Presupposition and Motor Response: The Case of Factive Verbs

Motivation This paper investigates the cognitive underpinnings of presupposition processing by focusing on its sensori-motor correlates. The relationship between language processing and motor activation has received great attention within the field of neuropsychology (see for a review Willems & Cassanto 2011; Kiefer & Pulvermüller 2012). Hand and foot-related action terms activate corresponding areas of the motor cortex (e.g. Hauk et al. 2004; Aziz-Zadeh et al. 2006; Frak et al. 2010). However, language-induced motor activation is task- and context-dependent (e.g. Raposo et al. 2009; Willems & Francken 2012). In particular, an action word embedded in a negated sentence (*I do not push the* button) or in a volitional one (*Fiona wants to sign the contract*) makes the activation of the action representation decrease (Tettamanti et al. 2008; Aravena et al. 2012, 2014).This might indicate that motor response is weaker or absent whenever the action is not part of the representation of the current *event model* (Radvansky et Zacks 2014). Under this perspective, the dominant factor is the *truth-value* in the current situation, as described by a sentence or text.

These findings open up the question of whether sensorimotor activity is modulated by further contextual factors. This paper focuses on the case of *presupposition triggers*, that is, words or constructions that convey simultaneously two pieces of information, the *entailed* content and the *presupposition.* For instance, *John stopped running*, entails that John does not run and presupposes that he has been running before. A dominant intuition in the literature is that the presupposition corresponds to a peripheral or secondary layer of information (see a.o. Ducrot 1972 and Stalnaker 1974). From an experimental point of view, an interesting case is that of *factive* verbs (Karttunen 1971) because, in contrast to other triggers, like *stop* or *again*, their presupposition is explicitly spelled out in their complement clause: *Paul knows that Mary throws the ball* presupposes that Mary throws the ball and entails that Paul is certain of that. The basic question we address here is the effect of (non-)factive structures on the motor activation associated with hand-related action verbs.

More specifically, we investigate whether action verbs in isolation or embedded under a factive give rise to different or similar activation patterns. If, as mentioned above, truth-value is the main factor, there would no noticeable difference between asserted and presupposed action verbs, whereas there would be one between asserted action verbs and action verbs under a belief, non factive, operator like *believe* or *think.* If the alleged peripheral status of presuppositions has a fast cognitive effect, it should affect the motor response in factive constructions. Finally, we evaluate the impact of presupposition *projection* under negation, i.e. the fact that a presupposition is interpreted as true when the trigger is negated (for projection in general, see Chierchia & McConnell Ginet 1990 a.o.).

Structure and material We present a series of studies based on the *grip force sensor* technique, where we measure hand-related pressure correlated with action verbs in the auditory modality (Aravena et al. 2012, 2014; Frak et al. 2010; Jeannerod 1994). In Study 1 (factive operators), we compare simple assertions (*Before leaving, Ines ties her shoes*) and factive constructions (*Daniel sees that Ann ties her shoes*). In Study 2 (non-factive operators), we replace factive with non-factive verb construction (*Daniel imagines that Ann ties her shoes*). In Study 3 (projection), we replace the factive verbs with *negated* factive verbs (*Robert is busy in the drawing-room, he does not see that Ghislaine ties her shoes*). Non-action VPs (e.g. *hire a player*) are used as a control in all three studies.

The stimuli for each experiment were 111 sentences, recorded in French by the same female speaker, who took special care to avoid focus accent on words. 37 different (non-)action verbs, 10 factive verbs and 8 non-factive verbs were used. Two pre-tests had allowed us

to select verbs and NP complements (e.g. *tie one's shoes*) strongly associated with hand movement, out of an initial list of 120 potentially hand-related verbs.

Participants were right-handed students with no known neurological pathology and no previous exposure to linguistics (30 participants, mean age 21.7, 34, m.a. 22.7 and 29, m.a. 21.6 for the respective experiments). They were paid for their participation. After two training sequences, the sentences were presented in 10 blocks (9 × 11 + 1 × 12) with a 30 second pause between two blocks. During listening, participants held an ATI 6-axis load cell of 68 g and the compression force (z-axis) was recorded continuously at a sampling rate of 1000 Hz. Participants had to hold the recording cell in a precise manner. In order to keep them focused on the sentences, they had to answer a control question at the end of each block.

Analysis and Results The data were processed and analyzed in R. Participants who did not hold the cell with a minimal constant pressure and showed a negative drift were eliminated (5,4 and 6 participants for Study 1, 2 and 3 respectively).

Anovas with repeated measures were applied in a variable time-span and constant time-shift moving window setting (spans from 200 ms to total duration, shift = 50 ms). The first two experiments supported the truth-value hypothesis, but with some nuances. In Study 1, simple assertions and factives are significantly different from non-action sentences (min p values = 0.025 and 0.01, window size = 300 ms, interval = 551-850 after (non-)action verb onset) and not significantly different from each other (min p value = 0.46, 300, 901-1200). In Study 2, simple assertions differ from belief contexts at a later stage (the min p value = 0.03 over 300 ms is reached for 1151-1450) and earlier from non-action (min p value = 0.25 at 551-850). Belief contexts and non-action do not differ. In Study 3, simple assertions differ from non-action a little later than in study 1 (min p value = 0.017 at 651-950) and differ markedly from negated factives (projection) (min p value = 0.01 at 901-1200). We also observed that, in Study 2 and 3 and over the regions where non-factive or projection sentences differ from simple assertions, the difference is not uniform across items. Pairing and comparing items with identical action verbs (e.g. *… ties hers shoes* vs. *imagines that … ties her* shoes) shows that 12 belief items and 11 projective items win significantly over their assertive mates.

This suggests that the motor effect of action verbs is not completely blocked by belief or negative projective environments. For belief environments, this can be explained by the fact that, even though the action described by the verb is not part of the current event model, it is part of the event model of the agent who entertains the belief attitude, in contrast to what happens with sentential negation or volitional sentences. Concerning projection, an online pre-test had shown that our stimuli are massively interpreted as implying the truth of the complement clause (84% of projective interpretations for 24 participants dealing with five randomly selected stimuli each). Moreover, we added an initial sentence to make the plausibility of a projective interpretation increase. So the results we got are at first sight a bit unexpected. However, it has been suggested for theoretical (Beaver et al. 2017) and empirical reasons (Tonhauser et al. 2018) that projection is not robust, and also that it comes at some cost in a number of cases (Schwarz & Tiemann 2016). So, it is not surprising that, overall, projective contexts do not favour motor response. Given the excellent time resolution of the grip force technique (Frak et al. 2010, Rossini et al. 1999), it is perfectly possible that projection takes place *after* motion response could develop and be detected. As a result, the projection experiment should not be taken as evidence that projection does not occur but rather that its time course does not parallel that of motor response, as elicited here. More generally, the reported experiments illustrate the intrinsic interest of the grip force technique for studying certain aspects of information structure in a non-invasive and temporally precise way. We are currently running a similar experiment on clefts (*It's Mary who ties her shoes*) and preparing another experiment on change-of-state verbs like *begin* or *stop*.