Investigating spatial processing of signs with modified palm orientation in German Sign Language (DGS) using eye-tracking

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Background. In signed languages, phonological parameters (handshape, palm orientation, location and movement) make up the smallest meaning-distinguishing elements. Palm orientations have often been disregarded in previous research since they render only a limited number of minimal pairs (Brentari, 2012). They do, however, become relevant when two signs are placed in relation to another. Objects are usually introduced via a noun phrase before they are established in signing space using classifier constructions (Perniss, 2007; Zwitserlood, 2012) which are highly iconic morphological elements that express events or states. This is achieved by mapping the object's form, location and/or orientation onto these iconic structures (Emmorey, 2002). Due to their inherent iconicity (Liddell, 2003), lexical signs like FENCE[1] in DGS (Fig. 1) do not require additional classifiers to be placed in signing space but use a modified palm orientation to indicate the relation. Still, a default palm orientation of these signs is described as lexically specified (Quer et al., 2017). In an eye-tracking study, we investigated whether palm orientation modification (Fig. 2) influenced the spatial processing of signs.

Method. We examined the eye movements of 14 Deaf signers (mean age: 33.5 years; 7 female) during a combined perception and selection task. The participants saw a video and two images, one of which they had to match to the video (picture selection via button press). The stimulus videos presented DGS utterances consisting of two signs with and without modified palm orientations. Utterances were either *double constellations*, i.e., containing the same referent twice such as FENCE-FENCE (Fig. 3), or *additional referent constructions*, i.e., a reference object, e.g., FENCE, and a moveable object, e.g., BALL (Fig. 4). Each stimulus set included four combinations of orientations comprised of the inherent palm orientations of the signs (lexically specified or modified) as well as the orientation of the signs towards each other.

Data. First, we analyzed the behavioral data by running linear mixed effects regressions with fixed effects for picture selection and palm orientation, and random effects for participants and stimulus set. The analysis revealed an interaction effect of picture selection and palm orientation (β = -.03; p < .05). Follow-up tests showed that participants matched images correctly more often when the signs presented two different palm orientations compared to those images with the same orientations. For additional referent constructions, the calculations showed a main effect for picture selection (β = -.02; p < .001). Follow-up tests demonstrated that the target image was selected significantly more often than the distractor image independent of the palm orientation modification. In the time course analysis, we examined the proportion of target looking (Fig. 5) using permutation-based analyses on divergences in the fixations between the two images to examine effects of palm orientation in the visual scene. For double constellations, no differences were detected for signs with the same palm orientation, but there was a significant difference in fixations when the palm orientations of the signs were facing different directions (p < .01). The analysis of additional referent constructions showed that the target image was fixated significantly more often than the distractor image when the lexicalized specified palm orientation of the reference object is used (p <.05).

Discussion. The participants successfully matched the object surfaces to the palm orientations, suggesting that palm orientation in DGS functions as an iconic indicator of spatial relations. Interestingly, signs presented in double constellations were matched correctly more frequently when the participants were presented with a sign combination consisting of a lexically specified and a modified palm orientation. We hypothesize that this might result from the more realistic depictions known from everyday life, where spaces are enclosed. When two different signs are set in relation to one another, i.e., additional referent constructions, they are matched more successfully when the reference object is presented with the lexically specified palm orientation, suggesting that the lexically specified palm orientation is easier to process. Our results demonstrate that palm orientation in such signs indeed seems to be lexically specified and that modifications of lexically specified palm orientations create a difference in the interpretation of spatial relations and thus influence spatial processing.

References. Brentari, D. (2012). Phonology. In R. Pfau, M. Steinbach & B. Woll (eds.), *Sign language: An international handbook* (pp. 21-54). Berlin: Mouton de Gruyter. **Emmorey, K. (2002).** *Language, Cognition and the Brain: Insights from Sign Language Research*. Mahwah, N.J.: Lawrence Erlbaum Associates. **Liddell, S.K. (2003).** *Grammar, Gesture, and Meaning in American Sign Language.* Cambridge: Cambridge University Press. **Perniss, P. (2007).** *Space and Iconicity in German Sign Language* (Dissertation). Radboud University Nijmegen, Nijmegen. **Quer, J., Cecchetto, C., Donati, C., Geraci, C., Kelepir, M., Pfau, R. & Steinbach, M. (2017).** *SignGram Blueprint. A Guide to Sign Language Grammar Writing.* Berlin/Boston: Mouton de Gruyter. **Zwitserlood, I. (2012).** Classifiers. In R. Pfau, M. Steinbach & B. Woll (eds.), *Sign language: An international handbook* (pp. 412-431). Berlin: Mouton de Gruyter.

Appendix.

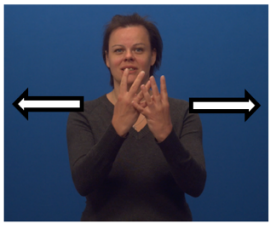

Fig. 1. FENCE in DGS

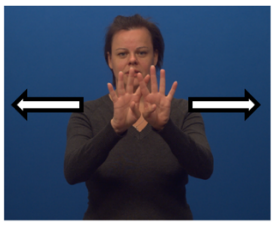

Fig. 2. FENCE in DGS with modified palm orientation away from the signer

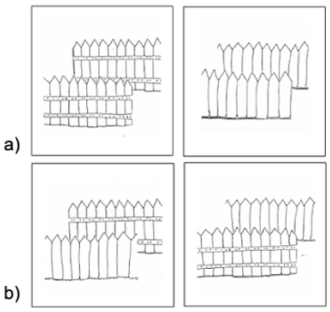

Fig. 3. FENCE presented in double constellations a) with the same orientation, i.e., both signs show the lexically specified or the modified palm orientation, and b) different orientations, i.e., a combination of lexically specified and modified palm orientation.

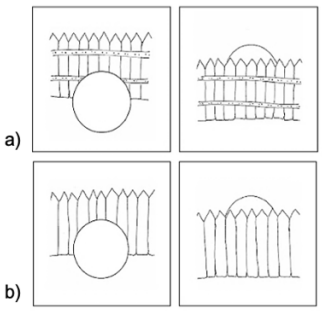

Fig. 4. FENCE presented in combination with an additional referent BALL. We distinguished between a) the lexically specified and b) modified palm orientations of the reference object FENCE.

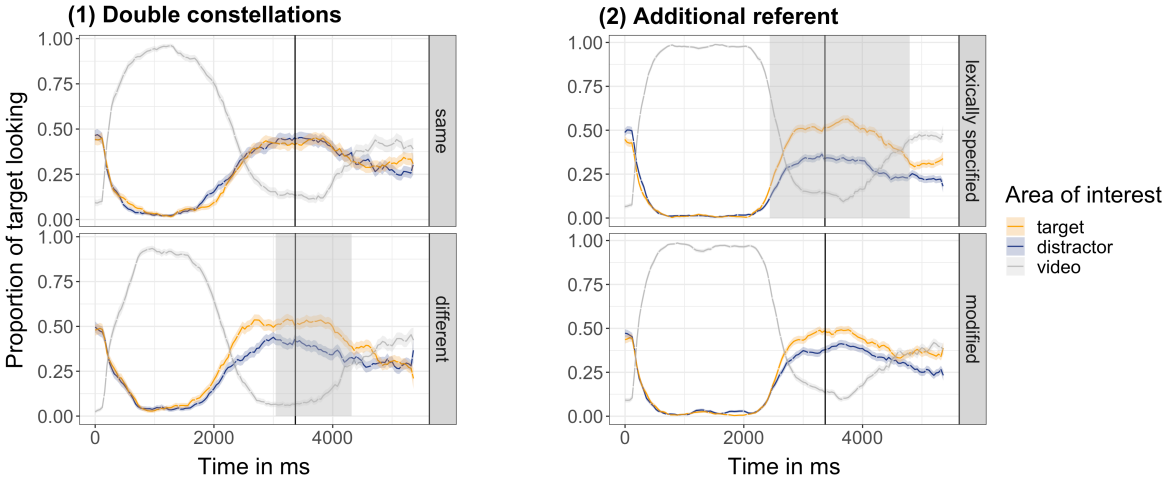

Fig. 5. Proportion of target looking across time for (1) Double constellations and (2) Additional referents. The views to the target (orange) and distractor (blue) image are shown as lines surrounded by shaded areas indicating standard error. The black bar indicates the end of the videos at 3371ms. The grey areas mark significant differences.

[1] Notational conventions: signs are glossed in small caps.