Redundant morphological marking facilitates children's learning of a novel construction

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Abstract

The presence of redundant marking in languages raises interesting questions about the balance of different pressures in language learning and use. Speakers tend to avoid redundant elements in production: omitting (or reducing) more predictable elements. At the same time, languages maintain different types of redundant marking, such as encoding thematic assignment by both word order and case marking. Why is redundancy found in languages even though speakers seem to avoid it? Here, we propose that redundant cues can facilitate learning. We test this hypothesis in an artificial language learning study with children, where either word order alone or both word order and case marking serve as cues for thematic assignment in a novel construction. Results show that children learned the redundant language better despite having to learn an additional morpheme. We discuss implications for the effect of different cognitive pressures on language change.

Keywords: redundancy; artificial language learning; language acquisition; language evolution

Introduction

It has long been claimed that languages exhibit an optimal trade-off between two competing pressures: minimizing effort and maximizing understandability (Givón, 1991; Haspelmath, 2008; Jäger, 2007; Jaeger & Buz, 2017; Piantadosi, Tily, & Gibson, 2012; Zipf, 1949). Under this view, redundant cues will be dispreferred in language use (because they increase effort without increasing understandability), eventually leading to their reduction in language structure (Fedzechkina, Newport, & Jaeger, 2016; Gibson, Piantadosi, et al., 2013; Givón, 1991; Jaeger, 2013). In line with this view, speakers seem to avoid redundant marking in production: more predictable messages are more likely to be omitted or reduced (Aylett & Turk, 2004; Cohen Priva, 2015; Frank & Jaeger, 2008; Jaeger, 2010; Kurumada & Jaeger, 2015; Levy & Jaeger, 2007). For example, speakers tend to omit optional case marking when the meaning it encodes is more predictable from context (Kurumada & Jaeger, 2015; Lee & Kim, 2012).

At the same time, redundant marking is attested, in different forms, in multiple language systems. For instance, a number of typologically diverse languages are documented as redundantly marking a single meaning using multiple morphological markers (defined as *multiple exponence*, Caballero & Harris, 2012; Harris, 2017). In Choguita Rarámuri, for example, words containing an inner derivational marker for causatives and applicatives can have a second, optional marker suffixed to the noun (Caballero & Kapatsinski, 2015). Languages can also redundantly mark the same grammatical information by more than one means: one such example is the encoding of thematic assignment (who is doing what to whom) by both word order and case marking (e.g., Icelandic, see Siewierska, 1998). That is, morpho-syntactic redundancy—where two linguistic cues are used to mark the same function—is found across language systems.

How can we reconcile the presence of redundancy in language structure with speakers' tendency to avoid it in production? One way is to examine the possible functions of redundancy: why does it come about in the first place and what advantage can it confer? Here, we propose that the answer may lie in the impact of redundancy on learning. In particular, we suggest that (a) redundancy can facilitate learning under certain conditions, and (b) if this is so, speakers may increase (or maintain) the use of redundant cues when conversing with learners, supporting their continued presence in language. This proposal is compatible with the principles of efficient communication: the balance between effort and understandability can change depending on the comprehension ease or difficulty within a conversation (Gibson, Bergen, & Piantadosi, 2013; Kurumada & Jaeger, 2015; Levy & Jaeger, 2007). Speakers may allow (or even prefer) more redundancy when the listener is seen as having more difficulty in comprehension, as in the case of learners. The two predictions—the facilitative effect of redundancy on learning and its increased use with learners—are related, but theoretically independent. In the present study, we focus on the first prediction: Does redundancy facilitate language learning? Our focus here is on morpho-syntactic redundancy: cases in which different morpho-syntactic cues encode the same information. In line with previous work, we treat the omission and reduction of linguistic material as reducing redundancy (Aylett & Turk, 2004; Jaeger, 2010; Kurumada & Jaeger, 2015).

The advantage of multiple cues in learning has been demonstrated for different domains, such as vision (Sloutsky & Robinson, 2013) and category formation

(Yoshida & Smith, 2011). Recent computational evidence suggests that multiple cues can also facilitate language learning (Monaghan, 2017). Monaghan (2017) examined learning new mappings between forms and meanings with multiple cues. The cues were probabilistic in the learning phase (appeared only some of the time), and were absent during testing (where only the labels appeared). In line with our prediction, the computational model showed that words were learned better from multiple cues (pointing, prosody, and distributional cues) compared to single cues. Importantly for the present research question, the multiple cues used in these studies involved the combination of linguistic and non-linguistic cues (e.g., pointing) where the non-linguistic cues did not have to be learned in and of themselves (they did not carry information beyond increasing attention to the label). Here, we go beyond this work to ask whether redundant *linguistic* cues can also facilitate language learning. If redundant morphological marking is facilitative, we should see improved learning despite the added complexity of having to learn an additional cue. We focus on the morpho-syntactic redundancy of word order and case marking and use the transitive construction as a test case.

The Transitive Construction

Languages use different cues to indicate who-did-what-to-whom in the transitive construction. Two prominent cues are word order and case marking[1]: looking at learning when both cues are used lets us examine the possible advantage of redundant marking. The contribution of different cues to sentence interpretation has been studied extensively within The Competition Model (MacWhinney, 1987). Stemming from this theoretical framework, studies in various languages have tested how children utilize these two cues to comprehend transitive constructions. Dittmar, Abbot-Smith, Lieven and Tomasello (2008) examined the relative reliance of German-speaking toddlers on word order and case marking. They found that 2;6-year-olds could comprehend transitive sentences only when there was redundant marking of agent and patient (both cues were used). These findings were replicated across several languages (Cantonese: Chan, Lieven, & Tomasello, 2009; Japanese: Matsuo, Kita, Shinya, Wood, & Naigles, 2012; Warlpiri: O'Shannessy, 2010), and are in line with the predictions of The Competition Model, according to which a convergence of cues should facilitate comprehension of thematic assignment (Bates, McNew, MacWhinney, Devescovi, & Smith, 1982; Bates & MacWhinney, 1989; Ibbotson & Tomasello, 2009). However, in many of these cases, the redundant form is also the prototypical and the most frequent form in child-directed speech (Dittmar et al., 2008; Ibbotson & Tomasello, 2009). Therefore, it is not clear whether comprehension was facilitated because of the redundant cues, or because of the greater frequency of the prototypical structures (which happened to also have redundant cues). These explanations are hard to tease apart using natural language data, since individual cues are often correlated with one another (Ibbotson & Tomasello, 2008), and confounded with frequency.

[1] There is typological and historical debate about the relation between those two cues (with many languages showing a trade-off between the two), we return to this in the discussion.

The Current Study

In the current study, we use an artificial language to assess the impact of redundant morpho-syntactic cues on children's learning of a novel language. We compare the learnability of transitive constructions in two artificial languages: one with fixed OSV word order and no additional cues to thematic assignment (the non-redundant language), and the other with the same fixed OSV word order but with additional redundant case marking on objects (the redundant language). We used OSV word order because it differs from the dominant word order of Hebrew (SVO) - the language of the children in our study. Following exposure, we tested both comprehension and production of sentences in the novel language. Although the language without the case marking is simpler, in the sense of having fewer elements to learn, we predict that the redundant language will lead to better comprehension of thematic assignment because it contains redundant cues to indicate who-did-what-to-whom. Our prediction about the effect of redundancy on prediction is less clear-cut. On the one hand, if redundant markers indeed facilitate learning in general, this could aid production as well. Alternatively, the need to produce an additional element could make the sentences harder to produce. Such a dissociation between comprehension and production pressures is documented in other linguistic domains (e.g., Harmon & Kapatsinski, 2017).

Method

Participants

60 children participated in the experiment (age range: 7;0-9;0y, mean age: 7.10y, 41 boys and 19 girls). All children were visitors at the Bloomfield Science Museum in Jerusalem. They were recruited for this study as part of their

Figure 1: A trial example in the Sentence comprehension test phase.

Table 1: regression model for comprehension scores

	Estimate	Std. Error	z -value	p-value
(Intercept)	1.80068	0.21181	8.501	**<0.0001 *****
Condition (R-language)	1.03624	0.20390	5.082	**<0.0001 *****
Trial number	0.03324	0.03046	1.091	0.275
Age	-0.36756	0.32724	-1.123	0.261

visit to the Israeli Living Lab in exchange for a small reward. Parental consent was obtained for all children. All children were native Hebrew speakers, and none of them had known language or learning disabilities.

Materials

In both language conditions, participants were exposed to the same lexicon, which was composed of 6 semi-artificial Hebrew nouns (Hebrew nouns with nonce suffixes) and two Hebrew verbs. All nouns corresponded to masculine human characters, that were differentiated by their profession (e.g., clown, chef). The verbs were the Hebrew translations of "kick" and "touch". The constituent order of the language in both conditions was the non-Hebrew like OSV. In the redundant language (henceforth R-language) a nonce case marking ("patz") followed all objects, while in the control language (C-language) there was no such case marking. This cue was also non-native-like: Hebrew doesn't have post-nominal case-marking on objects. Participants saw and described the exact same drawings in both conditions[2].

Procedure

Participants were told they were going to meet some aliens who "say things differently from us" and that they would learn to speak like these aliens. Children were randomally assignmed to one of the two language conditions. Children sat with headphones in front of a computer next to a research assitant that provided them with verbal instructions. They saw drawings and heard recorded descriptions of these drawings in the alien-language (concatenated from recordings of the individual words spoken by a female Hebrew speaker). The experiment had several stages. First, a noun exposure phase, in which children saw each character, heard its name in the alien language, and had to repeat each name outloud (6 trials, one per noun). In both conditions, only the noun label was presented (without case marking). This was followed by a noun comprehension test (12 trials, two per noun) where participants saw two drawings, heard one label and had to match the label to the correct drawing. Feedback was provided after each trial. The following phase was sentence exposure (12 trials) where children saw a drawing of a transitive action (involving two of the characters, all characters could appear as agents and patients), heard a transitive sentence, and had to repeat it. The position of the agent and the patient in the drawing (left vs. right) was counterbalanced. The next stage was a sentence comprehension test (12 trials) where children saw two drawings of events, heard a sentence, and had to match the sentence to the correct drawing (see Figure 1). All the sentences here involved previously unheard combinations of agents and patients. The children had to use the mouse to choose the matching drawing. No feedback was given. The next phase was sentence production (12 trials) where chlidren saw previously unseen drawings of a transitive actions and had to describe them in the alien-language. Children's descriptions were recorded. Children in the R-language condition had one additional sentence forced-choice phase (12 trials) where they saw a previously unseen drawing, heard two descriptions of it, and had to choose the correct one. One option had case marking (like the sentences they heard before) and one was without case marking (as in the C-language). Children had to say which was a better way to describe the drawing by pressing on "1" or "2", corresponding to the order in which the options were presented. This phase was added to ensure that children in the R-language condition noticed the case marking cue.

Results

Comprehension

Children successfully learned the language (better than chance) in both conditions (C-language: M=65%, SD= 26%, t-test (29) = 3.1, p=0.004; R-language: M=91%, SD= 12%, t-test (29) = 26.8, p<0.0001). We used a mixed-effect logistic regression model to examine the effect of language condition on sentence comprehension (using the glmer function in R software, Bates, Maechler, Bolker, & Walker, 2015), and the maximum random effect structure justified by the data that converged, Barr, Levy, Scheepers, & Tily, 2013). The dependent variable was accuracy on each trial (as a binary variable). The model included fixed effects for condition (R-language vs. C-language, effect coded), age and trial number as centered continuous factors, and random intercepts for participants (see Table 1 for full model). As predicted, children showed better learning in the R-language condition (91% vs. 65%, β=1.04, SE=0.2, p<0.0001, Figure 2). Importantly, the difference in sentence comprehension

[2] The drawings were drawn by Sara Rolando from the University of Edinburgh, courtesy of Kenny Smith and Jennifer Culbertson

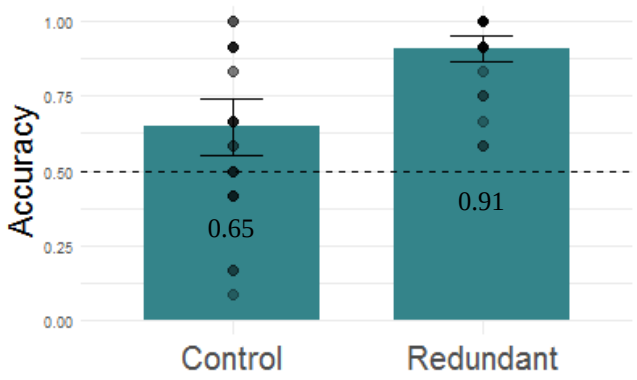

Figure 2: Accuracy scores by language condition. The dashed line indicates the chance level; error bars indicate confidence intervals; individual points indicate by-participant means.

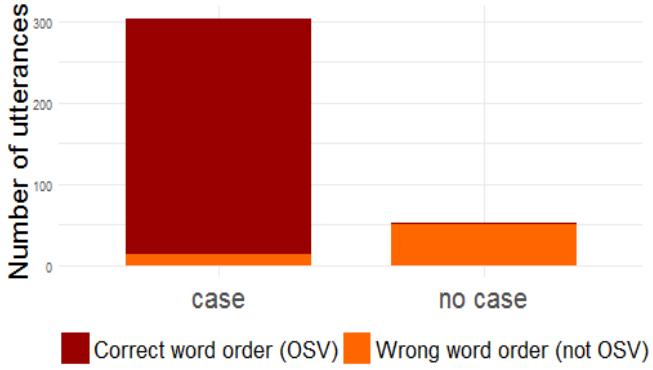

Figure 3: Production of correct word order (OSV) by production of case marking for children in the R-language condition.

did not stem from differential learning of the lexicon, both groups learned the nouns equally well (99% vs. 97%, t(58)=0.88, *p*=0.38).

Production

Children's productions were transcribed and coded for word order and vocabulary accuracy. Both measures were binary, and were scored by a research assistant blind to the condition and the experimental hypothesis. We used a mixed-effect logistic regression model to examine the effect of language condition on these production measures. The dependent variable was word-order accuracy on each trial (as a binary variable). The model included fixed effects for condition (R-language vs. C-language, effect coded), age and trial number as centered continuous factors, and random intercepts for participants. We found no significant difference in word order accuracy between the two conditions, although the trend was in favor of the R-language (82% vs. 69%, β=0.42, SE=0.86, *p*>0.6). We used the exact same model with lexical errors as the predicted variable and found no effect of condition here as well (0.1% vs. 0.07%, β=0.2, SE=0.18, *p*>0.2). Production did not seem to be facilitated in the R-language condition.

To further look at the possible facilitative effect of the redundant case marking, we looked only at the productions of children in the R-language condition (since only learners of the R-language had the potential to use both cues in production). We noticed several interesting patterns. First, children produced case marking in the majority of their productions (M=85%, SD=35%), indicating that they treated the cue as an inherent part of the system, despite its redundancy and the additional effort involved in producing it. Second, children produced the correct word order in most of the sentences (M=82%, SD=32%), indicating they managed to learn the non-Hebrew order. Interestingly, word order accuracy was impacted by the production of case marking: word order was more accurate when case marking was produced (291 correct utterances vs. 13 incorrect utterances) and was less accurate when it was not produced (only 1 correct utterance vs. 51 incorrect ones). To quantify this effect, we ran an additional model in which word-order accuracy on each trial was the dependent variable. The model included fixed effects for case marking on each trial (presence or absence, effect coded), age and trial number as centered continuous factors, and random intercepts for participants (see Table 2 for full model). In line with our hypothesis, case-marking had a significant effect on word order accuracy β=10.35, SE=2.7, *p*=0.0001, Figure 3).

Finally, we looked at participants' responses in the forced-choice part to sentences with and without case marking (note that only participants that learned the R-language had this additional part). Participants generally preferred the sentences with the case marking (M=88%, SD=19%), indicating, again, that they noticed the cue and learned it as part of their language.

Table 2: regression model for production scores in the R-language condition

	Estimate	**Std. Error**	**z -value**	**p-value**
(Intercept)	0.0826	1.8311	0.045	0.964019
Case	10.3504	2.7000	3.833	**0.0001 *****
Age	0.8787	2.5566	0.344	0.731079
Trial number	1.0889	0.7204	1.512	0.130652

Discussion

The presence of redundancy in languages is puzzling: if speakers are driven by a bias for efficient communication (Aylett & Turk, 2004; Cohen Priva, 2015; Jaeger, 2010; Kurumada & Jaeger, 2015; Levy & Jaeger, 2007), why do languages use more than one cue to convey the same information? Our study set out to test the prediction that redundant marking could be facilitative in learning circumstances. Our results show that having a redundant morpheme facilitates children's learning of thematic assignments. Although the R-language was more complex than the C-language, since it contained an additional cue to attend to and learn, children learned a non-native like word order better in this condition. The redundant morpheme benefited not only comprehension, but also production of the correct word order: despite the additional effort involved in producing it, word order was more accurate when case marking was produced. Taken together, these findings suggest that redundancy can be functional in learning circumstances. This is in line with previous work on the effect of learning from multiple cues (Monaghan, 2017; Sloutsky & Robinson, 2013; Yoshida & Smith, 2011). It further suggests that redundant cues can help language learning even when these cues need to be learned themselves.

These findings are of relevance for a recent influential proposal about the impact of different kinds of learners on the morphological complexity of a language. The Linguistic Niche hypothesis (Lupyan & Dale, 2010) proposes a causal link between the proportion of L2 speakers in a community and the degree of morphological complexity of the language. The prediction is that languages with more L2 speakers will have less complex morphology, a prediction that is supported by a large-scale study of over 2000 languages. Importantly, the proposed mechanism rests on the assumption that children and adults differ in the impact of redundancy on learning: whereas child learners benefit from redundant cues (leading to their existence in language), adult learners do not (leading to their simplification). While intuitively appealing, there is no direct evidence that children and adults differ in their response to redundant cues in learning. Building on the current findings, we are currently running a version of this study on adults to see if they indeed differ from children in the impact of redundant cues on learning. The Linguistic Niche hypothesis predicts that adult learning should be less facilitated by redundant cues. On the other hand, adult learners benefit from repetition (e.g., Jensen & Vinther, 2003; Onnis, Waterfall, & Edelman, 2008), and therefore may benefit from redundant cues as well.

Our findings document an effect of morpho-syntactic redundancy on learning, but they need to be extended in several ways. First, children in the R-language were exposed to the redundant morphome in both exposure and test. We are currently running additional versions of the study to better understand the impact of the redundant cue on exposure/testing. Second, we want to know if similar faciliatitve effects can be found for other linguistic domains beyond the learning of thematic assigment. Finally, the current study did not examine the prediction that redundancy is found more when conversing with learners. In an additional line of work, we investigate whether learning interactions are in fact characterized by more redundant marking, and whether this, in combination with their facilitative role can give rise to patterns of redundant marking in language.

Finally, the current findings are informative for our understanding of how languages are shaped by different cognitive pressures. Although in many languages the input children hear contains multiple cues for thematic assignment (Dittmar et al., 2008; Ibbotson & Tomasello, 2009), different typological studies suggest languages tend to trade off between these cues. In particular, languages that rely on word order to encode thematic assignment often lack productive case marking (Blake, 2001; Koplenig, Meyer, Wolfer, & Mu, 2017; Siewierska, 1998). Furthermore, several historical studies document this trade-off overtime in some Latin languages (e.g., Old English, Marchand, 1951, though see Detges, 2009; Pintzuk, 2002 for challenges to this claim). Recent experimental work suggests that this trade-off reflects speakers' bias for efficient communication (Fedzechkina et al., 2016; Roberts & Fedzechkina, 2018): When participants learned a novel language with fixed word order and optional case marking, they tended to decrease the use of case marking relative to their input. On the surface, these findings seem to contrast with our own: learners reduced the use of a redundant morpheme. However, this highlights the differential impact various pressures can have on language. First, case marking was deterministic in our design (case marking in the R-language was present on 100% of the objects), therefore, it is likely that participants were trying to faithfully reproduce it (see discussion in Fedzechkina et al., 2016). More importantly, we saw facilitation in comprehension: the impact of communicative and learnability pressures may differ for production and comprehension (e.g., Harmon & Kapatsinski, 2017). While redundancy may facilitate comprehension, it is costly in production (Zipf, 1949). These competing pressures (ease of production vs. understanding) may be weighted differently depending on the conversational situation: learning circumstances (or conversing with learners) may benefit from redundancy while other situations will not, leading to the observed trade-off between case-marking and word order seen in languages.

In sum, we have shown that children learn thematic assignment better from a language that has both word order and case marking, despite having to learn an additional morpheme. The present study serves as an important first step for understanding the functionality of having both cues.

References

Aylett, M., & Turk, A. (2004). The Smooth Signal Hypothesis: A functional explanation for relationships between redundancy, prosodic prominence, and duration

in spontaneous speech. *Language and Speech*, *47*(1), 31–56.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing : Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. Journal of Statistical Software, 67,1–48.

Bates, E., & Macwhinney, B. (1989). Functionalism and the Competition Model. In B. Macwhinney & E. Bates (Eds.), The crosslinguistic study of sentence processing (pp. 3–76). New York: Cambridge University Press.

Bates, E., McNew, S., MacWhinney, B., Devescovi, A., & Smith, S. (1982). Functional constraints on sentence processing: A cross-linguistic study. Cognition, 11(3), 245–299.

Blake, B. J. (2001). *Case*. Cambridge: Cambridge University Press.

Caballero, G., & Harris, A. C. (2012). A working typology of multiple exponence. In F. Kiefer, M. Ladányi, & P. Siptár (Eds.), *Current issues in morphological theory: (Ir)regularity, analogy and frequency. Selected papers from the 14th International Morphology Meeting, Budapest* (pp. 163–188). Amsterdam: John Benjamins Publishing.

Caballero, G., & Kapatsinski, V. (2015). Perceptual functionality of morphological redundancy in Choguita Rarámuri (Tarahumara). *Language, Cognition and Neuroscience*, *30*(9), 1134–1143.

Chan, A., Lieven, E., & Tomasello, M. (2009). Children's understanding of the agent-patient relations in the transitive construction: Cross-linguistic comparisons between Cantonese, German, and English. *Cognitive Linguistics*, *20*(2), 267–300.

Cohen Priva, U. (2015). Informativity affects consonant duration and deletion rates. *Laboratory Phonology*, *6*(2), 243–278.

Detges, U. (2009). How useful is case morphology? The loss of the Old French two-case system within a theory of preferred argument structure. In J. Barðdal & S. Chelliah (Eds.), *The role of semantic, pragmatic, and discourse factors in the development of case* (pp. 93–120). Amsterdam: John Benjamins Publishing.

Dittmar, M., Abbot-Smith, K., Lieven, E., & Tomasello, M. (2008). German Children's Comprehension of Word Order and Case Marking in Causative Sentences. *Child Development*, *79*(4), 1152–1167.

Fedzechkina, M., Newport, E. L., & Jaeger, T. F. (2016). Balancing Effort and Information Transmission During Language Acquisition: Evidence From Word Order and Case Marking. *Cognitive Science*, (March), 1–31.

Frank, A. F., & Jaeger, T. F. (2008). Speaking Rationally : Uniform Information Density as an Optimal Strategy for Language Production. *The 30th Annual Meeting of the Cognitive Science Society (CogSci08)*, 939--944.

Gibson, E., Bergen, L., & Piantadosi, S. T. (2013). Rational integration of noisy evidence and prior semantic expectations in sentence interpretation. *Proceedings of the National Academy of Sciences*, *110*, 8051–8056.

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.

Givón, T. (1991). Markedness in Grammar : Distributional , Communicative and Cognitive Correlates of Syntactic Structure. *Studies in Language*, *15*(2), 335–370.

Harmon, Z., & Kapatsinski, V. (2017). Putting old tools to novel uses: The role of form accessibility in semantic extension. *Cognitive Psychology*, *98*, 22–44.

Harris, A. C. (2017). *Multiple Exponence*. New York: Oxford University Press.

Haspelmath, M. (2008). Frequency vs . iconicity in explaining grammatical asymmetries. *Cognitive Linguistics*, (19), 1–33.

Ibbotson, P., & Tomasello, M. (2009). Prototype constructions in early language acquisition. *Language and Cognition*, *1*, 59–85.

Jaeger, T. F. (2010). Redundancy and reduction : Speakers manage syntactic information density. *Cognitive Psychology*, *61*(1), 23–62.

Jaeger, T. F. (2013). Production preferences cannot be understood without reference to communication. *Frontiers in Psychology*, *4*(April), 1–4.

Jaeger, T. F., & Buz, E. (2017). Signal Reduction and Linguistic Encoding. In E. Fernández & H. Cairns (Eds.), *The Handbook of Psycholinguistics* (pp. 38–81). Hoboken: John Wiley & Sons.

Jäger, G. (2007). Evolutionary Game Theory and Typology: A Case Study. *Language*, *83*(1), 74–109.

Jensen, E. D., & Vinther, T. (2003). Exact Repetition as Input Enhancement in Second Language Acquisition. *Language Learning*, *53*(3), 373–428.

Koplenig, A., Meyer, P., Wolfer, S., & Mu, C. (2017). The statistical trade-off between word order and word structure – Large-scale evidence for the principle of least effort. *PLoS ONE*, *12(3)*.

Kurumada, C., & Jaeger, T. F. (2015). Communicative efficiency in language production : Optional case-marking in Japanese. *Journal of Memory and Language*, *83*, 152–178.

Lee, H., & Kim, N. (2012). Non-Canonical Word Order and Subject-Object Asymmetry in Korean Case Ellipsis. In *Proceedings of the 19th International Conference on Head-Driven Phrase Structure Grammar Chungnam* (pp. 427–442).

Levy, R., & Jaeger, T. F. (2007). Speakers optimize information density through syntactic reduction. In B. Schlökopf, J. Platt, & T. Hoffman (Eds.), *Advances in neural information processing systems (NIPS) 19* (pp. 849–856). Cambridge: MIT Press.

Lupyan, G., & Dale, R. (2010). Language Structure Is Partly Determined by Social Structure. *PLoS ONE*, *5*(1).

MacWhinney, B. (1987). The Competition Model. In B.

MacWhinney (Ed.), Mechanisms of language acquisition (pp. 249–308). Hillsdale, NJ: Lawrence Erlbaum.

Marchand, H. (1951). The syntactical change from inflectional to word order system and some effects of this change on the relation verb-object in English. *Anglia*, *70*, 70–89.

Matsuo, A., Kita, S., Shinya, Y., Wood, G. C., & Naigles, L. (2012). Japanese two-year-olds use morphosyntax to learn novel verb meanings. *Journal of Child Language*, *39*(3), 637–663.

Monaghan, P. (2017). Canalization of Language Structure From Environmental Constraints : A Computational Model of Word Learning From Multiple Cues. *Topics in Cognitive Science*, *9*, 21–34.

O'Shannessy, C. (2010). Competition between word order and case-marking in interpreting grammatical relations : a case study in multilingual acquisition, *38*(2011), 763–792.

Onnis, L., Waterfall, H. R., & Edelman, S. (2008). Learn locally , act globally : Learning language from variation set cues. *Cognition*, *109*(3), 423–430.

Piantadosi, S. T., Tily, H., & Gibson, E. (2012). The communicative function of ambiguity in language. *Cognition*, *122*(3), 280–291.

Pintzuk, S. (2002). Morphological case and word order in Old English. *Language Sciences*, *24*, 381–395.

Roberts, G., & Fedzechkina, M. (2018). Social biases modulate the loss of redundant forms in the cultural evolution of language. *Cognition*, *171*, 194–201.

Siewierska, A. (1998). Variation in major constituent order : a global and a European perspective *. In A. Siewierska (Ed.), *Constituent Order in the Languages of Europe* (pp. 475–552). Berlin: Mouton De Gruyter.

Sloutsky, V. M., & Robinson, C. W. (2013). Redundancy Matters: Flexible Learning of Multiple Contingencies in Infants. *Cognition*, *126*(2), 156–164.

Yoshida, H., & Smith, L. B. (2011). Linguistic Cues Enhance the Linguistic Cues of Perceptual Learning. *Psychological Science*, *16*(2), 90–95.

Zipf, G. K. (1949). *Human behavior and the principle of least effort: An introduction to human ecology*. Cambridge: Addison-Wesley Press.