Using electromagnetic articulography in LSF: A new approach to sign language kinematics

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Introduction. Anticipatory coarticulation in spoken language underlines speakers' adaptation to the complex communication process by reducing or increasing articulatory effort. When unconstrained by the perceptual demands of the linguistic system, the speech motor system tends to minimize the physical costs leading to a higher overlap of articulatory movement patterns (H&H model [1]). Coarticulation has been found in sign language (SL) in terms of anticipatory movements in handshape and/or location (e.g., [2]–[4] for American Sign Language, ASL), but the coarticulatory strategies used remains unclear. We present the first kinematic study on coarticulation in sign production in French Sign Language (LSF) using 3D-Electromagnetic Articulography (EMA). We aim to provide evidence for anticipatory coarticulation patterns in handshape in one LSF signer in various hypo-/hyper-articulation conditions in the spatio-temporal dimensions. We suggest the interpretation of the observed variation as the result of different dynamical patterns of overlapping organization, triggered and constrained by the phonological structure.

Methods. For this novel approach, one native deaf signer of LSF was recorded with EMA and a time-synchronized video set-up. EMA sensors were placed on the head, torso, arms, and fingers. The task consisted of the production of phonological pairs of signs (= X1 and X2) composed of '1'- and/or '3'- handshapes varying in location (Table 1): 22 pairs were repeated 3 times (= 66 trials) in 4 conditions: normal and fast signing, whisper, and L2-directed speech. For the analysis, the kinematic end of X1 and beginning of X2 were annotated with ELAN [5] based on articulatory landmarks. To capture the extension/closing of fingers in target pairs, the 3D Euclidean distance between the thumb and the pinkie finger, its velocity and acceleration were measured. The SL data were analyzed in the framework of dynamical systems (Task Dynamics/Articulatory Phonology; e.g., [6,7]) that directly maps low-dimensional phonological information onto a high-dimensional space of continuous phonetic cues. This framework allows a quantitative assessment of coarticulatory variation in SL, such as reduction and deletion, that accounts for variation as induced by different speaking styles. Statistical analyses will be carried out by using linear mixed models.

Results. First, this study proves that the use of EMA is efficient in SL studies. Even though some adjustments are required to fit the visual-gestural modality (e.g., the signing space under the electro-magnetic field must be controlled), fine grained manual articulatory gestures can be measured with EMA. Second, in line with previous studies on ASL, our articulatory data show evidence of coarticulation with anticipatory movements of fingers extension before the end of X1 in several trials, including various signs in both '1-3' and '3-1' combinations (cf. example of normal signing in Figure 1). In signs with repetitive movements, the kinematic data allows to detect partial or full truncation of the movement as opposed to its complete repetition, which are not always visible on video. A detailed description of the productions in all conditions and a presentation of statistical results will be presented at the conference.

Discussion. Our current investigation demonstrates remarkable efficacy by facilitating precise kinematic measurements both temporally and spatially. The use of 3D EMA is a promising method to capture coarticulatory patterns of overlapping organization in the visual-gestural modality of SL. Within a dynamical framework adapted from TD/AP, we can model a variety of coarticulatory patterns in SL in a coherent way. This approach aims to provide a good alternative to other, more expensive and less affordable kinematic methods and to constitute a new foundation for the future of laboratory phonology in SL.

Table 1. List of signs to create target pairs ('1-3'/'3-1'; 18 pairs) and control pairs ('1-1'/'3-3'; 4 pairs) per location.

	'1'-handshape	'3'-handshape
forehead	GERMAN	ROOSTER
mouth	ORDER	BAR
neutral space	HAVE-TO	APARTMENT

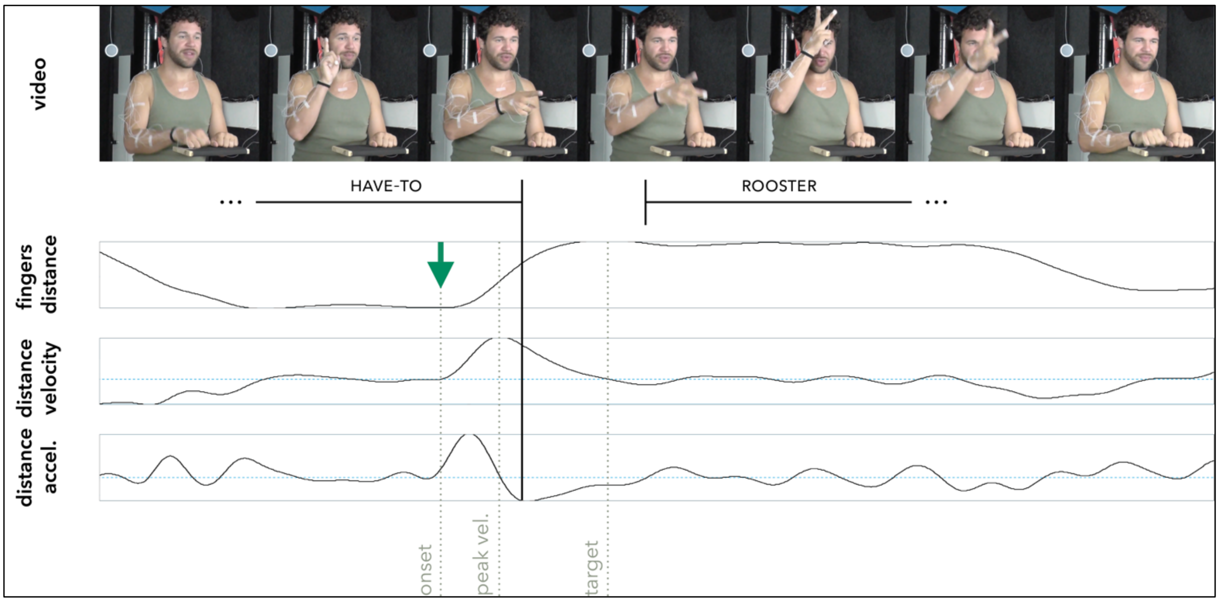

Figure 1. Example of coarticulation in the sequence HAVE-TO – ROOSTER ('1-3') in the normal condition. 3D Euclidean distance between the thumb and the pinkie finger, velocity and acceleration show that the *extension* onset (arrow) starts before the kinematic end of HAVE-TO (solid line), i.e. the articulation of the second handshape overlaps with the articulation of the first one *before* the end of the sign.

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