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Brief article

Cross-linguistic gestures reflect typological universals: A subject-initial, verb-final bias in speakers of diverse languages

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ABSTRACT

In communicating events by gesture, participants create codes that recapitulate the patterns of word order in the world's vocal languages (Gibson et al., 2013; Goldin-Meadow, So, Ozyurek, & Mylander, 2008; Hall, Mayberry, & Ferreria, 2013; Hall, Ferreira, & Mayberry, 2014; Langus & Nespor, 2010; and others). Participants most often convey simple transitive events using gestures in the order Subject–Object–Verb (SOV), the most common word order in human languages. When there is a possibility of confusion between subject and object, participants use the order Subject–Verb–Object (SVO). This overall pattern has been explained by positing an underlying cognitive preference for subject-initial, verb-final orders, with the verb-medial order SVO order emerging to facilitate robust communication in a noisy channel (Gibson et al., 2013). However, whether the subject-initial and verb-final biases are innate or the result of languages that the participants already know has been unclear, because participants in previous studies all spoke either SVO or SOV languages, which could induce a subject-initial, verb-late bias. Furthermore, the exact manner in which known languages influence gestural orders has been unclear. In this paper we demonstrate that there is a subject-initial and verb-final gesturing bias cross-linguistically by comparing gestures of speakers of SVO languages English and Russian to those of speakers of VSO languages Irish and Tagalog. The findings show that subject-initial and verb-final order emerges even in speakers of verb-initial languages, and that interference from these languages takes the form of occasionally gesturing in VSO order, without an additional bias toward other orders. The results provides further support for the idea that improvised gesture is a window into the pressures shaping language formation, independently of the languages that participants already know.

1. Introduction

Recent work on improvised communication by gesture has revealed that patterns in people's nonlinguistic communication can provide insight about the range of variation in human languages. Specifically, when using

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gestures to represent an event with an actor, a patient, and an action, in many cases people convey first the actor (the 'Subject'), then the patient (the 'Object'), then the action (the 'Verb'), even if this specific word order is not present in any language they know (Gibson et al., 2013; Goldin-Meadow, So, Ozyurek, & Mylander, 2008; Hall, Mayberry, & Ferreria, 2013; Hall, Ferreira, & Mayberry, 2014; Langus & Nespor, 2010; and others). Among languages with a dominant word order, about half have verb-final word order, and about, 90% have subject-initial order (Dryer, 2002, 2005). The emergence of a subject-initial, verb-final order in improvised gestural codes suggests that its cross-linguistic prevalence might arise because that order is the 'default' or most natural way for humans to convey information about events. This idea is bolstered by the presence of SOV word order in certain emerging linguistic systems, such as Nicaraguan Sign Language (Senghas, Coppola, Newport, & Supalla, 1997) and Al-Sayyid Bedouin Sign Language (Sandler, Meir, Padden, & Aronoff, 2005). For some possible reasons why SOV order is preferred, primarily based on information-structural concerns and the semantics of the verb, see Gibson et al. (2013) and Schouwstra, van Leeuwen, Marien, Smit, and de Swart (2011, 2014).

The findings from gesture studies also suggest a motivation for verb-medial word orders. The prevalence of SVO order (about 40% of languages) might arise because that order conveys the separate roles of the Subject and Object in a way that is more robust to noise (Gibson et al., 2013). Suppose Alice is trying to convey a meaning to Bob, and that Alice and Bob have agreed to use SOV order. Alice will send her message as Noun–Noun–Verb. If Bob fails to receive one of the nouns, then he has received the message Noun–Verb. If the entity represented by the received noun can be interpreted plausibly as either an actor or a patient, then Bob has no way of knowing whether the received noun is an the Subject or Object—he does not know if he has received SV or OV. However, if Alice and Bob agree to use SVO order, then their code is more robust to this kind of noise. If Alice uses SVO order, sending a message as Noun–Verb–Noun, but Bob misses one of the nouns, then the message he has received is either Noun–Verb or Verb–Noun. By observing on the position of the noun relative to the received verb, he can deduce whether it is the Subject or Object. In both SOV and SVO codes, it is word order which provides the signal about which noun is Subject and which is Object, with the rule that the Subject precedes the Object. The SVO code conveys this ordering information more robustly in the presence of noise.[1]

For this reason, messengers might prefer SVO order in circumstances where communicative robustness is important. Supporting evidence comes from the studies of Meir et al. (2010), Hall et al. (2013) and Gibson et al. (2013), who find that people gesture in SVO order more often when the agent and the patient of the action are both human and thus are both plausible as agents. We call these kinds of events *reversible* because the agent and the patient could be plausibly reversed. SVO order for complex reversible events emerges even in gestures of speakers of strict verb-final languages (e.g. Japanese and Korean), indicating that the use of SVO gestures cannot be explained solely by the influence of speakers' known language structures. The communicative robustness of SVO order might explain its status as the second most common word order. SOV languages might become SVO to increase signal robustness, or they might maintain SOV when there is sufficient case marking on noun phrases to distinguish between agents and patients.

The communication-by-gesture scenario differs subtly from the exposition about Alice and Bob above. In the exposition above, Alice and Bob agreed on a word order code before communicating. In the gesture scenario, Alice and Bob do not agree on a code beforehand. Rather, Alice must produce a message such that Bob can determine its meaning without knowing the code in advance. So Alice must adopt some strategy that will distinguish the Subject from the Object for Bob, even though Bob does not know what code Alice is using. In that case, Alice must rely on the assumption that Bob shares her own word order biases: i.e., she believes that if Bob receives a message Noun–Noun–Verb, he will conclude that the first noun is the Subject, since that is how *he* would have sent the message. Similarly, if Bob receives a noisy-channel-corrupted message Verb–Noun, he can conclude that the received noun is the Object by reasoning that if it were the Subject, then it would have been initial, due to a strong shared Subject-initial bias. Thus the use of SVO for robust communication depends on a strong bias for an initial Subject, and a weaker bias for a late verb.

The central role of the Subject-initial and Verb-final biases in these explanations raises the question of the source of those biases. An obvious source of bias could be from languages which experimental participants already know. To date, gesture experiments have only been conducted on speakers of SVO and SOV languages; the structures of these languages have been found to have strong effects on gesture order. For example, Gibson et al. (2013) find that SVO order is essentially absent in gestural descriptions of simple reversible actions by Japanese and Korean speakers, emerging only for reversible actions in embedded clauses. The effects of other language types on gestures are unknown. In this paper, we perform the gesture experiments with speakers of VSO languages, who might lack a Subject-initial bias, or for whom it might be weaker. If the bias is substantially weaker, we would not expect speakers of those languages to use SOV gestures; nor would we expect them to switch to SVO to communicate reversible events, since the SVO code is only robust to noise when decoded by a receiver with a subject-initial bias.

The existence of effects of known languages, coupled with the fact that experiments have only been conducted on speakers of SOV and SVO languages, raises the possibility that the striking observed subject-initial bias may be a

[1] The exposition here assumes that noise takes the form of a *deletion channel*, which deletes elements of the message without leaving a trace. It is possible to derive the same predictions using an alternative noise channel, a *transposition channel*, where adjacent symbols are swapped in order. Robustness against such a channel might also explain effects such as the avoidance of adjacent similar NPs in relative clauses (Gennari & MacDonald, 2009).

result of the subject-initial nature of all the languages studied so far. More complex interactions are also possible: for example, verb-final orders might arise in part due to a language bias from SVO languages, because speakers of those languages have experience with verb-final sentences in intransitive sentences, which are SV. Similarly, speakers of SOV languages have experience with verbs immediately following subjects, which might influence them to produce SVO order for confusable sentences. The typological narrowness of the languages studied so far limits our ability to determine the source of the subject-initial, verb-final bias in gestures.

Furthermore, the exact form of the interference that native language exerts on ad-hoc gestural codes remains unclear from the existing literature. Experimental results so far are compatible with at least two hypotheses. (1) First, it is possible that participants simply adopt the dominant word order of their native language wholesale, gesturing in a given order because they are mentally substituting gestures for words in natural language sentences. (2) Second, it is possible that known languages exert a more subtle form of influence, by strengthening or weakening biases for subjects to come early or late. In that case, for example, we might expect speakers of a VSO language to produce SVO gestures, since the VSO order would induce a 'verb-early' bias which might not be strong enough to overcome an underlying subject-initial bias. Because previous work has only studied speakers of SVO and SOV languages, it has not been possible to distinguish between interference in the form of simple recapitulation of orders from known languages (hypothesis 1), or interference as changes in biases for certain words to come early or late (hypothesis 2).

In this paper, we demonstrate that the subject-initial, verb-final bias arises regardless of known languages by performing the gesture communication experiment on speakers of two VSO languages, Irish and Tagalog (Borsley & Roberts, 1996; Comrie, 1990). We compare results with gestures from speakers of two SVO languages, English and Russian. VSO languages would not induce a subject-initial bias, and they would not induce potential verb-final or verb-second biases due to intransitive SV constructions. We find that speakers of VSO languages do produce some VSO orders in gestures; this gesture order has never been observed from speakers of other languages. However, while speakers of SOV languages gestured overwhelmingly in SOV orders for simple events (Gibson et al., 2013), we find that speakers of VSO languages gesture only occasionally in VSO order, preferring SOV and SVO. The distribution of gesture orders is similar to the distribution of orders from speakers of SVO languages, only with occasional VSO gestures; this suggests that interference from known languages takes the form of simple recapitulation of the language's dominant order.

Another issue that has been raised regarding the interpretation of gesture studies is that the modality of gesture might introduce constraints that do not apply to vocal speech. When gesturing an action performed by a human, people might use their body to take the role of the agent. Since they are acting the role of the agent, they may be reluctant to gesture an animate object before gesturing the verb (Hall et al., 2013). This tendency does not have a direct analogue in vocal speech. Although our experiments were not conducted to directly address this issue, we discuss the issue in light of our data below.

2. Methods

Native or highly proficient bilingual speakers of English, Russian, Modern Irish, and Tagalog were invited to participate in a gestural communication experiment. They were shown a set of short videos depicting three kinds of simple events: intransitive events, such as a girl jumping, nonreversible events, such as a boy lifting a car, and reversible events, such as a boy lifting a girl. Fig. 1 shows an example of the images in the videos. They were then asked to communicate the content of the video to an experimenter verbally. They also performed the task using gesture only on the same set of videos in the same order. The order of these two tasks was counterbalanced between participants. There were 26 videos per task: 2 training and 24 test events, taken from Gibson et al. (2013), with any instructions in the videos in the target language (e.g., "Ready to practice?" = "Handa na sa pagsasanay?" in Tagalog). Experimenters gave instructions about the tasks only in the target language. As in Gibson et al. (2013), Participants were asked to not use their own body as a symbol for a subject or an object in a sentence. Their responses were videotaped

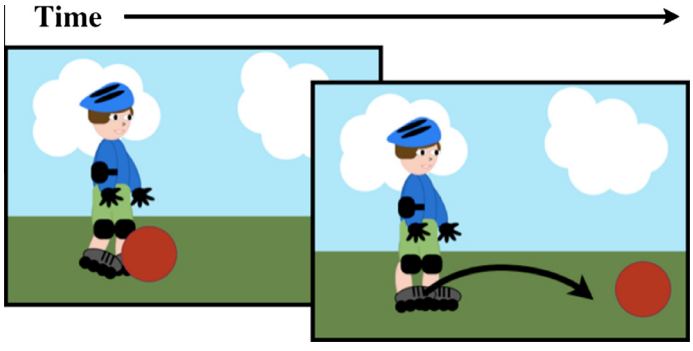

Fig. 1. An example of a video shown to participants, indicating the action "the rollerskater kicked the ball." Animations were created by Kim Brink.

and coded offline. One third of gesture trials were recoded; we evaluated inter-annotator agreement using Cohen's κ on these trials, with the baseline probability of agreement calculated using 100 random permutations of the data.

2.1. Participants

2.1.1. English participants

The data presented here for English are the same as in Gibson et al. (2013). No subjects reported knowledge of any sign language.

2.1.2. Russian participants

13 Russian-speaking participants were recruited at MIT and from the local community in the Greater Boston area through a department online sign-up system and an announcement at the MIT Russian club. All participants were briefly interviewed by the experimenter to evaluate their proficiency in Russian. One participant was excluded from the final sample because she reported thinking in English during the task and using English as her primary language at home, and she had an English accent. The final sample consisted of 15 subjects (6 male) and their age ranged between 18 and 40 years (M = 29.8). All participants in the final sample were bilingual and learned English as a foreign language. 10 subjects reported high daily use of Russian (at least 50%), and 3 reported no or low daily use of Russian. 11 subjects were educated in Russian for 9–19 years.

2.1.3. Irish participants

12 highly proficient Irish-English bilinguals were recruited at University College Dublin. All recruitment materials were in Irish only, and participants were selected from a group with very high levels of Irish usage, specifically those students who had qualified through an interview to live in grant-aided campus accommodation requiring that students speak Irish to each other. Participants' ages ranged from 18 to 40 (mean 21.2 years), and eight were female. Four participants were from officially designated Irish-speaking communities in the west of Ireland, and 10 had Irish spoken in their homes while growing up. Eleven participants reported high current use of Irish (ranging from 50% to 90%, Mean = 66% daily use), and only one reported less, at approximately 20% current daily use of Irish. Ten participants had attended all-Irish-medium or predominantly Irish-medium schools, and the remainder had had some Irish-medium instruction.

2.1.4. Tagalog participants

There were 11 Tagalog participants (8 female): 10 were recruited at the University of the Philippines-Diliman in Quezon City and one was recruited in the City of Navotas, also within Metro Manila. The participants' age ranged between 24 and 64 (mean 42.8). Those recruited at the University of the Philippines-Diliman had all finished at least a Bachelor's degree, were either bilingual or multilingual, and were all employed in the university. All of these participants reported English as the second language in which they were most proficient, following Tagalog. The participant recruited in Navotas City reported to have little knowledge of English.

3. Results

Gestures for transitive events produced by speakers of all four languages followed the same basic pattern: (1) For nonreversible events, SOV order was dominant or as common as SVO: for speakers of all languages but Irish, SOV responses outnumbered SVO responses, and for speakers of Irish the proportions of the two orders were nearly the same. (2) For reversible events, SVO order were most frequent, outnumbering SOV responses in all languages. Fig. 2 shows the proportions of responses in each three-word order for each language for nonreversible events. Fig. 3 shows the data for reversible events. Some gestures had complex orders such as SOSV or SOVSOV; since there were many different complex orders, we omitted the complex orders from the figures for visual clarity. We include those orders in the regressions below, and present proportions for all orders in tables in an Appendix A. We find strong inter-annotator agreement (for Russian speakers, Cohen's κ = 0.95; for Irish speakers, Cohen's κ = 0.78; and for Tagalog speakers, Cohen's κ = 0.78).

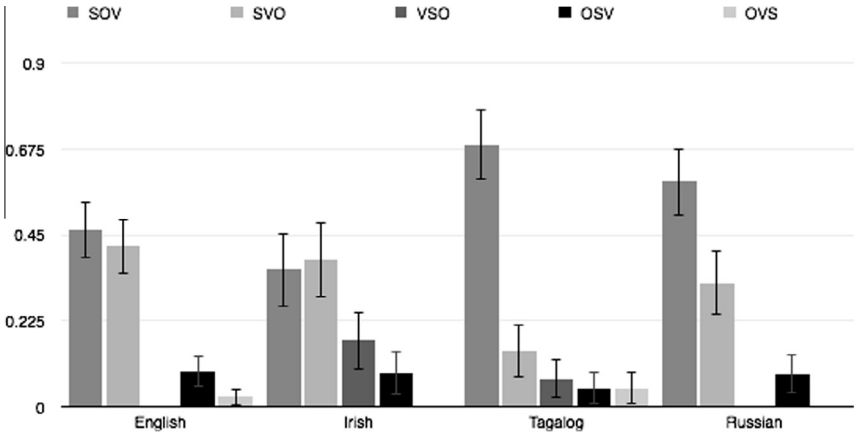

Fig. 2. Proportions of responses in basic three-word orders for nonreversible events (inanimate objects).

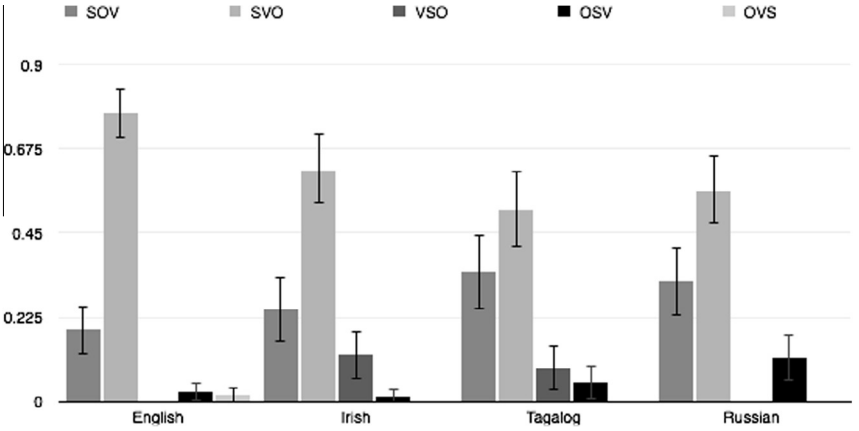

Fig. 3. Proportions of responses in basic three-word orders for reversible events (human objects).

Interference from proficiency in a verb-initial language was evident in the presence of verb-initial responses by speakers of Irish and Tagalog, two verb-initial languages. This order was never produced by speakers of English or Russian (here), nor by speakers of Japanese or Korean in Gibson et al. (2013). Furthermore, the choice of word order in gesture seemed to vary among individual speakers of the same language. In our sample, only three Irish speakers used VSO order. One of those subjects used VSO order 88% of the time and the other two used it less than a third of the time. In Tagalog, one subject used VSO order in 64% of transitive gestures, and two other subjects each used it only once.

There is a noticeable difference between the Irish and Tagalog data: Irish speakers in our sample were more likely to use SVO order. This is very possibly due to the fact that there is now universal bilingualism among Irish speakers (Stenson, 1993) making it almost impossible to find adult Irish-speakers who do not have very high proficiency in English also. Despite bilingualism, all Irish participants' verbal responses were verb-initial. Attributing the Irish pattern to English influence makes sense in light of the analysis of gesture data among Japanese-English bilinguals in Brown and Gullberg (2008) who find that their gesture behaviour is more similar to the pattern observed in English monolinguals than to Japanese monolinguals (see also Athanasopoulos, 2009; Athanasopoulos, Damjanovic, Krajciova, & Sasaki, 2011).

The increase in verb-medial responses for reversible events is significant. The proportion of SOV and SOVS responses decreased in favor of responses such as SVO and SVSO. A logistic regression predicting whether the object appears before the verb shows that this decrease in probability is significant: $p < 0.001$ for Tagalog, 95% confidence interval on the logistic regression slope $[-0.46, -0.19]$; $p = 0.006$ for Irish, 95% confidence interval $[-0.32, -0.06]$; $p < 0.001$ for Russian, 95% confidence interval $[-1.53, -0.44]$; $p < 0.001$ for English, 95% confidence interval $[-0.50, -0.30]$.

In addition, we can use these data to test the hypothesis of Hall et al. (2013), that gesturers resort to SVO order in order to prevent gesturing OV, which might result in the object being interpreted as the subject due to its adjacency to the verb. In support of that hypothesis, Hall et al. (2013) find no decrease in OSV orders for reversible events. We also find that the usage of OSV order does not significantly correlate with reversibility in any language, though it is sometimes trending, with the effect in the direction such that reversible events are less likely to be expressed as OSV (by logistic regression, $p = 0.12$ for Tagalog, 95% CI $[-1.29, 1.54]$; $p = 0.06$ for Irish, 95% CI $[-4.16, 0.07]$; $p = 0.47$ for Russian, 95% CI $[-0.54, 1.15]$; $p = 0.10$ for English, 95% CI $[-2.39, 0.20]$). When we expand our scope to all orders *containing* OSV, such as SOSV and SOSVO, we also find no significant effects of object reversibility, and the direction of the effect is variable. In English and Irish, reversible events are less likely to be expressed with an order containing OSV ($p = 0.08$ for English, 95% CI $[-1.81, 0.11]$; $p = 0.15$ for Irish, 95% CI $[-2.12, 0.31]$). In Russian and Tagalog, reversible events are also more likely to be expressed with such an order (but not significantly; $p = 0.45$ for Russian, CI $[-0.54, 1.23]$; $p = 0.81$ for Tagalog, 95% CI $[-.90, 1.15]$). Pooling data across all languages, the proportion of OSV orders for nonreversible events is 6.7%, and for reversible events it is 4.8%, with the difference not significant by a χ-squared test ($\chi^2 = 1.34$, $p = 0.24$). Thus we have a null result on the effect of reversibility on OSV order (see Appendix A for our observed data on all orders).

We also examined the data for effects of the relatively free word order and case marking in Russian and Tagalog. One might expect more variation in gesture order for speakers of languages with freer word order. However, we did not observe any such effect. Using Shannon entropy to measure variability in gesture order, we find 2.36 for English, 2.60 for Irish, 1.39 for Russian, and 2.51 for Tagalog. The gestures of speakers of languages with freer word order are not more variable. In our results, influence from known languages is limited to the presence of VSO gestures produced by speakers of VSO languages.

4. Conclusions

We find that subject-initial and verb-final orders emerge even in the gestures of speakers of languages without subject-initial or verb-final constructions, suggesting

that there is some cognitive preference for subject-initial and verb-final structures in communication. Speaking a VSO language seems to induce only a small bias on gesture orders, which takes the form of occasionally gesturing in the order VSO. This suggests that the influence of known languages on gesture order does not take the form of modulating biases for subjects and verbs to come early or late, but rather consists of participants sometimes adopting the dominant order of a language wholesale while gesturing. We also find that SVO word order is prevalent even in gestures of speakers of VSO languages, suggesting that SVO word order is not simply an intrusion of the gesturer's known languages, but rather a strategy adopted for this communicative situation.

The results of the present experiments support the following model of word-order variation, based on cognitive and communicative factors: SOV order is a default preferred order, while SVO word order has the advantage of being more robust to noise, in the sense of Shannon (1949) theory of communication. Hence, gesturers use SVO more frequently when there is a potential confusion between an agent and a patient, preferring it to orders such as SOV where the object and the subject both precede the verb. This might explain the observed tendency for SOV lanimportant. Supporting evidence comes from the studiesguages to evolve to SVO order, with the reverse occurring less frequently (Newmeyer, 2000).

The provenance of VSO languages within this ontology is not entirely clear. The existence of VSO languages, along with the extreme rarity of OSV/OVS/VOS languages, suggests that the underlying cognitive verb-final bias is weaker than the subject-initial bias. By placing the verb first, VSO languages might make argument structure easier to learn, since the verb is already known by the time the hearer receives the nouns (Pozzan & Trueswell, submitted for publication). Also, while VSO languages do not adhere to the apparent verb-final bias we have postulated, if they have case marking then they are just as communicatively robust as SOV languages. Dryer (2002, 2005) finds that about 47% of VSO languages have case marking, compared to 14% of SVO languages and 72% of SOV languages. That VSO languages are less likely to have case marking could be because many VSO languages also have frequent SVO constructions (for example, Arabic and Biblical Hebrew are VSO in the perfect aspect, but SVO in the imperfect aspect).

The communicative explanation for the crossover from SOV to SVO gestures raises the possibility of languages that directly adopt the mechanism of SOV order for inanimate objects and SVO order for animate objects. It is widely attested for languages to case-mark objects only if they are animate or definite (Aissen, 2003), but we are not aware of a language which *categorically* uses different word orders depending on the animacy or definiteness of the object. However, it remains possible that languages with relatively free word order might tend to use SVO when the object is animate or definite, while using SOV otherwise. A potential example is Hungarian, which is usually SVO for definite objects and SOV for indefinite objects. It will be hard to evaluate this claim until detailed information on crosslinguistic quantitative syntax is available. Languages with different fixed orders depending on the animacy of the object might also be harder to learn. We leave the fleshing out and evaluation of these hypotheses for future work.

In finding a null result for the effect of reversibility on OSV order, the results here do not contradict the hypothesis of Hall et al. (2013), that the decline in OV orders for reversible events is due to a dispreference for gesturing an action performed by an agent directly after pantomiming an animate patient. Under that theory, both SVO and OSV orders should arise when O is animate. It seems reasonable to us that this might be a factor in the dispreference of OV orders, but the communicative account specifically predicts a large increase in SVO orders as opposed to OSV orders, which the data bear out. Nevertheless, the low frequency of OSV gestures in the data make it hard to draw any strong conclusions.

The gestural paradigm provides a unique opportunity to observe the spontaneous creation of a communication code, and to study the pressures that shape constraints on those codes. This study validates that the paradigm can be used to uncover patterns independent of the structure of the known languages of the subjects, but that this interference does exist and must be considered.

The noisy channel model of word order variation provides a framework for explaining much cross-linguistic word order variation: languages starting as SOV languages should either have case marking to robustly communicate

Table 1
Observed gesture orders for nonreversible events.

	English	Russian	Irish	Tagalog
SO	0	0	0	1
SV	0	0	0	2
VS	0	0	0	0
OV	41	0	0	4
VO	3	0	1	0
SOV	55	69	29	57
SVO	50	38	31	12
VSO	0	0	14	6
OSV	11	10	7	4
OVS	3	0	0	4
VOS	0	0	0	0
SOSV	6	0	0	1
SOVS	0	0	0	0
SOVO	0	0	1	1
SVOV	0	0	3	0
SVSO	0	0	1	0
OSOV	2	0	0	0
OSVO	0	0	0	2
OVOV	1	0	0	0
SOSOV	2	0	0	3
SOSVO	0	0	0	0
SOVSO	0	0	0	0
SOVSV	0	0	0	0
SOVOV	0	0	0	1
SVOSV	0	0	2	0
SVOVO	0	0	0	0
SVOVV	0	0	1	0
VSOVS	0	0	0	0
VSOOS	0	0	0	0
OSSVO	0	0	0	0
OSVOV	0	0	0	1
SOSVSO	0	0	1	0
OSOSVO	0	0	0	0
VSVOVS	0	0	0	0

Table 2
Observed gesture orders for reversible events.

	English	Russian	Irish	Tagalog
SO	0	0	0	0
SV	2	0	0	0
VS	0	0	0	0
OV	5	0	0	0
VO	3	0	0	0
SOV	23	33	20	31
SVO	93	58	51	40
VSO	0	0	10	7
OSV	3	12	1	4
OVS	2	0	0	0
VOS	0	0	0	0
SOSV	1	1	3	3
SOVS	1	0	0	0
SOVO	0	0	0	0
SVOV	0	0	1	0
SVSO	0	0	0	0
OSOV	1	0	0	0
OSVO	0	0	0	1
OVOV	0	0	0	0
SOSOV	3	0	1	0
SOSVO	0	0	4	0
SOVSO	0	0	2	0
SOVSV	0	0	1	0
SOVOV	0	0	0	0
SVOSV	0	0	0	0
SVOVO	1	0	0	0
SVOVV	0	0	0	0
VSOVS	0	0	0	0
VSOOS	0	0	0	1
OSSVO	0	0	1	1
OSVOV	0	0	0	0
SOSVSO	0	0	0	0
OSOSVO	2	0	0	0
VSVOVS	0	0	1	0

subject and object, or they should develop into SVO languages, in which case the relative position of the words provides a robust signal about subject- and objecthood. The distribution of observed word orders can be explained by these general pressures, which have also been found to influence other aspects of natural language, such as phonological inventories, (Lindblom & Maddieson, 1988), phonological processes (Hume & Bromberg, 2005; Cohen Priva, 2008), and the structure of the lexicon (Piantadosi, Tily, & Gibson, 2011; Zipf, 1949).

Appendix A

See Tables 1 and 2.

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