants were simply copying the constituent orders seen in their prime videos. It is possible that some constituent order choices were the result of alignment with participants' interlocutor which in this case was the prime videos. Linguistic alignment may influence the form of communicators' utterances, even with a non-human interlocutor (Branigan, Pickering, Pearson, & McLean; 2010). However, the results rule out that concern because the prevalence of (S)VO orders increased over rounds over all prime types, including SOV-only priming.

As mentioned above, (S)VO orders increased in every priming group over rounds of the experiment. In other words, all participants, even those who were viewing videos in exclusively SOV order, began producing more (S)VO orders as they gained experience in comprehending gesture strings. What causes this increase? The noisy-channel hypothesis proposes that experience in comprehension may contribute. According to the noisy-channel hypothesis, the reason for language users to switch to SVO order from SOV order is to diminish ambiguity about whether the actual subject or the actual object is the subject in a sentence (Gibson et al., 2013). Though participants were not communicating directly with an interlocutor, their gestures had communicative intent, and some participants may have been aware of the fact that the videos would be watched later. The present results support the noisy-channel hypothesis as at least a partial explanation for the shift to SVO order, because an over-rounds increase in produced (S)VO orders was observed in every priming group (SOV-primed, SVO-primed, or equally primed).

Some of this study's most important findings are that priming effects are evident outside of developed language, in relatively simple gesture. In formal accounts, there is no prediction of a parallel between language and pantomime. Therefore, even the shift in reversible events to SVO order should not necessarily have been observed outside of developed language, in gesture. Because a reversibility effect was observed, the formal explanation may not best account for all present observations. While the formal explanation may be a part of language priming, an additional functional explanation is needed. Functional accounts explain word and constituent order change not as specific to language, but generally due to communicative context and other broad factors (Dryer, 2006) and therefore are consistent with the present results. At this time,

consequently, functional explanations of the shift to SVO order are more compelling because they offer a simpler explanation of results.

What supports the idea that pantomime is primed just like language is? There is interesting evidence that it is possible to prime thematic roles, and that they may be what is being primed here (Pappert & Pechmann, 2014). Though syntax may not exist to be primed in pantomime, thematic roles are present. If priming could cross between languages – where syntax may differ, but thematic roles stay the same – it would support the likelihood of priming's existence in pantomime too.

Many past spoken language priming studies have focused on monolingual speakers, but there has also been evidence that priming can extend between known languages for bilingual language speakers (McDonough, 2006). In one study that is similar to the present experiment but in the spoken modality, confederate scripting and picture matching were used to elicit different sentence structures from participants, any of which were usable in both of participants' languages. The results showed successful priming for only some types of constructions and not others, but were nevertheless indicative of syntactic priming having occurred even in participants' second language (McDonough, 2006). If priming effects can occur in a second language, priming may really be a broad phenomenon that can reach much further than one's native language and can be seen in not just a second or third language, but in non-language communication such as pantomime and gesture as well.

The present results replicated previous findings of an advantage for (S)VO constituent orders in reversible events (Hall & Ferriera, in prep). An advantage for (S)VO orders in non-reversible events was also observed in the SVO-prime and equal-prime conditions, similar to the full change seen in some natural languages (Gell-Mann & Ruhlen, 2011). The explanation that

has previously been given for the shift to SVO order only explains the shift seen in reversible events, not in non-reversible events. This is because the noisy-channel hypothesis, and others, hinge on the SVO shift as a way to diminish possible ambiguity between the agent and patient's actual roles. Non-reversible events lack this potential confusion, so the fact that the SVO advantage has now been noted even when reversible events were not taken into account is important because it is not explained by previously supported hypotheses. The present study uniquely links an ease in comprehension of SVO orders to increased production of them even in non-reversible events. Therefore, present results support explanations of a shift to SVO order that is due to language users' experience as comprehenders, and is not strictly tied to formal language, as it is being seen in gestured pantomime as well.

A limitation of the present study is that some participants may have become aware of the fact that the supposed past participant shown in the priming videos was actually a confederate. During post-experiment debriefing, participants were informed that the person pictured in the videos they had viewed was actually a confederate. When they were told this, some participants expressed that they had thought the person looked too confident or seemed too good at the tasks, and that they had had a feeling that the person was not who they were told. This awareness of the minor deception may have caused some participants either to follow along with the word order shown in the videos, or to ignore the videos entirely and simply use a word order that they had begun using on their own. Future studies could use an in-person confederate for participants to comprehend. The confederate would be trained as to what gestures to produce, and to make sure that the confederate was not influenced by the gestures and constituent orders produced by the true participant.

Following the previous discussion of priming's place in relation to participants' native language(s), another target for future research is to replicate the current study but with participants who are native speakers of SOV languages, not SVO languages as in this experiment. The current study excluded bilingual speakers of English and any SOV language, but it would be informative to observe any differences between the performance of our participants, and participants whose native language is a SOV language (and who are not fluent in a SVO language as well). Some counter-evidence has already been seen for the idea that the prevalence of SVO orders is simply due to participants' native language pressures. Hall and Ferriera have found that (S)VO constituent orders do not become prevalent even for English speakers if the stimuli include no reversible events (in prep). Therefore, is it unlikely that SVO-language-speaking participants are strongly influenced by the word order of their native language. If our results could be replicated using SOV speakers, great support would be given to the notion that our observed prevalence of (S)VO constituent orders is not due - even in part - to native-language grammatical pressures.

The present results demonstrate that communicative pressures influence word order choices in pantomime. More generally, these same pressures may influence the patterns in natural languages, and the shift to SVO word order may arise partially due to experience as a comprehender – even if the communication being comprehended is not in SVO order. It is clear that comprehension experience plays a part in driving word order changes over time, and that the shift to SVO order is not unique only to developed language.

References

Branigan, H. P., Pickering, M. J., Pearson, J., & McLean, J. F. (2010). Linguistic alignment between people and computer. Journal Of Pragmatics, 42(9), 2355-2368. doi:10.1016/j.pragma.2009.12.012

Dryer, Matthew S. (2006). "Descriptive theories, explanatory theories, and basic linguistic theory". In Felix Ameka; Alan Dench; Nicholas Evans. *Catching Language: Issues in Grammar Writing.* Berlin: Mouton de Gruyter. pp. 207–234.

Dryer, Matthew S. & Haspelmath, Martin (eds.) 2013. *The World Atlas of Language Structures Online.* Leipzig: Max Planck Institute for Evolutionary Anthropology. (Available online at http://wals.info, Accessed on 2015-01-05.)

Fischer, S. (1975). Influences on word order change in American Sign Language. In C. N. Li (Ed.), *Word order and word order change* (pp. 3–25). Austin, TX: University of Texas Press.

Gell-Mann, M. & Ruhlen, M. (2011). The origin and evolution of word order. *Proceedings of the National Academy of Sciences, USA, 108*, 17290–17295.

Gibson, E., Piantadosi, S. T., Brink, K., Bergen, L., Lim, E., & Saxe, R. (2013). *A noisy-channel account of crosslinguistic word-order variation.* Psychological Science, 24(7), 1079-1088. doi:10.1177/0956797612463705

Givón, T. (1979). *On understanding grammar.* New York: Academic Press.

Hall, M. L., Mayberry, R. I., & Ferreira, V. S. (2013). *Cognitive constraints on constituent order: evidence from elicited pantomime.* Cognition 129, 1–17. doi: 10.1016/j.cognition.2013.05.004

Hall, M. L., & Ferreira, V. S. (manuscript in preparation). Effects and non-effects of least-joint-effort in a gestural communication task.

Kayne, R. S. (1994). *The antisymmetry of syntax.* Cambridge: MIT Press.

Langus, A., & Nespor, M. (2010). *Cognitive systems struggling for word order.* Cognitive Psychology, 60(4), 291-318. doi:10.1016/j.cogpsych.2010.01.004

McDonough, K. (2006). *Interaction and syntactic priming: English L2 speakers' production of dative constructions.* Studies in Second Language Acquisition, 28, 179–207.

Napoli, D., & Sutton-Spence, R. (2014). *Order of the major constituents in sign languages: implications for all language.* Frontiers In Psychology, 51-18. doi: 10.3389/fpsyg.2014.00376

Pappert, S. & Pechmann, T. (2014). Priming word order by thematic roles: No evidence for an additional involvement of phrase structure. *The Quarterly Journal Of Experimental Psychology*, *67*(11), 2260-2278. doi:10.1080/17470218.2014.918632

Sandler, W., Meir, I., Padden, C., & Aronoff, M. (2005). *The emergence of grammar: Systematic structure in a new language.* Proceedings of the National Academy of Sciences. 2005; 102(7):2661–2665.

Schouwstra, M. & de Swart, H. (2014). *The semantic origins of word order.* Cognition, 131(3), 431-436. doi:10.1016/j.cognition.2014.03.004

Sells, P. (Ed.). (2001). *Formal and empirical issues in optimality theoretic syntax*. CSLI Publications.

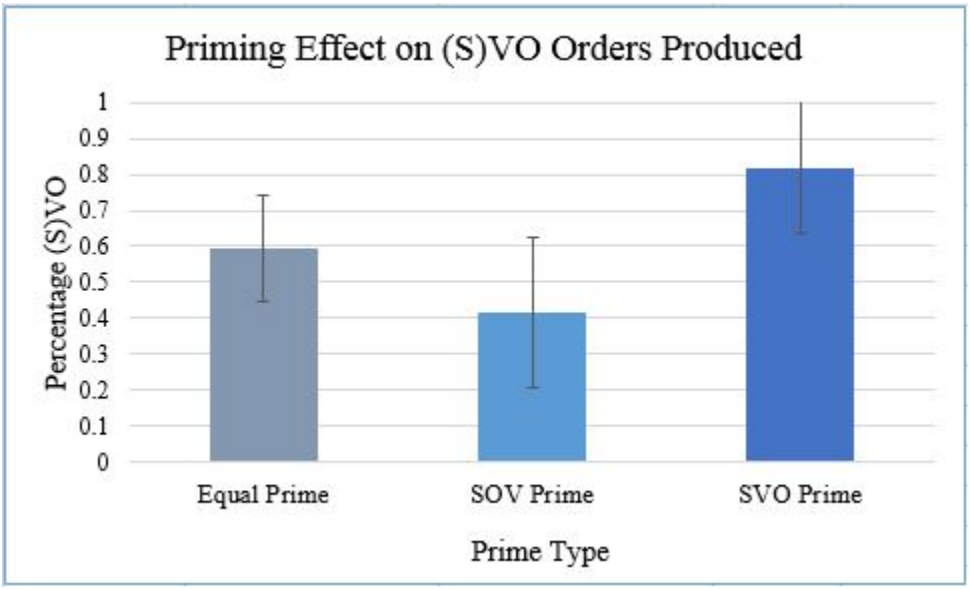

Figure 1. Main effect of priming condition on (S)VO orders produced, collapsed across reversibility, round, and starting role. Error bars represent 95% confidence interval.

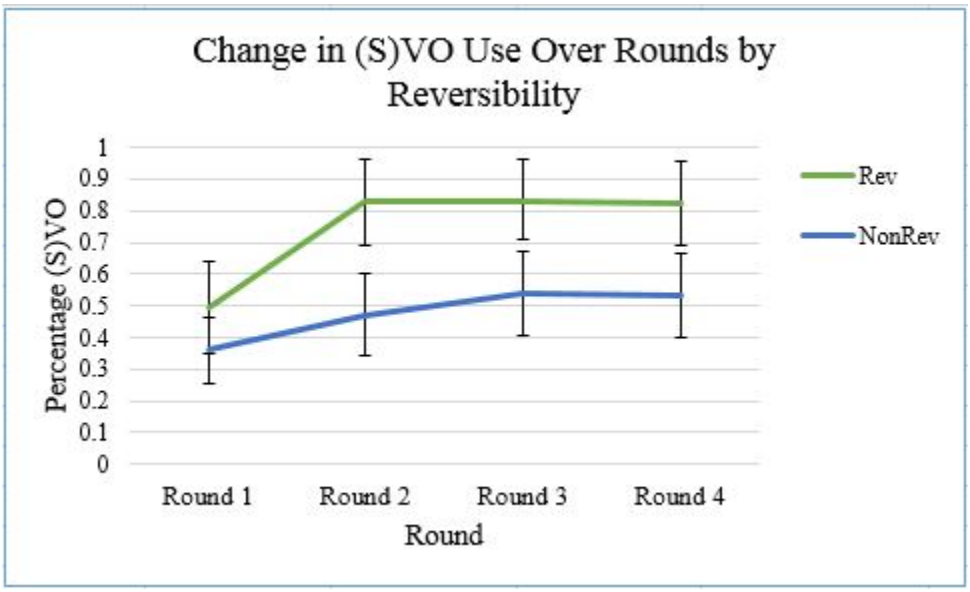

Figure 2. Change in (S)VO use over rounds by reversibility, collapsed across priming condition and starting role. This figure illustrates the increases over time in use of (S)VO constituent orders, seen for both reversible and non-reversible event types. Error bars represent 95% confidence interval.