Do grammatical alignments have an effect on language processing?

Aitor Egurtzegi, Department of Comparative Linguistics

In the grammatical descriptions of the world's languages, one of the fundamental syntactic features is the morphosyntactic alignment of arguments, i.e. that different types of arguments of verbs — such as S (the sole arguments of intransitives), and A (agent) and P (patient) arguments of transitives — are treated alike by the grammar. For example, in nominative-accusative languages like German, S and A arguments are aligned with respect to case marking: they both receive nominative case, in contrast to the P argument that carries accusative case. Recent advances in the neuroscience of language have shown the neural correlates of other fundamental aspects of syntax, such as hierarchy [1] and constituent structure [2]. However, we don't know yet to what extent neural processes are sensitive to morphosyntactic alignment.

There is evidence about the similarities in processing for the S/A alignment in language comprehension experiments, where participants interpret semantic role-ambiguous NPs as agents, but never as patients. In this case, this can also be interpreted as the agent preference, which makes comprehenders interpret semantic role-ambiguous NPs as agents. For example, in a German sentence like [...] *dass Bertram Surferinnen gratuliert (hat | haben),* there is ambiguity between an A-P and P-A reading for the noun phrases *Bertram* and *Surferinnen* before the sentence-final auxiliary verb is encountered. Comprehenders treat *Bertram* as the agent, and if *Bertram* is a patient, then they have to reassign the roles: this reassignment effect can be seen in electrophysiological activity. Apart from German [3], previous work on language comprehension has shown that the agent preference is also found in various languages which are typologically diverse, such as Hindi [3], Chinese [4], Basque [5], or Turkish [6].

Nevertheless, it's unknown whether these processing strategies regarding alignment also hold for language production. Does alignment lead to costlier processing during sentence planning or grammatical encoding because of the competition between two constructions? Does this natural grouping of semantic roles into a single morphological case facilitate production or does it make it harder because the cases that are aligned need to be kept apart? The aforementioned comprehension effects show that the natural grouping between S and P is unfavorable in comprehension. On a different note, in this project we've shown that in Hindi, alignment has an effect on sentence production: when two initial structures are competing to be the chosen structure for the sentence because they're morphologically aligned (such as S and A competing in the early stages of sentence planning, with S being part of an SV structure and A part of an APV structure), there is more brain activity. Therefore, the following questions need to be answered:

1) Do these effects in language production show up because of a semantic role alignment that languages have? Is it due to an agent preference?

2) Can we tease apart the effects of the agent preference from the effects of grammatical alignment with sentence processing evidence?

For my research, I am using Basque as a test case. Basque has a full S/P alignment. Hence, in Basque, a transitive agent is never marked as S or P, but it carries an overt case marker specific for A.
Thus, S and P arguments take the same case marker (absolutive) (examples 1-2), and A argument takes the ergative case marker (example 2).

(1) atezain**a**	mugitu da	
the goalkeeper.ABS **(S)**	moved has	
(2) atezain**ak**	baloi**a**	harrapatu du
the goalkeeper.ERG **(A)**	the ball.ABS **(P)**	has caught

Basque is a good test case for this because the case alignment it has involves S/P and not S/A or the actions performers. Therefore, we can know if alignment plays a role in sentence planning or if it is the agent preference that is more relevant for sentence production.
In this talk, I will show experimental evidence from the production of Basque sentences in order to shed light on these questions. In particular, we are testing if the stronger brain activity comes from the competition between two underlying structures that are aligned. I will present a sentence production experiment on Swiss German and Basque, where I used eye tracking and EEG. Participants produced transitive and intransitive sentences by using ergative-marked Agents (Basque transitive), absolutive-marked Soles (Basque intransitive), or nominative-marked S/A (Swiss German transitives and intransitives).
For the eye tracking analysis, we look at differences in fixations towards the agent or the patient. Therefore, since we need to have more than one region of interest on the stimulus in order for participants to have more than one region to look at, only transitive events can be used [7]. Our eye tracking results show that both languages have equal fixation distributions for agents and patients in the early stages of sentence planning (200-800ms), after the gist of the stimulus has been processed, and before speech onset begins (figure 1). With these data we built two Bayesian hierarchical regression models [8], and show that the patterns of fixations to the agents in the pictures does not differ between Basque and Swiss German [9].
With the EEG recorded data, we are planning on running a within-language comparison between intransitive and transitive sentences. More specifically, we are looking at oscillatory neural activity in the Theta (4-8Hz) and Alpha (8-13Hz) bands. These bands are known for cognitive control [10] and for material retrieval and memory reactivation [11]. If there is more activity in Basque intransitive sentences compared to transitives, then we would argue that alignment plays an important role in sentence production. However, if there is less activity in intransitives than in transitives, we could argue that the agent preference is stronger than alignment in sentence production.

1. Ding N, Melloni L, Zhang H, Tian X, Poeppel D. Cortical tracking of hierarchical linguistic structures in connected speech. Nat Neurosci. 2016;19: 158–164.

2. Nelson MJ, El Karoui I, Giber K, Yang X, Cohen L, Koopman H, et al. Neurophysiological dynamics of phrase-structure building during sentence processing. Proc Natl Acad Sci U S A. 2017;114: E3669–E3678.

3. Bickel B, Witzlack-Makarevich A, Choudhary KK, Schlesewsky M, Bornkessel-Schlesewsky I. The neurophysiology of language processing shapes the evolution of grammar: evidence from case marking. PLoS One. 2015;10: e0132819.

4. Wang L, Schlesewsky M, Bickel B, Bornkessel-Schlesewsky I. Exploring the nature of the “subject”-preference: Evidence from the online comprehension of simple sentences in Mandarin Chinese [Internet]. Language and Cognitive Processes. 2009. pp. 1180–1226. doi:10.1080/01690960802159937

5. Erdocia K, Laka I, Mestres-Missé A, Rodriguez-Fornells A. Syntactic complexity and ambiguity resolution in a free word order language: behavioral and electrophysiological evidences from Basque. Brain Lang. 2009;109: 1–17.

6. Demiral SB, Schlesewsky M, Bornkessel-Schlesewsky I. On the universality of language comprehension strategies: evidence from Turkish. Cognition. 2008;106: 484–500.

7. Griffin ZM, Bock K. What the eyes say about speaking. Psychol Sci. 2000;11: 274–279.

8. Bürkner P-C. brms: An R Package for Bayesian Multilevel Models Using Stan [Internet]. Journal of Statistical Software. 2017. doi:10.18637/jss.v080.i01

9. Vehtari A, Gelman A, Gabry J. Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC [Internet]. Statistics and Computing. 2017. pp. 1413–1432. doi:10.1007/s11222-016-9696-4

10. Cohen MX, Donner TH. Midfrontal conflict-related theta-band power reflects neural oscillations that predict behavior. J Neurophysiol. 2013;110: 2752–2763.

11. Piai V, Roelofs A, Rommers J, Maris E. Beta oscillations reflect memory and motor aspects of spoken word production. Hum Brain Mapp. 2015;36: 2767–2780.