On the Universality of Cognitive Biases in Natural Language: The Case of Noun Phrase Internal Ordersing

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Abstract

The present study experimentally investigates the order of NP-internal modifiers in gesture modality as practiced by Turkish speaking participants in an attempt to understand the natural order within NPs cross linguistically, whether the participants' preferences reflect a homomorphism bias, and whether their preferences are influenced by their native language. For these purposes, Turkish-speaking participants (N=44) randomly assigned to two conditions where access to their native language was suppressed in the first block (suppression-first condition) or where access to their native language was suppressed in the second block (no-suppression-first condition). Under both conditions, the participants were asked to improvise gestures to describe visuals showing geometric shape clusters varying in distance, number and features. Results of the experiment indicate that the majority of gesture strings produced by Turkish speaking participants is homomorphic and the mostly preferred NP internal order is Dem<Num<N<Adj which implies that the NP internal order preferences of Turkish speaking participants are not directly influenced by the surface structure of NP order in spoken Turkish.

Keywords: Gesture; homomorphism bias; native language; NP internal order; surface structure of NP; suppression

INTRODUCTION

Typological studies on natural languages reveal some remarkable and striking similarities hidden in linguistic diversity. One of the main issues discussed in the field of linguistics for many years is whether certain commonly observed structures in the world's languages reflect some of the universal features of human cognition. Traces of the fact that languages have universal features despite their apparent diversity have been displayed, among many others, through noun phrase constructions (henceforth, NPs). NPs are constituents in a language which in its simplest form contain a noun (NP → N), although they can in principle be more complex with the addition of a determiner as in "a/the/that/these cat(s)" (NP → Det N), an adjective as in "black cat" (NP → A N), or a numeral as in "three cats" (NP → Num N). All these modifiers may appear within a single NP as in English "those three black cats", which is represented by the structure NP → Det Num A N (see Carnie, 2012 for an introduction to the syntax of nouns phrases, and the discussion in Section 1.2 where in more recent literature the NPinternal structure is argued to be strictly hierarchical). Both common and idiosyncratic properties of the structure of NPs in languages beyond English have been a prolific domain of syntactic studies focusing on typology (cf. REFS). Furthermore, the study of these constructions has also become a field of intense empirical investigation in an attempt to have an understanding of what kind of clues noun phrase internal ordering might potentially yield about human cognition in general.

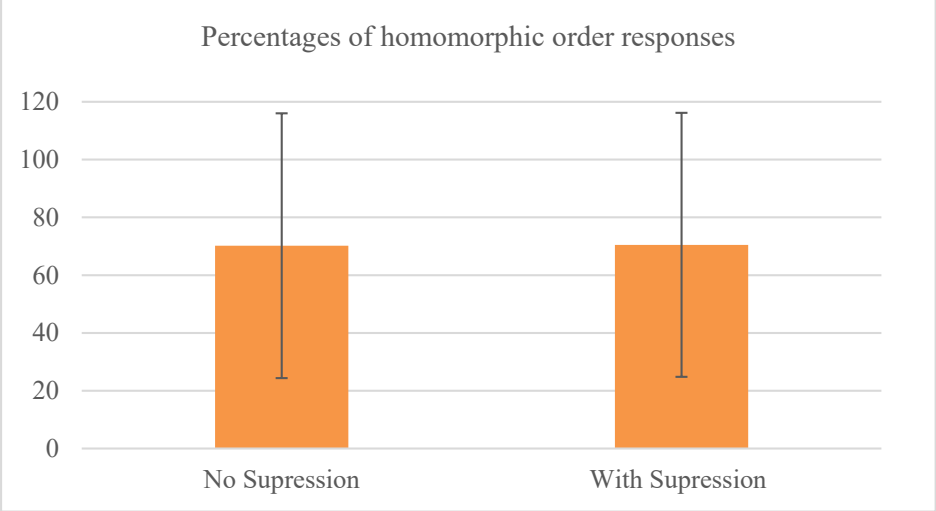
RESULTS

Participant responses were binary coded according to two possible output forms, whether the gesture order is homomorphic or not. When a gesture string was homomorphic, the string was coded as '1' and if not, as '0'. In total, six responses were removed before any further analysis: three of them were discarded because the participants' video recordings were difficult to interpret and code due to an Internet connection problem while the other three responses were left out because of an application error. This resulted in a total of 0.85% responses being removed from the whole data set. The remaining data were then analyzed by using R (R Development Core Team, 2017).

A number of statistical analyses were performed on the data. To examine the distributions, means and standard deviations, descriptive statistics were used. To analyze the data, a generalized linear mixed-effects regression model (binomial family, with the bobyqa optimizer) was fitted to the participants' data with crossed random effects by participant and item (Baayen et al., 2008). The model contained the item-level variable 'Condition' (No Suppression vs. With Suppression) as fixed effects. For the random-effect structure of the model, initially a model was constructed with random intercepts and slopes for all fixed effects and when this maximal model failed to converge, we gradually simplified the random-effect structure to reach the best model (Barr et al., 2013). We used the Akaike Information Criterion (AIC) for model comparison, which provides a measure that penalizes complexity and leads to predictors being kept only when they substantially contribute to explaining variance in the data (see Venables and Ripley, 2002). The model with the lower AIC value was selected and this procedure was repeated until the simplification process did not produce a model with a lower AIC. Sum-coded contrasts were employed for the factor Condition when checking for simple effects. The final version of the model included only by participant random slope for condition. The effect sizes are reported by using model coefficients in log odds (β), standard errors (*SE*), and *z*-statistics.

The first research question this study aims to answer is whether speakers of Turkish use homomorphic gesture order when they need to improvise gestural communication for noun phrases. In line with the findings of the original study of Culbertson et al. (2020), the gesture strings produced by the Turkish-speaking participants of the present study were also homomorphic. As shown in Figure 6, however, the percentage of homomorphic gesture strings under the no-suppression condition was 70.2%, while it was 70.5% under the suppression condition. (no-suppression; $M = 70.2 \pm 45.8$ *;* with-suppression; $M = 70.5 \pm 45.7$)

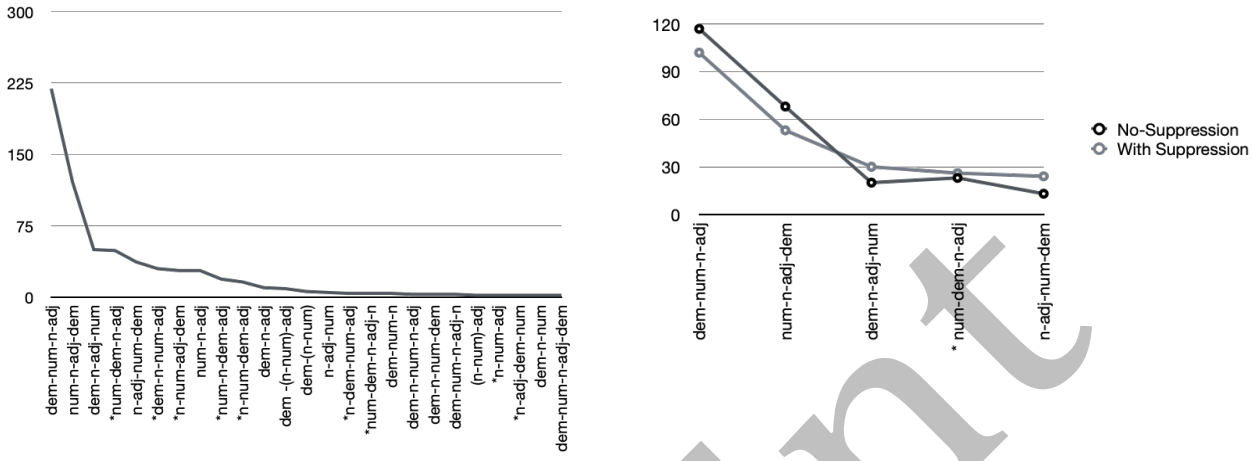
Figure 6



Another research question this study attempts to answer is what the natural order of units in a noun phrase is when it is non-verbally represented. The raw frequency of gesture orders preferred by the Turkish speaking participants is shown in Figure 7 and 8 below. An analysis of the frequencies reveals that **Dem<Num<N<Adj** is the natural order of NP in gestural communication: out of 350 gesture responses, 219 were in this order. The mostly attested order was **Dem<Num<N<Adj** was also found in the original study by Culbertson et al. (2020). However, speakers of Turkish in the present study and the speakers of English in Culbertson et al.'s (2020) study differ in terms of the second mostly attested order. While in the original study **Dem<N<Adj<Num** was identified as the second mostly attested order, in the current study the participants opted for **Num<N<Adj<Dem** as the second most popular order (See 7B). Though they are not identical, the fact that both sequences are homomorphic is worth considering. Also note that the most popular NP-internal order attested in both the original and the current study (i.e., Dem<Num<N<Adj) do not reflect the basic NP-internal order of spoken Turkish and English, which is **Dem<Num<Adj<N**.

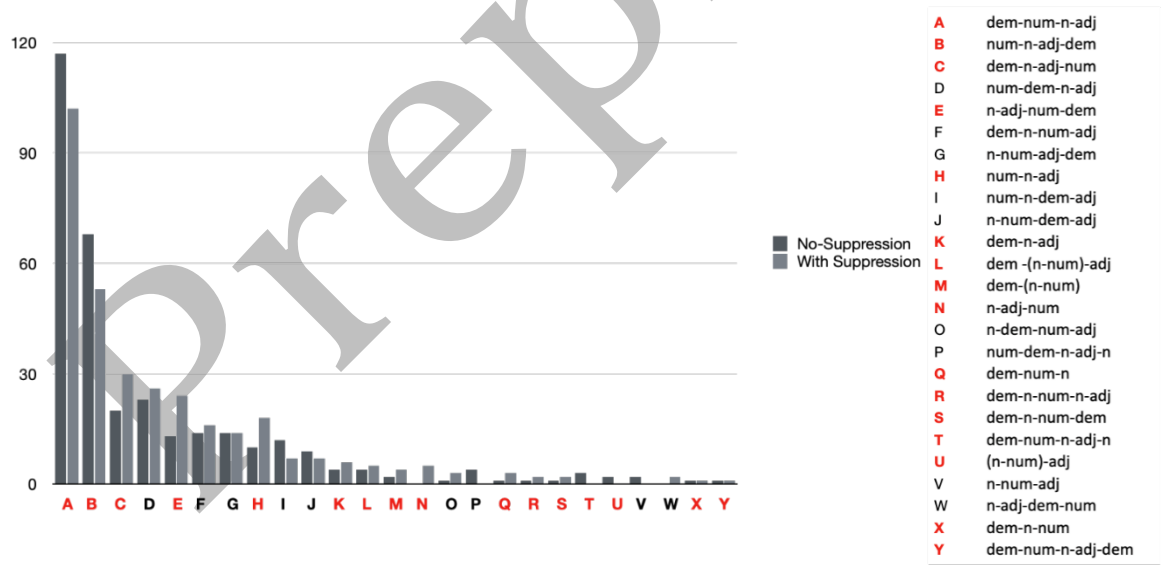
Figure 7

AB



Note. (A) The frequency of gesture orders preferred by the Turkish-speaking participants (B) Comparison of the most frequent gesture orders by the Turkish speakers under no-suppression and with-suppression conditions. In both figures, orders preceded by stars are non-homomorphic.

Figure 8



*Note.*The comparison of raw frequencies of gesture orders produced by the Turkish-speaking participants under no-suppression and with-suppression conditions. Homomorphic orders are indicated by red letter codes; black letter codes are for non-homomorphic orders. All gesture orders produced by the participants in the study (x-axis), the number of times an order produced by the participants (y-axis). The majority of orders under both conditions were homomorphic; however, the basic NP order in Turkish (Dem-Num-Adj-N) was not produced by any of the participants.

Another question that the participants were asked in the beginning of the study concerned the issue of whether the non-verbal communication of the NP-internal order is susceptible to the language a person speaks. In order to address this question, we suggested integrating a suppression condition to the original design of the experiment laid out in Culbertson et al.'s (2020) study as an extension. The goal of invoking suppression on some participants was to see whether suppressing speakers' (conscious) access to their knowledge of native language would have any impact on the NP-internal orders they would produce. The results of the statistical analysis indicated no significant effect of the suppression condition on the responses of the participants (no-suppression; M= 72.7±44.7; with-suppression; M=63.4±48.2; p = 0.478). The implication of this finding is that speakers who were subjected to the suppressing/shadowing condition (With Suppression Group) displayed a production behavior quite similar to those speakers who were not subjected to the suppressing/shadowing condition (No Suppression Group). In other words, the two groups did not have a major difference in terms of accessing or not accessing to the knowledge of their native language, which was revealed by the observation that their performance in producing (non-) homomorphic gesture orders did not differentiate dramatically.

DISCUSSION

Typological and empirical studies conducted on the NP internal order have indicated some tendencies in noun phrase constructions since some orders are noticeably more frequent than others. What these preferences might tell us about human cognition in general will be discussed briefly in this section.

One of the research questions this thesis attempts to answer is whether the speakers of Turkish, a language with homomorphic prenominal NP order, produce homomorphic gesture strings if they are to improvise gestural communication for NPs. The hypothesis we have proposed predicts that speakers of Turkish will produce homomorphic gestural counterparts of NPs. The analysis of data supports our hypothesis: the data from our empirical study suggests that the majority of the gesture strings produced by the Turkish speaking participants was homomorphic regardless of the condition (suppression or no-suppression). Under the no-suppression condition where the participants had no hindrance to resort to (the knowledge of) their native language, the percentage of homomorphic gesture strings was 70.2% while under the suppression condition, the percentage was only very slightly higher with 70.5%. The results suggest that speakers of Turkish have a clear tendency to improvise gestures expressing homomorphic NP orders.

Typological studies focusing on spoken languages indicate that homomorphic orders of NP, which are possible to recover from the underlying hierarchical structure indicated in Figure 2 are more commonly attested in the existing languages of the world when compared to non-homomorphic orders. In line with the typological tendencies in spoken languages, we have found evidence for the Turkish speaking participants to have a robust preference for homomorphic orders of NP when they need to improvise gesture for communicative purposes as four of the top five mostly preferred NP-internal orders being homomorphic as shown in Figure 7 in Results Section (e.g., **Dem<Num<N<Adj**, **Num<N<Adj<Dem**, **Dem<N<Adj<Num**, and **N<Adj<Num<Dem**). In all these orders, the linear proximity of the modifiers to the noun is generally considered to be the indication of the semantic closeness of the modifier to the noun. The results of the gesture experiment in Culbertson et al. (2020) are quite similar to the present study although the proportion of homomorphic gesture responses from the participants in the former study is higher (98%

vs. ~70%, respectively). This difference might be explained by the number of participants; responses from 16 participants were included in the original study by Culbertson et al. (2020), whereas in our study responses collected from 44 participants were analyzed. In both studies, participants' strong preference for homomorphic gesture strings, regardless of their native language, might indicate a cognitive bias. It is clearly not possible, however, to argue that this is a consequence of the fact that the participants' languages both involve prenominal orders of modifiers (i.e., Dem<Num<Adj<N). This is particularly not a reasonable conclusion in light of the findings from both Culbertson et al. (2020) and the present study that the most popular homomorphic orders in gestural communication experiments are not identical to the canonical NP-internal orders in the native languages (English and Turkish, respectively) of the participants. It may be reasonable, however, to conjecture that native speakers of a language with homomorphic NP-internal order relies on the knowledge of the hierarchical structure stated in Figure 2/Figure 3, and this allows (perhaps, forces) them to produce homomorphic orders regardless of whether it is the spoken language or a gestural communication system. As a matter of fact, the suppression condition in the present study was intended to prevent native speakers from appealing to the knowledge of their native language, it turned out however that native speakers of Turkish did not produce at all in the experiment orders that correspond to the NP-internal order of spoken Turkish (i.e., Dem<Num<A<N is missing from the set of orders produced). Crucially, this was also true of those participants who participated in the experiment under the no-suppression condition. In light of these findings we find it reasonable to argue for the validity of one of the following conclusions: (i) the issue of "access to the knowledge of (their native) language" was just not relevant in contrast to what the present study anticipated (as stated through the implementation of the suppression – no-suppression contrast) because the experiment involved a gestural communication task, and being so it just did not tap on such knowledge, or (ii) although the suppression/shadowing task had an impact on preventing participants appealing to their knowledge of language consciously, it was not strong enough a 'barrier' to prevent native speakers' unconscious access to their knowledge of language; in other words, no matter how one tries to suppress one's access to knowledge of language, one can only prevent one's access to explicit processes of production (and perhaps also comprehension) behavior, but blocking access to unconscious

knowledge of language is just not possible. We must admit that there is at this point not much unequivocal evidence supporting either of the alternatives mentioned here. Nevertheless, we would like to discuss each alternative briefly. We will then turn to the question of whether any of the findings of the present study can be used as evidence for either of the alternatives.

If it is the first alternative that we assume to be providing an account for the observed facts, then we are basically taking it for granted that the homomorphism bias is not a consequence of native speakers' linguistic knowledge (i.e., U(niversal) G(rammar) in the sense of Chomsky 1965, 1986, 1995, a.o.), and it follows from the "world" as Culbertson et al. (2020) conjectures. To be more explicit, since the task was not a verbal (linguistic) one but more of a verbally mediated non-verbal task ('silent gesture paradigm' as called by Culbertson et al., 2020), there may be reasons to not expect for native speakers' linguistic knowledge to come into play. The observed homomorphism bias must then be accounted for as a consequence of the way the world is perceived and articulated by humans; Culbertson et al. (2020, 699) suggest "…thatobjects are more closely associated with their properties than with their numerosities; objects and their numerosities are in turn more closely associated than objects and their location and/or relation to the speaker. *These nested conceptual representations* (*which are not linguistic in nature)* [italics mine, SA], combined with the linguistic categories Noun, Adjective, Numeral, and Demonstrative, form the basis of the hierarchy from which noun phrase linear order is derived." And crucially, they argue on the basis of an information-theoretic measure of strength of association that the NP-internal order may in principle be learnable from observing the world, and it need not depend on innate knowledge of language as suggested in work by Noam Chomsky and others.[1]

[1]Culbertson et al. (2020) defend their position strongly though not without caveats. They say that "[T]he skewed distribution of orders across languages may thus come from a pressure to be homomorphic combined with a universal hierarchical structure derived (in part) from properties of the world around us." Notice the phrase "in part" in parentheses in this quote; the implication is that it is still safer to leave room for mind-internal, and possibly languages-specific, factors to be a factor in the explanation.

If it is the second alternative that we keep to in providing an account for the observed facts, then we would have to assume that native speakers' tacit/innate knowledge of language is what they depend on no matter whether it is a verbal or a non-verbal task. If true, then the lack of any significant difference between the two groups (i.e., suppression and no-suppression) can possibly be interpreted as indicating that access to linguistic knowledge is just simply impossible to block; it is so deeply rooted that native speakers cannot escape it. This would further imply that the manipulation of the variable "suppression" was in principle futile.

We now turn to addressing the question of whether any of the findings of the present study can be argued to provide support for either of the alternatives. It should be noted at the outset that most findings can in principle be argued to support either approach, so in this respect it is hard to come by evidence that clearly teases the two approaches apart. Thus, we will assume here a weaker position in discussing the findings. Nevertheless, we think that at least a minority findings can be argued to favor one of the approaches over the other.

For one thing, we find it quite striking that 4 of the 5 most frequently gestured orders in our study are homomorphic, and they correspond to the first 4 of the 5 most frequently found NP-internal orders in spoken languages reported in the typological study of Dryer (2018) (cf. Table 1, where red-painted orders indicate those that are homomorphic).

Table 1

Rankings of NP Orders in Typology and Gesture Study

Rank	Dryer 2018	Our Study
1	**N-A-Num-Dem**	**Dem-Num-N-A**
2	**Dem-Num-A-N**	**Num-N-A-Dem**
3	**Num-N-A-Dem**	**Dem-N-A-Num**
4	**Dem-N-A-Num**	Num-Dem-N-A
5	**Dem-Num-N-A**	**N-A-Num-Dem**
6	N-A-Dem-Num	Dem-N-Num-A
7	N-Dem-A-Num	N-Num-A-Dem
8	**Dem-A-N-Num**	**num-n-adj**
9	Dem-N-Num-A	Num-N-Dem-A
10	N-Num-A-Dem	N-Num-Dem-A
11	N-Dem-Num-A	**Dem-N-Adj**
12	**Num-A-N-Dem**	**Dem-(N-Num)-A**
13	**A-N-Num-Dem**	**Dem-(N-Num)**
14	Num-N-Dem-A	**N-Adj-Num**
15	A-N-Dem-Num	N-Dem-Num-A
16	Dem-A-Num-N	Num-D-N-A-N
17	Num-Dem-A-N	**Dem-Num-N**
18	N-Num-Dem-A	**Dem-N-Num-N-A**
19	A-Num-Dem-N	**Dem-N-Num-Dem**
20	A-Dem-Num-N	**Dem-Num-N-A-N**
21	Num-A-Dem-N	**(N-Num)-A**
22	Num-Dem-N-A	N-Num-A
23	A-Dem-N-Num	N-A-Dem-Num
24	A-Num-N-Dem	**Dem-N-Num**
		Dem-Num-N-A-Dem

It is also quite striking a fact that the second most frequent order in Dryer's (2018) corpus, namely **Dem<Num<A<N**, is completely missing in the gesture orders produced by the participants of the present study, despite the fact that **Dem<Num<A<N** is the predominant order in spoken Turkish. Though, somewhat surprisingly perhaps, our participants did not rely on the NP-internal order of their native language in their improvisation of the gestures,

the top 5 of their production involved more homomorphic strings than non-homomorphic ones as Table 1 shows above. While the former fact may suggest that the nature of the task (silent gesture paradigm) forced participants to stay away from their linguistic knowledge (knowledge of native language, in particular), the latter may be interpreted as indicating that the nature of the task did not play a critical role in preventing them relying on linguistic knowledge. One may object that this latter can also be accounted for under Culbertson et al.'s (2020) approach assuming that homomorphic orders are also favored in their framework, though for different reasons from Chomsky's. True, but we would like to emphasize here the fact that 4 of the top 5 gesture orders produced correspond to the 4 of the top 5 of Dryer's (2018) spoken language corpus. That match in frequencies between gesture orders attested in the present study and those of spoken languages is somewhat unexpected given the fact that participants were prompted to use gestures to explain a given scene. There are *at least* 24 different ways to put each relevant item in the scene into gesture orders.[2] Why, of the 24 possible orders, did participants opt for 4 of those that are most frequent in spoken languages? We leave this question open just pointing out to the fact that no such similarity with spoken languages is warranted in a silent gesture experiment, but this is what we observe.

Another observation worth discussing here concerns the most attested of the gesture orders, namely **Dem<Num<N<Adj**. Recall that this is also the most attested gesture order of NPs in the Culbertson et al. (2020) study, which also involved a silent gesture paradigm. First of all, this order does not fully reflect the order of NPs in either Turkish or English, which are the native languages of the participants in both studies, and both languages display **Dem<Num<Adj<N** order within NPs. One wonders why both speakers of Turkish and English dominantly produced the order **Dem<Num<N<Adj** in a gesture experiment. Thinking that gestures form the bases of sign languages, we decided to see if sign languages might have anything to suggest in this matter. In a sense, we explore whether modality

[2]We say "at least" in the main text because, in the gesture paradigm experiments, participants may go beyond logically possible 24 orders by omitting items or by multiplying them. For example, there were cases in the data set where "N and Num" appear as a single gesture, which produce the order Dem<[N+Num]<A with actually three items.

might matter on how NP-internal order is organized. In a comparative study on NPs in signed and spoken languages Coons (2022) hypothesizes that the most common language patterns in spoken languages are also common in signed languages, and a comparison of data from the 41 signed languages and the data from spoken languages in the World Atlas of Language Structures (WALS) reveals similar NP order patterns. Regarding the NP structures of the signed languages included in the same study, **N<Adj** order (with 39%) is more commonly observed than **Adj<N** (with 24.4%), **Num-N** (with 41.7%) is preferred over **N<Num** (with 30.6%), and in one third of the signed languages (with 33.3%), signers primarily use **Dem<N** order. When these binary choices are extrapolated to anticipate NP-internal order from these data, we would arrive at two probable strings: **Dem<Num<N<Adj** or **Num<Dem<N<Adj**. The former order is homomorphic, and significantly the most preferred gesture order in both our study and that of Culbertson et al.'s (2020), while the latter order is non-homomorphic, it is also the fourth mostly preferred order in our study. Coons' (2022) findings on the NP-internal order in sign languages provides a perspective as to how to interpret the dominance of **Dem<Num<N<Adj** among our participants (and those of Culbertson et al.'s, 2020). Simply put, it is possible to conclude that it is a modality effect, although it is worth noting that sign languages are natural languages in all intents and purposes, and yet gestures improvised by non-signing participants in our study can in no way be equated with sign languages.

CONCLUSION

To conclude, this study has demonstrated that when prompted to improvise gestures in describing a scene, participants with Turkish as their native language, have dominantly produced gesture strings that are homomorphic, and thus replicated the findings reported in another study that used the silent gesture paradigm, namely Culbertson et al. (2020). Unlike Culbertson et al. (2020), the present study attempted to see whether suppressing native speakers' appeal to their knowledge of (native) language would make a difference in the results, but no significant results have been reached between groups whose production was suppressed and those no such suppression was applied. The overall results

could in principle be interpreted as what Culbertson et al. (2020) have suggested, namely that the homomorphism bias is one of a (domain) general cognitive tendency guided by humans' interaction with the world. Properties of objects that humans acquire by observing the world might be reflected in semantic scope relations which shape word orders in natural languages. As Culbertson et al. (2020) claims humans might be building semantic relations and might be creating conceptual representations by observing the world, resulting in hierarchical linguistic representations.

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