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Action relevance in linguistic context drives word-induced motor activity

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Abstract

Many neurocognitive studies on the role of motor structures in action-language processing have implicitly adopted a “dictionary-like” framework within which lexical meaning is constructed on the basis of an invariant set of semantic features. The debate has thus been centered on the question of whether motor activation is an integral part of the lexical semantics (embodied theories) or the result of a post-lexical construction of a situation model (disembodied theories). However, research in psycholinguistics show that lexical semantic processing and context-dependent meaning construction are narrowly integrated. An understanding of the role of motor structures in action-language processing might thus be better achieved by focusing on the linguistic contexts under which such structures are recruited. Here, we therefore analyzed online modulations of grip force while subjects listened to target words embedded in different linguistic contexts. When the target word was a hand action verb and when the sentence focused on that action (John signs the contract) an early increase of grip force was observed. No comparable increase was detected when the same word occurred in a context that shifted the focus towards the agent’s mental state (John **wants** to sign the contract). There mere presence of an action word is thus *not sufficient* to trigger motor activation. Moreover, when the linguistic context set up a strong expectation for a hand action, a grip force increase was observed even when the tested word was a pseudo-verb. The presence of a known action word is thus *not required* to trigger motor activation. Importantly, however, the same linguistic contexts that sufficed to trigger motor activation with pseudo-verbs failed to trigger motor activation when the target words were verbs with no motor action reference. Context is thus not by itself sufficient to supersede an “incompatible” word meaning. We argue that motor structure activation is part of a dynamic process that integrates the lexical meaning potential of a term and the context in the online construction of a situation model, which is a crucial process for fluent and efficient online language comprehension.

1. Introduction

A growing number of evidence supports the idea that the brain’s motor structures are implicated in the processing of language referring to motor actions (for a review see Hauk & Tschentscher, 2013). However, the crosstalk that the neural networks underlying motor actions entertain with language processes is not well understood. Currently, the theoretical approaches that aim at accounting for the role of motor activation during action-language processing mainly focus on the question of whether

42 language-induced motor activity should be considered as an integral part of lexical semantics or,
43 rather, as resulting from ensuing “higher-level” processes involved in the construction of mental
44 representations of the described state of affairs (Bedny & Caramazza, 2011; Hauk, Davis, Kherif, &
45 Pulvermüller, 2008; Hauk, Shtyrov, & Pulvermüller, 2008; van Elk, van Schie, Zwaan, & Bekkering,
46 2010). Answering this question is believed to solve the issue of whether motor activation is relevant
47 for action-language processing or merely an epiphenomenon (for reviews on the theoretical accounts
48 in this debate, see Meteyard, Cuadrado, Bahrami, & Vigliocco, 2012; Pulvermüller, 2013). However,
49 determining whether language-induced motor activation is part of one of these two processes implies
50 considering lexical meaning access and the representation of the situation described by the context as
51 separated processes. Such a dichotomic view, however, is grounded in models of lexical meaning
52 representation currently regarded as no longer tenable (see also Egorova, Shtyrov, & Pulvermüller,
53 2013; Hoenig, Sim, Bochev, Herrnberger, & Kiefer, 2008; Raposo, Moss, Stamatakis, & Tyler,
54 2009). A better understanding of language-induced motor activity may thus require a shift in
55 theoretical perspective.

56 Research on the role of language induced sensorimotor activation has generated a large body of
57 sometimes conflicting experimental results (see e.g., Hauk, Johnsrude, & Pulvermüller, 2004 vs.
58 Postle, McMahon, Ashton, Meredith, & de Zubicaray, 2008; Buccino et al., 2005 vs. Pulvermüller,
59 Hauk, Nikulin, & Ilmoniemi, 2005; for a review see Willems & Francken, 2012). While these
60 inconsistencies could be seen as an obstacle for the understanding of the crosstalk between language
61 and motor structures, they could alternatively be regarded as providing important insights into the
62 nature of this phenomenon: the heterogeneity in the findings could well indicate that the recruitment
63 of sensorimotor structures crucially depends on the linguistic and extra-linguistic context (see Hoenig
64 et al., 2008; Mirabella, Iaconelli, Spadacenta, Federico, & Gallese, 2012; Papeo, Rumiati, Cecchetto,
65 & Tomasino, 2012; Papeo, Vallesi, Isaja, & Rumiati, 2009; Rueschemeyer, van, Lindemann,
66 Willems, & Bekkering, 2010; Sato, Mengarelli, Riggio, Gallese, & Buccino, 2008; Tomasino &
67 Rumiati, 2013; for a recent review, see Yang, 2013; see also van Dam, van Dijk, Bekkering, &
68 Rueschemeyer, 2011; Willems & Casasanto, 2011). That the context a word is uttered in partially
69 determines its meaning is well established among linguists and psycholinguists (e.g., Allwood, 2003;
70 Elman, 2011). According to Allwood (2003) for instance, lexical meaning representations emerge
71 from multiple interactions within a broad knowledge structure. This word knowledge, that Allwood
72 refers to as the “meaning potential” of a word, comprises the set of all the information that the word
73 has been used to convey either by an individual or by a language community. Within the bounds of
74 this meaning potential, the kind of event, property, or entity a given word is taken to denote shift
75 according to the context the word occurs in.

76 In line with the above view, a vast number of psycholinguistic studies have demonstrated early
77 effects of context on lexical semantics processing (for a review, see Spivey & Huette, in press). For
78 example, Federmeier, Wlotko, De Ochoa-Dewald, & Kutas (2007) recorded ERPs as participants
79 read target words in weakly constraining (e.g., “Mary went into her room to look at her gift”) or
80 strongly constraining (e.g., “The child was born with a rare gift”) sentence contexts. The authors
81 analyzed the N400 ERP-component, whose magnitude is positively correlated to interpretative
82 problems, and found a smaller N400 for the same target words in the strongly compared to the
83 weakly constraining contexts. The brain thus seems to use context information to generate likely
84 upcoming stimuli and to prepare ahead of time for their processing (see also Bicknell, Elman, Hare,
85 McRae, & Kutas, 2010; Chambers & Juan, 2008; Kako & Trueswell, 2000; Kamide, Altmann, &
86 Haywood, 2003). Note that this “lexical anticipation” phenomenon involves evaluating the
87 contextual properties of a word and not merely its characteristics as an entity of the mental lexicon.

88 The whole event evoked when processing a sentence within a given context restricts the set of
89 potential word referents (Bicknell et al., 2010; Chambers & Juan, 2008; Kako & Trueswell, 2000;
90 Kamide et al., 2003; Kukona, Fang, Aicher, Chen, & Magnuson, 2011). In other terms, lexical
91 meaning access profits from a representational state of the situation described by the context (e.g.,
92 Hagoort and van Berkum, 2007; Metusalem et al., 2012; Nieuwland & van Berkum, 2006). This
93 representational state, which can assimilate information about time, social relations, mental acts,
94 space, objects, and events (Frank & Vigliocco, 2011; MacWhinney, 2005), has been termed by
95 linguists and philosophers as “mental models” or “situation model” (Johnson-Laird, 1983; Van Dijk
96 & Kintsch, 1983; Zwaan & Madden, 2004; Zwaan & Radvansky, 1998). As demonstrated by
97 Nieuwland & Van Berkum (2006), situation models can even overrule constraints provided by core
98 lexical-semantic features such as animacy, which, in classic linguistic semantics, is encoded in the
99 mental lexicon. Hence, when participants listened to a story about a dancing peanut that had a big
100 smile, the canonical inanimate predicate “salted” for the inanimate object “peanut” elicited a larger
101 N400 component than the animate predicate “in love”. Situation models can thus neutralize
102 processing difficulties due to animacy violations, confirming that lexical meaning does not
103 necessarily involve an initial context-independent semantic computation.

104 Despite the remarkable body of evidence regarding the context dependency of lexical meaning,
105 these results have rarely been taken into account in the cognitive neuroscience literature that
106 discusses the role of motor structures in action-language processing. In fact, many researchers in this
107 domain seem to have implicitly relied on theoretical views that apprehend word recognition and
108 semantic processing in a form-driven, exhaustive, bottom-up fashion (Swinney & Love, 2002;
109 MacDonald & Seidenberg, 2006). In this manner, semantic and pragmatic context exerts its effects
110 only after word meaning has been elaborated. What is more, it seems as if it is tacitly assumed that
111 words have fixed meanings that are accessed like entries in a dictionary (c.f. “conceptual stability”;
112 Hoenig et al., 2008. See also Elman, 2011). However, within a theoretical frame that considers
113 lexical meaning access as an interactive process, integrating information from many different
114 sources, the question of whether language-induced motor activation is an integral part of lexical
115 meaning or a mere effect of the ensuing construction of a situation model (Bedny & Caramazza,
116 2011; Chatterjee, 2010; Hauk et al., 2008) does not make sense. Therefore, this issue will not
117 satisfactorily inform the main interrogation regarding the function of motor activation in action-
118 language processing. We believe that an understanding of the role of motor structures in the
119 construction of linguistic meaning requires a detailed exploration of the context under which motor
120 structures are recruited during action-language processing.

121 Critical results along this line were provided by Taylor & Zwaan (2008). These authors
122 demonstrated that in a sentence describing a manual rotation (e.g., “He placed his hand on the gas
123 cap, which he opened slowly”), compatible motor responses (i.e., manual rotation of a knob in a
124 congruent direction with the linguistically described activity) are facilitated during reading the verb
125 “opened”. Motor responses are also facilitated while reading of the adverb that modifies the action
126 verb (i.e., “slowly”), but not while reading of the adverbs that modify the agent (e.g., “He placed his
127 hand on the gas cap, which he opened happily”). According to Taylor & Zwaan (2008), the
128 difference between the two conditions is explained by the fact that the adverbs that modify the action
129 maintain the linguistic semantic focus on the action described in the sentence. Note that these results
130 suggest that motor structure activation is sustained beyond the lexical-entity of the action term,
131 extending to the broader linguistic event in which the word is embedded. Results from our laboratory
132 further support this view. By analyzing online grip force variations that index cerebral motor activity
133 in response to target words (c.f. Frak et al., 2010), our study revealed an increase of grip force

134 starting around 200 ms after the onset of a manual action word when the word occurred in an
135 affirmative sentence (e.g. “Fiona lifts the luggage”), but not when it occurred in a negative sentential
136 context (“Fiona does *not* lift the luggage”) (Aravena et al., 2012). Our interpretation of these data is
137 that in affirmative context, motor features of the target word are activated because of the *relevance* of
138 the action within the situation model. In negative contexts the motor features remain irrelevant in
139 spite of the actual presence of the action word in the sentence, because the sentence-induced situation
140 model does not focus on the action.

141 In the present study, we present two experiments that further investigate how the sentential
142 context modulates word-induced motor activation. As in our previous studies (Frak et al., 2010;
143 Aravena et al., 2012), we measured grip force variations while subjects listen to words that describe
144 manual motor actions. Note that an increase of word-induced grip force can be interpreted as an
145 incomplete inhibition of the output of primary motor cortex activity (Frak et al., 2010; Jeannerod,
146 1994). No motor task associated to the linguistic process was required, as participants were asked to
147 count how many sentences contain a name of a country. This ensured the ecology of the experimental
148 environment as it simulates a quite natural linguistic situation.

149 In Experiment 1 we set out to investigate the effect of linguistic focus on action-verb induced
150 motor activity by making use of the *volition modality* (“want to do”, see Morante & Sporleder, 2012).
151 Volition is a grammatical modality that pertains to the intentions of an agent with respect to an
152 action. It sets an action in an *irrealis mood* indicating that the relevant situation or action has not yet
153 happened. Indeed, wanting to do X presupposes that X is not currently being done or taking place.
154 Hence, the situation model evoked by the volition modality does not focus a motor action. In
155 Experiment 2 we assessed the degree of context-dependency of language-induced motor activation
156 by measuring motor activity at the point where the target word is expected. For example, for an
157 utterance beginning with “With his black pen, James...” the word “writes” is a continuation that is
158 far more likely than the word “walk”, as the former evokes a more plausible action for the use of the
159 “black pen” (see Bicknell et al., 2010; Matsuki et al., 2011). To investigate the anticipatory effects of
160 an action context on the subsequent word processing, we used either a pseudo-verb with no
161 associated reference or a verb whose associated reference was incompatible with the action meaning
162 anticipated by the context. In keeping with the findings of our experiment with negative contexts, we
163 predicted that the processing of an action word should neither be sufficient nor even necessary to
164 activate motor structures. Hence:

165 a. An action word (e.g., to soap) embedded in a volitional sentence whose focus is on the mental
166 state of the agent (i.e., “Jamal **wants** to soap his dirty shirt”) should not trigger an increased grip
167 force.

168 b. In a context that primes properties of a hand-action verb, a pseudo-verb (e.g., “With his black
169 pen, Paul **griles** the contract”) should suffice to trigger an increase in grip force. However, given that
170 contextual parameters are actualized rapidly by incoming words, contextual cues that could otherwise
171 trigger motor activity should fail to do so if the ensuing verb is not compatible with the anticipated
172 action meaning (e.g., “With his black pen, Paul **plans** to sign the contract”).

173

174 2. Materials and methods

175

176 **2.1. Experiment 1: Volition**
177

178 Ethics Statement

179 All of the participants in this study gave an informed written consent. The study was approved by the
180 Ethical Committee CPP (Comité de Protection des Personnes) Sud-Est II in Lyon, France.

181
182 Participants

183 All of the participants were French undergraduate students (18 to 35 years old; mean age = 21.7, SD
184 = 1.5) and right-handed (Edinburgh handedness inventory (Oldfield, 1971), with normal hearing and
185 no reported history of psychiatric or neurological disorders. Twenty-five participants (including 13
186 females) participated in this study. Eight participants were eliminated from the analysis due to an
187 extremely weak signal throughout the experiment, thus preventing the capture of grip-force. We used
188 a grip-force mean below 0.13V in combination with the absence of signal changes throughout the
189 experiment as criteria for discarding participants from the analyses.

190
191 Stimuli

192 A total of 115 French sentences served as stimuli (see Appendix A). Ten were distractor-sentences
193 containing a country name. The data from the trials using the distractor-sentences were not included
194 in the analysis. Thirty-five target-action words were embedded into action-in-focus and volition-in-
195 focus sentences resulting in 70 total sentences corresponding to the two conditions of the experiment:
196 the action-in-focus and the volition-in-focus condition. All of the target action words were verbs
197 denoting actions performed with the hand or arm (e.g., scratch or throw). Thirty-five sentences
198 containing common nouns denoting concrete entities with no motor associations were used for
199 comparison with earlier studies (e.g., Frak et al., 2010; Aravena et al., 2012). The target nouns and
200 verbs were controlled for frequency, number of letters, number of syllables and bi- and trigram
201 frequency (New, Pallier, Ferrand, & Matos, 2001, see Appendix C). Three examples of experimental
202 stimuli are provided in Table 1.

203 All critical verbs were in the present tense and in neutral 3rd person. Verbs always occurred in the
204 same position of the sentence. The sentences were spoken by a French male adult. His voice was
205 recorded using Adobe Soundbooth and the recordings were adjusted to generate similar trial lengths
206 using the Audacity 1.2.6 software. Two pseudo-randomized sentences lists were generated from
207 trials; these lists contained uniform distributions of the different sentence types. The two lists were
208 alternated between participants. The mean word duration was 459 ms (SD = 97 ms) for the nouns and
209 415 ms (SD = 78 ms) for the verbs. There was an interval of 2000 ms between the sentence
210 presentations.

211

Condition	Sentence	English approximate translation
action-in-focus	Dans la salle de sport, Fiona <u>souève</u> des haltères.	<i>At the gym, Fiona <u>lifts</u> the dumbbells.</i>
volition-in-focus	A l'intérieur de l'avion, Laure <u>veut soulever</u> son bagage.	<i>In the plane, Laure <u>wants to lift</u> her luggage.</i>

Nouns	Au printemps, Edmonde aime le <u>bosquet</u> de fleur de son jardin.	<i>In the spring, Edmonde loves the <u>flower-bush</u> in her garden</i>
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212

213 Table 1: Example of stimuli used in the experiment 1 and their approximate English translation.
 214 Underlined words represent the target words. Words in bold type represent the linguistic focus of the
 215 sentence.

216

217 Equipment and data Acquisition

218 Two distinct computers were used for data recording and stimulus presentation to ensure
 219 synchronization between audio files and grip-force measurements (estimated error <5 ms). The first
 220 computer read the play-list of the pseudo-randomized stimuli. The second computer received two
 221 triggers from the first computer, which indicated the beginning and the end of the play-list. This
 222 second computer also recorded the incoming force signals from the load cell at a high sampling rate
 223 of 1 KHz. To measure the activity of the hand muscles, a standalone 6-axis load cell of 68 g was used
 224 (ATI Industrial Automation, USA, see Figure 1). In the present study, force torques were negligible
 225 due to the absence of voluntary movement; thus, only the three main forces were recorded: F_x, F_y
 226 and F_z as the longitudinal, radial and compression forces, respectively (Figure 1b).

227

228 Procedure

229 Participants wore headphones and were comfortably seated behind a desk on which a pad was placed.
 230 They were asked to rest their arms on the pad, holding the grip-force sensor in a precision grip with
 231 their right hand (see Figure 1). The thumb, index and middle fingers remained on the load cell
 232 throughout the experiment. Holding the sensor with the index, thumb and middle finger implies more
 233 stability of the object (i.e. less grip force variations due to finger adjustments) than holding it with the
 234 index and thumb only.

235 The Experimenter demonstrated how to hold the grip sensor and participants were requested to hold
 236 the cell without applying voluntary forces.

237 The cell was suspended and not in contact with the table. The participants kept their eyes closed for
 238 the duration of the experiment. They were verbally instructed to listen to the spoken sentences. Their
 239 task was to silently count how many sentences contained the name of a country. To avoid muscular
 240 fatigue, a break of 10 seconds was given every 3 min. The total length of the experiment was 12 min.

241

242 Data analysis

243 Prior to the data analysis, each signal component was pretreated with the Brain Vision Analyzer 2.0
 244 software (Brain Vision Analyzer software, Brain Products GmbH, Munich, Germany). The data were
 245 filtered at 10 Hz with a fourth-order, zero-phase, low-pass Butterworth filter, and a notch filter (50
 246 Hz) was applied in case that artifact caused by electrical power lines would have persisted. Finally, a
 247 baseline correction was performed on the mean amplitude of the interval from -400 to 0 ms prior to
 248 word onset. The baseline correction was implemented because of a possible global change in grip-
 249 force during the session (12 min), and because we are only interested in grip-force changes. Thus, we
 250 adjusted the post-stimulus values by the values present in the baseline period. A simple subtraction of
 251 the baseline values from all of the values in the epoch was performed. As the participants were asked
 252 to hold the grip-force sensor throughout the experiment, a “negative” grip-force refers to a lesser
 253 grip-force and not to the absence of grip-force, which is impossible in this context. Only F_z

(compression force) was included in the analysis as this parameter was determined to be the most accurate indicator of prehensile grip-force. The Fz signals were segmented offline into 1200 ms epochs spanning from 400 ms pre-stimulus onset to 800 ms post-stimulus. The segments with visually detectable artifacts (e.g., gross hand movements) and the trials that showed oscillations exceeding the participant's mean force were isolated and discarded from the analysis. A mean of 6,04 segments (17,2%) were discarded per condition. The Fz signals for action words in action-in-focus, action words in volition-in-focus and nouns were averaged for each participant and the grand mean was computed for each condition.

We selected three time windows (i.e., 100-300 ms, 300–500 ms and 500–800 ms after word onset) that were identified as critical phases during the processing of words in auditory sentences in Friederici's (2002) model and that were used previously in our work for language-induced grip-force analysis (Aravena et al., 2012). Given that the conduction time between the primary motor cortex (M1) and hand muscle is approximately 18–20 ms (estimations using TMS, Rossini, Rossi, Pasqualetti, & Tecchio, 1999), we added 20 ms to each of these windows, resulting in 120-320 ms for the first window, 320–520 ms for the second time window and 520–800 ms for the third. For each condition, the averaged grip-force values in the three time windows were compared with their proper baseline (i.e., averaged grip-force values over the segment between –400 to 0 ms before target word onset) using a one-sample t test against zero; for a window that presented significant grip-force modulations with respect to the baseline, a comparison between the conditions was performed using repeated measures of Analysis of Variance (ANOVA). Post hoc two-by-two comparisons were performed using the Bonferroni test. Since statistical significance is heavily dependent upon sample size, and our study sample was smaller than 20, we also report “effect sizes” (Cohen's *d*; Cohen, 1988). An effect size is calculated by taking the difference of the mean between two conditions and dividing this difference by the pooled standard deviation of the two conditions. This allows estimating how many standard deviations difference there is between the conditions. According to Cohen (1988) and effect size of .20 (i.e. a difference of a fifth of the standard deviation) is a small effects size. A medium effect size is .50 and a large effect size is .80.

2.2. Experiment 2: Pseudo-verbs

Ethics Statement

All participants in this study gave an informed written consent. The study was approved by the Ethical Committee CPP (Comité de Protection des Personnes) Sud-Est II in Lyon, France.

Participants

All of the participants were French undergraduate students (18 to 35 years old; mean age = 21.7, SD = 2.1) and right-handed (Edinburgh Inventory definition (Oldfield, 1971)), with normal hearing and no reported history of psychiatric or neurological disorders. Nineteen subjects (including 10 females) participated in this study and none had participated in Experiment 1.

Stimuli

A total of 158 French sentences served as stimuli (see Appendix B). Ten were distractor-sentences containing a country name. The data from the trials using the distractor-sentences were not included

297 in the analysis.

298 For this experiment, thirty-seven pseudo-verbs were created obeying French's phonotactic
 299 constraints using the « Lexique Toolbox » of the data base Lexique 3 (New et al., 2001). The
 300 soundness of the verb as a French verb was controlled (see Appendix D). Thirty-seven target non-
 301 action words were utilized. All non-action words were verbs denoting no action performed with the
 302 hand or arm (e.g., decide, think), as confirmed by the stimuli validation process (see Appendix D).
 303 Thirty-seven target action words were included. All action words were verbs denoting actions
 304 performed with the hand or arm (e.g., scratch or throw) as established by the stimuli validation
 305 process (see Appendix D).

306 All the target words were controlled for frequency, number of letters, number of syllables and bi- and
 307 trigram frequency (New et al., 2001).

308 The thirty-seven action verbs, the 37 pseudo-verbs and the 37 non-action verbs were embedded into
 309 action contexts. The 37 target non-action verbs were also embedded into non-action contexts.

310 Action contexts were designed in such a way that the first adverbial phrase and the subject of the
 311 sentence coded a situation, which anticipated a hand action. The degree of effector specificity (i.e.,
 312 hand action) of action contexts and the action verb cloze probability were controlled. The “degree of
 313 effector specificity” was defined as how representative of a hand action was the action encoded by
 314 the sentence. All actions encoded by sentences were highly prototypical as hand actions. Cloze
 315 probability was defined as how easy was to anticipate a hand action verb from the previous sentential
 316 context. Only the contexts that induce highly cloze probability of hand action verbs were considered
 317 as action contexts (see Appendix D).

318 In summary, the present study exploited four conditions:

- 319
- 320 a) action_{context} action_{verb} condition (action verb in action context)
 - 321 b) action_{context} pseudoverb condition (pseudo-verb in action context)
 - 322 c) action_{context} non-action_{verb} condition (non-action verb in action context)
 - 323 d) non-action_{context} non-action_{verb} condition (non-action in non-action context).
- 324

325 Four examples of experimental stimuli are provided in Table 2.

326 All critical verbs were in the present tense and in neutral 3rd person. Verbs always occurred in the
 327 same sentential position (see Table 2). The sentences were spoken by a French female adult. Her
 328 voice was recorded using Adobe Soundbooth and the recordings were adjusted to generate similar
 329 trial lengths using the Audacity 1.2.6 software. Three lists of 37 action contexts (A, B and C) were
 330 created to avoid context repetition between the 3 action context conditions. Action words were
 331 included in A, when pseudo-verbs were included in B and non-action words in C, and they were
 332 included in B when pseudo-verbs were in C and non-action in A, etc. Therefore, 3 pseudo-
 333 randomized sentences lists were generated from such balanced combination (ABC, BCA, CBA) in
 334 addition to the non-action C-non-action V list and the ten country sentences. These lists contained
 335 uniform distributions of the different sentence types. The three lists were alternated between
 336 participants. The mean word duration was 459 ms (SD = 97 ms). There was an interval of 2000 ms
 337 between the sentence presentations.

338

339

Condition	Sentence	English approximate translation

action _{context} action _{verb}	Avec son stylo noir, Paul <u>signe</u> le contrat	<i>With his black pen, Paul <u>signs</u> the contract</i>
action _{context} pseudoverb	Avec son stylo noir, Paul <u>grile</u> le Contrat	<i>With his black pen, Paul <u>griles</u> the contract</i>
action _{context} non-action _{verb}	Avec son stylo noir, Paul <u>projette</u> de signer le contrat	<i>With his black pen, Paul <u>plans</u> to sign the contract</i>
non-action _{context} non-action _{verb}	Une fois de plus, Thomas <u>songe</u> à rassembler toute la famille	<i>One more time, Thomas <u>dreams</u> to assemble all the family</i>

340 Table 2: Example of stimuli used in the experiment 2 and their approximate English translation.
341 Underlined words represent the target words.

342

343 Equipment and data Acquisition

344 The equipment and data acquisition from Experiment 1 were used in Experiment 2 (see also Aravena
345 et al., 2012).

346

347 Procedure

348 The procedure from Experiment 1 was repeated with the exception that in the current experiment
349 prior to the beginning of test participants were verbally instructed to apply a specific minimal force
350 on the cell (i.e., between 0.08 and 0.13 V; that was surveyed by the experimenter in the visual signal
351 online registration software) and maintain it throughout all the experiment without applying other
352 voluntary forces. This instruction served to assure the operative capture of the signal, insofar as an
353 extremely weak signal prevents the detection of grip-force variations as shown in experiment 1 (from
354 which eight participants were eliminated due to frail signals). The total length of the experiment was
355 18 min.

356

357 Data analysis

358 The analysis used for Experiment 2 was the same used in Experiment 1.

359

360

361 3. Results

362 3.1. Results Experiment 1: Volition

363

364 Figure 2 plots the variations in grip-force amplitude as a function of time after target word onset for
365 the three experimental conditions (volition-in-focus condition, action-in-focus condition and nouns
366 condition). The top panel displays individual data for the three conditions and the bottom panel
367 compares data of the three conditions averaged over all participants. As is obvious from the figure,
368 for the action-in-focus condition a steady increase in the grip force (the compression force

369 component of the load cell (Fz)) was observed soon after target words presentations and it is
 370 maintained until the last interval. By contrast, the volition and the nouns condition remained nearly
 371 constant at baseline.

372 For the action-in-focus condition the test against the baseline revealed a significant increase in the
 373 grip-force in the three time windows [$p=.013$, $p=.009$, $p=.005$ for 120-320ms, 320-520ms, 520-
 374 800ms respectively]. No significant effects against baseline were observed for the volition-in-focus
 375 or for the nouns condition.

376 The ANOVA revealed significant effects of the conditions in the last two time windows ($F(2,$
 377 $32)=3.4505$, $p=.043$ and $F(2, 32)=5.6477$, $p=.007$ respectively). Post hoc comparison (Bonferroni) for
 378 the second window showed that the Action condition ($M = 0.08$ V, $SD = 0.1$) differed significantly
 379 from the Volition condition ($M = -0.01$ V, $SD = 0.1$) [$p = .05$] and just failed to be significantly
 380 different from the Noun condition ($M = -0.009$ V, $SD = 0.08$) [$p = .06$ ns)]. In the last window post
 381 hoc comparison revealed that the Action condition ($M = 0.14$ V, $SD = 0.19$) different from the
 382 Volition condition ($M = -0.02$ V, $SD = 0.18$) [$p = .02$] as well as from the Noun condition ($M = -0.03$
 383 V, $SD = 0.8$) [$p = .007$]. Table 3 summarizes the effect sizes (Cohen d) of the different comparisons.
 384 In all time windows large effect sizes were found for the difference between the Action vs. Nouns
 385 conditions as well as between the Action vs. Volition conditions.

386 All together these analyses confirm that the same action words embedded in sentences whose focus is
 387 on the mental state of the agent do not increase grip force in the same way as when they are
 388 embedded within sentences that focus the action.

<i>Time window 120-320 ms</i>	Nouns	Volition
Action	0.92	0.78
Volition	0.13	
<i>Time window 320-520 ms</i>	Nouns	Volition
Action	0.99	0.76
Volition	0.08	
<i>Time window 520-800 ms</i>	Nouns	Volition
Action	1.26	0.92
Volition	0.08	

389
 390 Table 3: Cohen's d for the differences between the various conditions in the three time windows.
 391

392 3.2. Results Experiment 2: Pseudo-verbs

393

394 Figure 3 plots the variations in grip-force amplitude as a function of time after target word onset for
 395 the four experimental conditions (action-action condition, action-pseudo-verb condition, action-non-
 396 action condition and non-action-non-action condition). The top panel displays individual data for the
 397 four conditions and the bottom panel compares data of the four conditions averaged over all
 398 participants. As is obvious from the figure, for the action-action condition and the action-pseudo-verb
 399 condition, a steady increase in the grip force (the compression force component of the load cell (Fz))
 400 was early observed, and maintained until the last interval. By contrast, the action-non-action
 401 condition appeared to cause a drop in the grip-force. Finally, non-action-non-action condition
 402 remained nearly constant at baseline.

403 For the Action-Action condition, the test against the baseline revealed a significant increase in the
 404 grip-force in the three time windows [$p = .01$, $p = .02$ and $p = .04$ for 120-320ms, 320-520ms, 520-

800ms respectively]. For the Action-Pseudo-verb condition, the test against the baseline also revealed a significant increase in the grip-force in the three time windows [$p = .01$, $p = .006$ and $p = .01$, respectively]. No significant effects against baseline were observed for the non-action verbs in the action context or for the non-action-non-action condition. The ANOVA was significant in all time windows ($F(3, 54)=4,558$, $p=.0064$, $F(3, 54)=5,2004$, $p=.0032$ and $F(3, 54)=3,251$, $p=.0287$, for the first, second and third window, respectively). Results of the post hoc tests (Bonferroni) are plotted in Table 4.

<i>Time window 120-320 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	p=0.010	p=0.019	<i>p=0.167</i>
Act. - Action		n.s	n.s
Act. - Pseudoword			n.s
<i>Time window 320-520 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	p=0,006	p=0,029	n.s
Act. - Action		n.s	<i>p=0.135</i>
Act. - Pseudoword			n.s
<i>Time window 520-800 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	<i>p=0,061</i>	<i>p=0,123</i>	n.s
Act. - Action		n.s	n.s
Act. - Pseudoword			n.s

Table 4: Results of the post hoc tests (Bonferroni) for the different contrasts.

The comparison of the three critical conditions (Action-Non-action vs. Action-Action and Action-Pseudo-verbs) revealed significant effects in the first two time windows. First time window: Action-Non-action condition ($M = -0.1$ V, $SD = 0.19$) differed significantly from the Action-Action ($M = 0.099$ V, $SD = 0.15$) [$p = .01$] as well as from the Action-Pseudo-verbs conditions ($M = 0.08$ V, $SD = 0.13$) [$p = .019$]. Second time window: Action-Non-action condition ($M = -0.1$ V, $SD = 0.3$) vs. Action-Action condition ($M = 0.16$ V, $SD = 0.28$) [$p = .006$] and vs. Action-Pseudo-verb condition ($M = 0.12$ V, $SD = 0.16$) [$p = .029$]. In the third time window the same tendency was also evident but the differences with the Action-Non-action condition did not reached significance: Action-Non-action condition ($M = -0.11$ V, $SD = 0.3$) vs. Action-Action condition ($M = 0.16$ V, $SD = 0.34$) [$p = .061$] and vs. Action-Pseudo-verb condition ($M = 0.13$ V, $SD = 0.23$) [$p = .123$]. By contrast, the comparison with the Non action-Non action condition did not survive the Bonferroni correction for multiple comparison (all p 's $> .05$).

Table 5 summarizes the effect sizes (Cohen d) of the different comparisons. In all time windows large effect sizes were found for the difference between the Action-Action vs. Action Non-action conditions as well as between the Action-Pseudoword vs. Action Non-action conditions. In the second and third time windows medium to large effect sizes were also found between the Action-Action vs. Non-action Non-action conditions and between the Action-Pseudoword vs. Non-action Non-action conditions.

<i>Time window 120-320 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	1.16	1.14	0.67
Act. - Action		0.09	0.33
Act. - Pseudoword			0.28
<i>Time window 320-520 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	1.02	1.05	0.39
Act. - Action		0.19	0.79
Act. - Pseudoword			0.81

<i>Time window 520-800 ms</i>	Act. - Action	Act. - Pseudoword	Non act. - Non action
Act. - Non action	0.84	0.90	0.27
Act. - Action		0.10	0.84
Act. - Pseudoword			0.61

436

437 Table 5: Cohen's d for the differences between the various conditions in the three time windows.

438

439 **4. Discussion**

440 Our experiments were designed to explore the impact of local linguistic context on word-induced
 441 neural activation of motor structures. There are two main results of this study. First, compatible with
 442 previous findings (Taylor & Zwaan, 2008; Zwaan, Taylor, & de Boer, 2010) our work shows that
 443 linguistic focus as defined by Taylor & Zwaan, (2008) modulates language-induced motor activity.
 444 The presence of an action word in an utterance is not in itself sufficient to trigger a related motor
 445 activation (see also Aravena et al., 2012; Raposo et al., 2009; Schuil, Smits, & Zwaan, 2013).
 446 Second, our data further shows that the linguistic surrounding and the knowledge of situation it sets
 447 up can be sufficient to activate the motor properties of a contextually expected action verb. The
 448 actual presence of a known action word is not necessary for the activation of motor structures (for
 449 similar results in pragmatic context, see van Ackeren, Casasanto, Bekkering, Hagoort, &
 450 Rueschemeyer, 2012). Importantly, however, the very same context can nonetheless fail to trigger
 451 relevant motor activation if the tested lexical item is a familiar word that has no associated motor
 452 features. Hence, contextual expectations set up by a given utterance are not in themselves sufficient
 453 to supersede a lexical meaning that does not involve a motor content. On the basis of this evidence,
 454 we argue that language-induced motor activation is neither driven by purely context-free lexical
 455 meaning access nor the result of a fully post lexical higher order operation. Rather, the activation of
 456 motor structure results from the dynamic interactions of available lexical and contextual information
 457 that take part in the online construction of a complex mental model associated with the processing of
 458 a sentence meaning.

459 In Experiment 1, we used the modal operator “vouloir” (to want) to manipulate the mode of access to
 460 a described action by shifting the linguistic focus towards the agent's attitude with respect to the
 461 action. "Modality" is a grammatical category that allows relativizing the validity of sentence meaning
 462 to a set of possible situations (Perkins & Fawcett, 1983). Agent-oriented modalities focus on the
 463 internal state of an agent with respect to the action expressed by a predicate (Bybee, Perkins, &
 464 Pagliuca, 1994). Volition thus focalizes the sentence on the agent's attitude towards the action rather
 465 than on the action itself (Morante & Sporleder, 2012). Our results show that motor structures were
 466 only recruited when the action verb was the focus of the sentence meaning and not when the sentence
 467 meaning focused on the agent's attitude towards the action. These findings are consistent with the
 468 linguistic focus hypothesis proposed by Taylor and Zwaan (2008) (see also Gilead, Liberman, &
 469 Maril, 2013; Zwaan et al., 2010). However, our study goes beyond what these authors found. Recall
 470 that Taylor & Zwaan (2008) showed that language-induced motor activation could “spill-over” from
 471 the actual action word to the linguistically adjacent post-verbal adverb, provided that the adverb
 472 modified the action. Our study goes further than these results because we show that motor activation
 473 for the *action word itself* can be switched on and off as a function of the linguistic focus. Critically,
 474 our study also provides the timing of the contextually constrained word induced motor activation:
 475 linguistic focus modulates motor activity within a temporal window that has been associated with
 476 lexical semantic retrieval (i.e 300-500 ms after word onset, see Friederici, 2002).

477

478 The results of our first experiment thus suggest that the processing of an action verb can rapidly
479 activate motor features of a denoted action. However, these motor features are only recruited when
480 the denoted action is *relevant* within the currently elaborated situation model. The sensitivity of
481 language-induced motor activation to the relationship between context and lexical semantics suggests
482 that motor structures could serve semantic specification.

483
484 The findings of Experiment 2 show that word induced motor activation involves an early evaluation
485 of the context against which the relevance of the action features of the potential verbs are determined
486 (for studies on the anticipatory referential interpretation see e.g., Bicknell et al., 2010; Chambers &
487 Juan, 2008; Kako & Trueswell, 2000; Kamide et al., 2003). Our sentences were designed so that a
488 fronted adverbial phrase and the subject of the sentence set up a situation in which a hand action was
489 anticipated (i.e., the action context). Following this sentential context the ensuing verb was either a
490 verb denoting a hand action, a verb denoting non-action, or a pseudo-verb unknown to the subject.
491 As expected, when the verb denoted a hand action, an increase of grip force was observed shortly
492 after word onset. Critically, grip force also increased with a pseudo-verb unknown to the listener, but
493 not when a known verb with no motor denotation was presented instead (e.g. “With his black pen,
494 James **plans** to ...”). These data clearly testify that the increase of grip force was not merely an effect
495 of context. One plausible explanation for our finding is that when a sentence contains an unknown
496 word, the process of meaning construction fills the semantic gap with the most adequate content
497 within the given context (in our case an action performed with the hand) until more information is
498 available. In other terms, the listener maintains the situation model elaborated from previous context
499 and integrates the unknown word into this representation. In our experiment, the instrument
500 described in the adverbial phrase as well as the human agent (i.e., “With his black pen, James...”)
501 anticipate hand-action relevant motor features. By integrating this information the listener models a
502 situation that foresees a particular action as a plausible thematic relation. When the ensuing verb is
503 unknown to the listener the elaborated situation model is maintained and motor structures are
504 recruited. However, when the ensuing verb is a known word that does not refer to an action, the non-
505 action verb updates the modeled situation and cancels action representation anticipated by the
506 context. Thus, contextual parameters might be understood as part of a representational state that is
507 constantly restructured and revised following incoming information (see also Bicknell et al., 2010;
508 Matsuki et al., 2011; McRae, Hare, Elman, & Ferretti, 2005).

509
510 The results of our second experiment thus suggest that the construction of a situation model allows
511 making rapid inferences and predictions for the elaboration of linguistic meaning. The brain
512 generates a continuous stream of multi-modal predictions and pattern completion based on previous
513 experiences (see, for example, Barsalou, 2009). This drive to predict is a powerful engine for online
514 language comprehension (Elman, 2009, Federmeier, 2007).

515
516 In conclusion, together with our previous findings (Aravena et al., 2012) the present results indicate
517 that the recruitment of motor structures during the processing of an action word hinges on specific
518 conditions: i) the context must focus on a motor action and ii) the tested word form must not be
519 *incompatible* with a contextually anticipated action, i.e., it has to be either compatible or neutral as in
520 the case of a pseudo-verb. Hence, the processing of an action word does not recruit motor structures
521 constantly. The same action word form that provokes motor activity in one linguistic context will
522 cease to do so in another one. Note further that in conditions in which word processing recruits motor
523 structures, this language-induced motor activity is observed within the time frames in which lexical
524 meaning are believed to be retrieved (Swinney and Love, 2002; Friederici, 2002).

525

526 Although an increasing number of recent studies has started to account for the context dependency
527 of motor activity (e.g. Mirabella et al., 2012; Papeo, et al., 2012; Rueschemeyer et al., 2010; Sato et
528 al., 2008; Tomasino & Rumiati, 2013) the majority of research programs are still strongly rooted in a
529 “dictionary-like” perspective of word meaning (see Elman, 2004, 2011; Evans & Green, 2006;
530 Evans, 2006 for critical reviews). The novelty of our work resides in the explicit integration of a
531 theoretical and experimental framework that could serve to link current models of sentence
532 processing to neurobiological data on action-meaning representation. The here observed on/off
533 switching of motor activity with a given lexical item could be interpreted as evidence against the
534 assumption that motor activity is necessarily a relevant part of the action word meaning (see also
535 Schuil et al., 2013). If motor semantic features were indeed accessed via a modular, exhaustive and
536 context-independent process (c.f. Swinney & Love, 2002) motor structures should be recruited in a
537 consistent and mandatory manner. This, however, is clearly not the case. Yet, “low level” lexical
538 semantic process and “higher level” processes of meaning integration are not serial, discrete, and
539 encapsulated operations (for other examples concerning semantics as well as syntax see Bicknell et
540 al., 2010; Chambers & Juan, 2008; Friston, 2003; Kamide et al., 2003; Matsuki et al., 2011; McRae
541 et al., 2005; Papeo, Rumiati, Cecchetto, & Tomasino, 2012). Context can anticipate motor semantic
542 features of lexical items (experiment 2) and can also switch them off when they are not relevant
543 within the situation model (experiment 1). Findings like these question the notion that motor
544 semantic features are “fixed parts” of the action word meaning (Egorova et al., 2013; Hoenig et al.,
545 2008; Raposo et al., 2009; Tomasino & Rumiati, 2013). Note that even when a verb such as “open” is
546 processed in isolation, comprehenders are likely to represent meaning by reference to some
547 *frequently* encountered situation e.g., opening a door or a bottle (see the situated concept
548 representation proposed by Barsalou (2003)).

549 The question about the functional or epiphenomenal nature of motor structures in action-language
550 processing might therefore not be put in terms of its participation to lexical semantics processing or
551 to the construction of situation models. Rather, to determine the role of motor structures in language
552 processes it is necessary to take into account the fact that language comprehension involves several
553 sources of information that are elaborated in parallel and continuously adjusted to make sense of an
554 utterance as it is perceived (Allwood, 2003; Cuyckens, Dirven, & Taylor, 2003; Elman, 2011).
555 Classical accounts of language-induced motor activity that sees language-induced sensorimotor
556 activity either as epiphenomenon (Hickok, 2009; Mahon & Caramazza, 2008) or as integral part of
557 word meaning (Barsalou, 1999; Glenberg, 1997; Pulvermuller, 1999) are both problematic in that
558 they assume a model that endorses a fixed, dictionary-like set of lexical representations. The here-
559 demonstrated rapidity, flexibility, and context dependency of language-induced motor activity to one
560 and the same word are not compatible with such view. Rather, following Evans and Green (2006)
561 and Elman (2011), we believe that words are “operators” that alter mental states (i.e., situation
562 models) in context-dependent and *lawful* ways. If the timing under which an effect occurs is
563 indicative of its source (lexical meaning or post-lexical) the early language-driven motor effects that
564 we observed in our experiments allow suggesting that motor activity takes part in the action word
565 meaning construction in conditions in which the action is in the linguistic focus.

566 In short, motor knowledge is part of the *meaning potential* of action words. It participates in the
567 construction of meaning when a currently modeled situation focuses the action and might serve
568 *meaning-specification*. It also allows prediction and pattern completion, which are important
569 processes for fluent and efficient online language comprehension.

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 767 further tests of the linguistic focus hypothesis. *Brain and language*, 112(3), 143–149.
 768

769 6. Figure legends

770 **Figure 1: Experimental material and setting.** a) A standalone 6-axis load cell of 68 g was used
 771 (ATI Industrial Automation, USA). b) The three main forces were recorded: F_x, F_y and F_z as the
 772 longitudinal, radial and compression forces, respectively. c) Participants hold the grip-force sensor in
 773 a precision grip with their right hand. **Bottom panel:** participants wore headphones and were
 774 comfortably seated behind a desk on which a pad was placed. They were asked to rest their arms on
 775 the pad, holding the sensor.

776 **Figure 2: Modulation of the grip-force amplitude as a function of time after target onset in**
 777 **Experiment 1 (Volition).** The top panel displays individual data for the three conditions (the bold
 778 lines represent the means and standard deviations) and the bottom panel compares data of the three
 779 conditions averaged over all participants. In the bottom panel we also show the standard error of the
 780 mean (SEM) around the mean value across the subjects (shaded regions). For the action-in-focus
 781 condition a significant increase in the grip force was observed soon after target words presentations
 782 and it is maintained over the three intervals. This enhanced grip-force is significantly different from
 783 the volition condition in the two last windows and from the nouns conditions in the last window.

784 **Figure 3: Modulation of the grip-force amplitude as a function of time after target onset in**
 785 **Experiment 2 (Pseudo-verbs).** The top panel displays individual data for the four conditions (the
 786 bold lines represent the means and standard deviations) and the bottom panel compares data of the
 787 four conditions averaged over all participants. In the bottom panel we also show the standard error of
 788 the mean (SEM) around the mean value across the subjects (shaded regions). For the action-action
 789 condition and the action-pseudo-verb condition, a significant increase in the grip force was early
 790 observed, and maintained until the last interval. This enhanced grip-force is significantly different
 791 from action-non-action condition in the two first intervals.

792

793 APPENDIX A : Sentences list Experiment 1.

794 Volition-in-focus Condition

795

- 796 1. Dans la menuiserie, Martin veut scier une planche de bois.
- 797 2. Dans le parc, Laurent veut jeter l'enveloppe par terre.
- 798 3. Dans la cuisine, Lucie veut râper des carottes pour la salade
- 799 4. Pour le piquenique, Timon veut saler les œufs durs
- 800 5. Dans la laverie, Celia veut tordre le linge pour l'égoutter
- 801 6. Dans la cour, Alice veut pincer la main de sa poupée

- 802 7. A la cantine, Elsa veut racler l'intérieur de la casserole.
 803 8. Devant l'église, Lilian veut serrer la main du futur mari.
 804 9. Dans la salle de prof, olivier veut signer la feuille d'évaluation
 805 10. Dans l'atelier d'art, amandine veut vernir le coffre
 806 11. Pour le petit déjeuner, Yvonne veut agiter la bouteille du lait
 807 12. Dans sa chambre, Cannelle veut épiler ses bras
 808 13. Au stade, Marion veut prendre son javelot gris
 809 14. Devant son miroir, Prune brosse ses cheveux ondulés
 810 15. A la plage, Cédric veut enfouir ses lunettes dans son sac
 811 16. A la ferme, Robert ne fauche pas le blé de son champ
 812 17. A la réunion, Delphine veut frapper sur la table avant de parler
 813 18. Sur un banc, Hector veut gratter le dos de son chien
 814 19. Dans la prison, Yannick veut griffer la main du gardian
 815 20. Au cirque, Philippe veut jongler avec de massues
 816 21. Sur le trottoir, Charles mendie avec son chapeau
 817 22. Sur la carte, Eloïse veut montrer son pays d'origine
 818 23. En coulisse, Sylvie veut peigner l'actrice principale
 819 24. Dans la batucada, Nicolas veut secouer les maracas
 820 25. Dans le pré, Greg veut arroser les tulipes
 821 26. Dans son manoir, Harry veut balayer le plancher
 822 27. Dans la salle de sport, Fiona veut soulever des haltères
 823 28. Dans sa villa, Lionel veut astiquer la rampe d'escalier
 824 29. À la crèche, Louise veut colorier la tête de son bonhomme
 825 30. Devant la boîte de nuit, Manon veut déchirer sa carte d'identité
 826 31. Sur sa toile, Julien veut dessiner les nuages blancs
 827 32. Devant son ordinateur, Richard veut Pianoter sur le clavier
 828 33. Dans son bain, Léo veut savonner ses pieds
 829 34. Sur son fauteuil, Claudia veut tricoter des chaussettes
 830 35. Dans les magazines, Luc veut découper des images de maison

831

832 Action-in-focus condition

833

- 834 1. Dans le sentier, Jean scie un tronc d'arbre.
 835 2. Dans la salle de classe, Bastien jette le papier dans la poubelle.
 836 3. Pour le diner, Berta râpe du fromage dans ses pâtes.
 837 4. Pour le barbecue, Abdala sale la viande.
 838 5. A la piscine, Adela tord la serviette qui est tombé dans l'eau
 839 6. A la fin du dîner, Abby racle le fond de son assiette.
 840 7. Dans le magasin, Camille serre le nœud de ses chaussures.
 841 8. Au bureau, Carlo signe le contrat.
 842 9. Dans le magasin d'antiquités, Danielle vernit la table.
 843 10. Dans la rue, David agite la main pour saluer.

- 844 11. A l'institut de beauté, Elena épile les jambes de sa cliente.
 845 12. Au concert, Elias prend le microphone
 846 13. Dans la salle de bain, Fabian brosse ses dents
 847 14. Dans cette caverne, Fanny enfouit les objets précieux
 848 15. Dans le jardin, Gaël fauche les mauvaises herbes.
 849 16. A l'entrée de la maison, Gabrielle frappe la porte.
 850 17. Dans l'atelier, Irène gratte la peinture qui a débordé.
 851 18. Avec un costume de chat, Ian griffe le sol.
 852 19. Dans les fêtes d'anniversaire, James jongle avec les oranges.
 853 20. Dans le métro, Joseph mendie un morceau de pain
 854 21. Par la fenêtre, Jacqueline montre le chemin.
 855 22. Le matin, Mathilde peigne ses longs cheveux.
 856 23. Dans le bar, Anne secoue la bouteille de jus.
 857 24. Le soir, Vicente arrose les plantes.
 858 25. En fin de journée, Karine balaye le trottoir.
 859 26. A l'intérieur de l'avion, Laure soulève son bagage.
 860 27. Dans la cuisine, Madeleine astique le dos de la casserole
 861 28. Dans la maison de sa grand-mère, Stéphane colorie les dessins
 862 29. A la poste, Maël déchire l'enveloppe de la lettre reçue.
 863 30. A la campagne, Rémi dessine le contour des montagnes.
 864 31. Dans les embouteillages, Patrick pianote sur le volant.
 865 32. Dans la douche, Pauline savonne les cheveux de son enfant
 866 33. Cet hiver, Sabine tricote une écharpe.
 867 34. A l'école, Salvador découpe des personnages en papier.
 868 35. Dans sa chambre, Mathilde peigne sa poupée.

869

870 Nouns condition

871

- 872 1. Dans la montagne, Léonard voit l'aigle qui plane.
 873 2. Dans le bois, Arthur contemple le hêtre qui date de 1780.
 874 3. Ce soir, Allan attend son avion pour aller en Écosse
 875 4. Sur la rive, Frank choisit un canoë pour se promener.
 876 5. Aujourd'hui, Aurélie découvre la grotte où est le trésor
 877 6. Dans le ciel, Willy regarde une étoile filante très lumineuse.
 878 7. Au zoo, Brigitte admire la toison fauve du tigre
 879 8. De sa fenêtre, Chloé apprécie le mûrier en face de la cabane.
 880 9. A l'aquarium, Damien observe le requin blanc
 881 10. A la fin de la promenade, Daniel aperçoit le canyon du regard
 882 11. A l'unanimité, Raphaël ouvre l'écluse au bateau.
 883 12. Sur la colline, Aurore cherche le moulin le plus grand.
 884 13. Par téléphone, Emma réserve la chambre d'hôtel
 885 14. Chez le notaire, Erick estime le terrain à sa valeur actuelle

- 886 15. Dans le centre commercial, Léa inspecte la vitrine avant d'entrer
 887 16. Dans la forêt, Emile explore le sentier embroussaillé
 888 17. Dans le désert, Abdallah vénère son chameau.
 889 18. Au printemps, Edmonde aime le bosquet en fleurs de son jardin
 890 19. Dans le parc d'attraction, Thierry visite la caverne du dragon
 891 20. Pendant la descente, Eléonore pense à la falaise derrière elle.
 892 21. En Patagonie, Françoise étudie le fameux iceberg géant.
 893 22. Dans son lit, Véronique rêve d'une licorne qui joue sur la pelouse
 894 23. A la ferme, Victoria prend soin du pommier de sa grand-mère.
 895 24. Dans ses rêves, Virginia imagine une prairie paisible.
 896 25. Deux ans plus tard, Paul se rappelle de la tempête qui a frappé le sud.
 897 26. Au fond du jardin, Yves a une oseraie très étendue
 898 27. Au magasin, Sylvain achète un grillage pour son pré.
 899 28. Quand il fait froid, Baptiste se souvient de la banquise de l'antarctique.
 900 29. De la réserve, Antonin surveille la barrière de l'entrée.
 901 30. Dans la maison, Nathan regarde la moquette du séjour.
 902 31. Dans son appartement, Ophélie partage la penderie avec sa colocataire.
 903 32. Dans sa maison de vacances, Oscar a besoin d'une rambarde pour les escaliers.
 904 33. Dans son quartier, Raoul maudit le monument de la place.
 905 34. Avant de mourir, Ryan lègue le cerisier à sa fille.
 906 35. Finalement, Tara obtient le chevalet le plus haut.

English approximate translation

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910

Volition-in-focus Condition

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1. In the joinery, Martin wants to saw a wooden plank.
2. In the park, Laurent wants to throw the envelop on the ground.
3. In the kitchen, Lucie wants to grate carrots for the salad.
4. For the picnic, Timon wants to salt the hard-boiled eggs.
5. In the launderette, Celia wants to wring the cloth out.
6. In the yard, Alice wants to pinch her doll's hand.
7. In the canteen, Elsa wants to scrape the inside of the saucepan.
8. In front of the church, Lilian wants to shake the future husbands' hand.
9. In the teachers' staffroom, Olivier wants to sign the evaluation sheet.
10. In the art studio, Amandine wants to varnish the chest.
11. For breakfast, Yvonne wants to shake the bottle of milk.
12. In her bedroom, Cannelle wants to wax her arms.
13. At the stadium, Marion wants to take her grey javelin.
14. In front of her mirror, Prune wants to brush her wavy hair.
15. At the beach, Cédric wants to bury his glasses in his bag.
16. At the farm, Robert wants to mow the wheat of his field.

- 928 17. At the meeting, Delphine wants to hit the table before she speaks.
 929 18. On a bench, Hector wants to scratch his dogs' back.
 930 19. In the prison, Yannick wants to scratch the warder's hand.
 931 20. At the circus, Philippe wants to juggle clubs.
 932 21. On the sidewalk, Charles begs for money with his hat.
 933 22. On the map, Eloïse wants to show her home country.
 934 23. Behind the scenes, Sylvie wants to comb the leading actress.
 935 24. During the batucada, Nicolas wants to shake the maracas.
 936 25. In the meadow, Greg wants to water the tulips.
 937 26. In his manor, Harry wants to sweep the floor.
 938 27. At the gym, Fiona wants to lift the dumbbells.
 939 28. In his villa, Lionel wants to polish the banister.
 940 29. At the nursery, Louise wants to color the head of the man she drew
 941 30. In front of the night club, Manon wants to tear her ID up.
 942 31. On his canvas, Julien wants to draw white clouds.
 943 32. In front of his computer, Richard wants to tap away on the keyboard.
 944 33. In his bathtub, Léo wants to soap his feet.
 945 34. In her armchair, Claudia wants to knit socks.
 946 35. In magazines, Luc wants to cut house images out.

947

948 Action-in-focus condition

949

- 950 1. On the path, Jean sees a tree trunk.
 951 2. In the classroom, Bastien throws the paper in the dustbin.
 952 3. For dinner, Berta grapes cheese in the pasta.
 953 4. For the barbecue, Abdala salts the meat.
 954 5. At the swimming pool, Adela wrings the towel that had fallen in the water.
 955 6. At the end of dinner, Abby scrapes the bottom of her plate.
 956 7. In the shop, Camille tightens her shoe laces.
 957 8. At work, Carlo signs the contract.
 958 9. In the antiques shop, Danielle varnishes the table.
 959 10. In the street, David waves the hand to say hello.
 960 11. At the beauty institute, Elena waxes her customer's legs.
 961 12. At the concert, Elias takes the microphone.
 962 13. In the bathroom, Fabian brushes his teeth.
 963 14. In this cave, Fanny buries precious objects.
 964 15. In the garden, Gaël mows the weed.
 965 16. At the house entrance, Gabrielle knocks on the door.
 966 17. In the workshop, Irène scrapes the paint that was spilt.
 967 18. With a cat costume, Ian scratches the floor.
 968 19. In birthday parties, James juggles oranges.
 969 20. In the subway, Joseph begs for a piece of bread.

- 970 21. Through the window, Jacqueline shows the path.
 971 22. In the morning, Mathilde combs her long hair.
 972 23. In the bar, Anne shakes the bottle of juice.
 973 24. In the evening, Vincente waters the plants.
 974 25. In the late afternoon, Karine sweeps the sidewalk.
 975 26. Inside the plane, Laure lifts her luggage.
 976 27. In the kitchen, Madeleine polishes the back of the saucepan.
 977 28. In his grand-mother's house, Stéphane colors the drawings.
 978 29. At the post office, Maël tears the envelop of the received letter up.
 979 30. In the countryside, Rémi draws the outline of the mountains.
 980 31. In the traffic, Patrick drums his fingers on the wheel.
 981 32. In the shower, Pauline soaps her child's hair.
 982 33. This winter, Sabine knits a scarf.
 983 34. At school, Salvador cuts paper men up.
 984 35. In her bedroom, Mathilde combs her doll's hair.
 985
 986 Nouns condition
 987
 988 1. In the mountain sky, Léonard sees the eagle gliding.
 989 2. In the woods, Arthur contemplates the beech dating from 1780.
 990 3. Tonight, Allan awaits his plane to go to Scotland.
 991 4. On the riverbank, Frank chooses a canoe for the day.
 992 5. In the sky, Willylooks at a bright shooting star.
 993 6. Today, Aurélie discovers the cave where the treasure is hidden.
 994 7. At the zoo, Brigitte admires the fleece of the fawn lion.
 995 8. From her window, Chloé appreciates the mulberry tree facing the cabin.
 996 9. At the aquarium, Damien observes the white shark.
 997 10. At the end of the walk, Daniel sees the canyon.
 998 11. Unanimously, Raphaël opens the lock for the boat.
 999 12. On the hill, Aurore looks for the biggest mill.
 1000 13. On the phone, Emma books the hotel room.
 1001 14. At the solicitor's office, Erick estimates the value of the site.
 1002 15. In the shopping center, Léa inspects the shop window before walking in.
 1003 16. In the forest, Emile explores the bushy path.
 1004 17. In the desert, Abdallah venerates his camel.
 1005 18. In spring, Edmonde likes her garden's fower grove.
 1006 19. In the theme park, Thierry visits the dragon cave.
 1007 20. During the descent, Eléonore thinks about the cliff behind her.
 1008 21. In Patagonia, Françoise studies the famous giant iceberg.
 1009 22. In her bed, Véronique dreams about a unicorn playing in the grass.
 1010 23. At the farm, Victoria takes care of her grand-mother's apple tree.
 1011 24. In her dreams, Virginie imagines a peaceful meadow.

- 1012 25. Two years later, Paul remembers the storm that hit the south.
 1013 26. In the back of the garden, Yves owns a vast rose garden.
 1014 27. In the shop, Sylvain buys a fence for his meadow.
 1015 28. When it is cold, Baptiste remembers the Antarctic ice field.
 1016 29. From the storeroom, Antonin watches the entrance gate.
 1017 30. In the house, Nathan looks at the living room fitted carpet.
 1018 31. In her apartment, Ophélie shares the wardrobe with her flatmate.
 1019 32. In his holiday house, Oscar needs a bannister for the stairs.
 1020 33. In the neighborhood, Raoul curses the historic monument.
 1021 34. Before he dies, Ryan bequeathes the cherry tree to his daughter.
 1022 35. Finally, Tara obtains the tallest easel.
 1023

1024 **APPENDIX B: Sentence list Experiment 2.**

1025 Action context – Action verb condition (A)

- 1026 1. Avec ses beaux outils, Jean scie de fines planches de bois.
 1027 2. En un mouvement rapide de la main, William jette le papier à la poubelle.
 1028 3. Sur son clavier, Anne tape une lettre de motivation.
 1029 4. Avec un balai, Chloé bat le tapis persan.
 1030 5. De ses deux mains, Marc tord la serviette qui est tombée à l'eau.
 1031 6. Avec ses deux doigts, Alex pince le bras de sa camarade de classe.
 1032 7. A l'aide d'une cuillère, Claire racle le fond de la casserole.
 1033 8. Grâce à une clé anglaise, Anna serre un boulon sur son vélo.
 1034 9. Avec son stylo noir, Paul signe le contrat de renouvellement.
 1035 10. Avec son pinceau brosse, Thomas vernit le meuble ancien.
 1036 11. De ses deux bras, Diane agite le drapeau pour appeler à l'aide.
 1037 12. Avec une petite pince, Emma s'épile les jambes pour l'été.
 1038 13. Avec des gants de caoutchouc, Pierre prend le mollusque gluant.
 1039 14. Avec son arc, Lucas tire sur la cible.
 1040 15. A grands coups de pelle, Laure enfouit son trésor au fond du jardin.
 1041 16. Munie de sa serpette, Elise fauche les mauvaises herbes avec son père.
 1042 17. A l'aide de son marteau, Louis frappe sur le clou à plusieurs reprises.
 1043 18. Avec l'éponge, Alain gratte l'assiette sale jusqu'à ce qu'elle brille.
 1044 19. A l'aide d'une carafe, Jeanne verse de l'eau dans les verres.
 1045 20. D'une seule main, Irène jongle avec quatre balles.
 1046 21. Avec sa brosse rose, Lyse peigne les cheveux de sa Barbie avec soin.
 1047 22. Avec un shaker, Julie secoue les ingrédients pour préparer un cocktail.
 1048 23. A grands coups de balai-brosse, Bruno balaye le plancher de son manoir.
 1049 24. Grâce à un cric, Maud soulève la voiture pour changer le pneu crevé.
 1050 25. Avec un vieux chiffon, Marie astique le coffre de sa grand-mère.
 1051 26. Avec ses beaux feutres, Yann colorie les animaux de la ferme.

- 1052 27. D'un coup de coupe-papier, Henri déchire l'enveloppe de la lettre tant attendue.
 1053 28. A l'aide de ses crayons de couleurs, Brice dessine un volcan en éruption.
 1054 29. De ses dix doigts, Nina pianote sur la table au rythme de sa chanson préférée.
 1055 30. Avec un gant de toilette, Steve savonne son enfant avant de le mettre au lit.
 1056 31. Equipée de ses longues aiguilles, Maxime tricote une écharpe rouge.
 1057 32. A l'aide de ciseaux, Sonia découpe des personnages en papier.
 1058 33. Avec son stylo à plume, Rose écrit une belle lettre à son amoureux.
 1059 34. Du bout du doigt, Max appuie sur le bouton rouge.
 1060 35. A l'aide de la bonne clé, Jacques ouvre le placard.
 1061 36. Avec un rouleau à pâtisserie, Jade aplatit la pâte à tarte.
 1062 37. A l'aide de grands couverts, Arthur remue la salade verte.

1063

1064 Action context – Non action verb condition (B)

- 1065 1. A l'aide d'une scie électrique, Alain répugne à scier un tronc d'arbre.
 1066 2. En un geste rapide, Lucas feint de jeter la feuille à la poubelle.
 1067 3. Avec sa raquette de tennis, Maud s'applique à taper dans la balle.
 1068 4. Avec un batteur électrique, Emma rechigne à battre le beurre en crème.
 1069 5. Avec ses doigts, Marie peine à tordre une petite tige de fer.
 1070 6. Avec une pince, Anne se lasse de pincer les fils électriques.
 1071 7. Avec une fourchette, Bruno aspire à racler le fond de la casserole.
 1072 8. A l'aide d'une tenaille, Julie choisit de serrer le boulon qui bouge un peu.
 1073 9. Un crayon à la main, Rose se résout à signer le contrat sans le lire.
 1074 10. Par petites touches de pinceau, Elise s'ingénie à vernir ses ongles en bleu turquoise.
 1075 11. Dans la bouteille, Chloé pense agiter la vinaigrette avant de la verser sur sa salade.
 1076 12. A l'aide d'une crème dépilatoire, Louis consent à s'épiler le dos.
 1077 13. A travers ses moufles, Jean tâche de prendre de la neige pour en faire une boule.
 1078 14. Avec son revolver, Thomas projette de tirer sur des bandits en fuite.
 1079 15. A l'aide d'une pioche, Sonia hésite à enfouir son butin en plein jour.
 1080 16. A l'aide d'une faux, Henri rage de faucher les blés à l'ancienne.
 1081 17. D'un coup de poing, Steve essaye de frapper son adversaire en plein visage.
 1082 18. Avec ses ongles, Diane se résigne à gratter le fond de son assiette.
 1083 19. A l'aide de l'arrosoir, Max prévoit de verser de l'eau sur les plantes.
 1084 20. Avec huit balles de cirque, Maxime envisage de jongler une heure sans s'arrêter.
 1085 21. A l'aide d'un démêlant, Anna souhaite peigner ses cheveux crépus.
 1086 22. A l'aide de couverts en bois, Lyse se tâte à secouer la salade.
 1087 23. A l'aide d'un balai bleu, Nina décide de balayer la terrasse.
 1088 24. D'un seul bras, Brice aime soulever la grosse valise de sa femme.
 1089 25. Avec une brosse spéciale, Arthur ambitionne d'astiquer le parquet de son salon.
 1090 26. A l'aide de ses crayons de couleur, Yann rêve de colorier les dessins de son cahier.
 1091 27. D'un geste brusque de la main, Alex tente de déchirer son vieux jean.
 1092 28. Avec ses beaux feutres, Laure prône de dessiner ce qu'elle voit par la fenêtre.

- 1093 29. Sur un clavecin noir, William compte pianoter une ancienne ritournelle.
 1094 30. Avec du gel douche, Claire se propose de savonner les pieds de ses enfants.
 1095 31. Dans son cours de tricot, Irène songe à tricoter des chaussettes.
 1096 32. Avec un couteau pointu, Jade désire découper son morceau de viande.
 1097 33. Avec un crayon à papier, Marc s'apprête à écrire des pense-bêtes sur des post-it.
 1098 34. Sur le bouton vert, Paul prétend appuyer de toutes ses forces.
 1099 35. D'un tour de poignée, Jacques daigne ouvrir la porte du grenier.
 1100 36. Du bout du doigt, Jeanne croit aplatir l'ourlet de son pantalon.
 1101 37. Avec une grande cuillère, Pierre conçoit de remuer la pâte à gâteau.
 1102
 1103 Action context -Pseudo verbs condition (C)
- 1104 1. A l'aide d'une tronçonneuse, Bruno plucotte les arbres marqués d'une croix rouge.
 1105 2. D'un seul bras, Rose enfoupe son adversaire à terre.
 1106 3. Avec son poing, Anne hésipère à la porte pour qu'on lui ouvre.
 1107 4. Avec un fouet, Jade pièpe les blancs d'œufs en neige.
 1108 5. A grands coups de maillet, Jeanne gâne le clou, qui devient inutilisable.
 1109 6. Avec une pincette, Alain tellule les feuilles de la partition.
 1110 7. A l'aide d'une spatule, Thomas tasepme la nourriture collée au fond du bol.
 1111 8. Avec un tournevis, Jacques dève les vis permettant de sa construction.
 1112 9. D'un tracé de plume, Henri prache une lettre écrite sur parchemin.
 1113 10. Avec un vieux chiffon, Diane sange le meuble ancien.
 1114 11. D'un mouvement énergétique de la main, Alex ésore la bouteille de jus.
 1115 12. Grâce à son épilateur électrique, Pierre se trasanne les jambes rapidement.
 1116 13. A l'aide de baguettes chinoises, Irène cétroche un sushi au saumon.
 1117 14. Avec une corde, Jean capame de l'eau du puits.
 1118 15. Avec une truelle, Lucas gricotte ses bien les plus précieux.
 1119 16. A coups de faucille, Max fanse les mauvaises herbes du jardin.
 1120 17. D'un coup de batte de baseball, Elise saude la balle qui parcourt plus de cent mètres.
 1121 18. A l'aide d'un grattoir, Chloé lore l'encre de chine qui déborde de sa lettre.
 1122 19. Avec la théière, Steve quopoud le thé dans les tasses en porcelaine.
 1123 20. Avec des boules multicolores, Maud caffre pour le plaisir de ses petits cousins.
 1124 21. Avec ses doigts, Marie haloque rapidement ses cheveux avant de sortir.
 1125 22. De ses deux mains, Maxime chencre le pommier pour en faire tomber les fruits.
 1126 23. A petits coups de balayette, Brice joine la chambre d'amis.
 1127 24. A l'aide d'un levier, Anna toupe la trappe qui mène au sous-sol.
 1128 25. Avec une brosse spéciale, Lyse britte le meuble ancien.
 1129 26. Avec des pastels, Yann achande les personnages de l'histoire.
 1130 27. En quelques traits de fusain, Arthur jotige un portrait de sa sœur.
 1131 28. Avec la déchiqueteuse, Marc vucle les contrats fallacieux.
 1132 29. Sur son synthé neuf, Nina épague en attendant son professeur de piano.
 1133 30. A l'aide d'un savon parfumé, Laure tassine ses mains.

- 1134 31. Avec la technique du crochet, Louis salait des chaussons pour son filleul.
 1135 32. A l'aide d'un cutter, Sonia shème des patrons en carton.
 1136 33. Muni d'un stylo à encre, Julie firre des poèmes dans son calepin.
 1137 34. Avec son pouce, Emma parmit sur la fenêtre pour l'ouvrir.
 1138 35. A l'aide d'un scalpel, Claire grille l'abdomen de son patient.
 1139 36. Avec un presse-papier, Paul vraie les feuilles qu'il veut ajouter à son herbier.
 1140 37. Grâce à une cuillère en bois, William commore les oignons qui cuisent dans la poêle.

1141

1142 Non action context – Non action verb condition

- 1143 1. Cet après-midi, Lucas décide de se promener dans la campagne.
 1144 2. Au mois d'août, Nina adore se baigner dans la mer.
 1145 3. Tous les six mois, Elise daigne appeler ses grands-parents.
 1146 4. Comme tous les matins, Irène s'apprête à se regarder dans le miroir.
 1147 5. A l'aéroport, Anne se propose d'accueillir les voyageurs.
 1148 6. Dans le parc, Marc projette de rêvasser tout l'après-midi.
 1149 7. A onze heures du matin, Sonia aime faire une pause café.
 1150 8. Pour une fois, Steve consent à laisser la parole aux autres.
 1151 9. Dans l'après-midi, Arthur envisage de s'assoupir sur sa chaise longue.
 1152 10. Pour Pâques, Emma espère recevoir beaucoup de chocolat.
 1153 11. En hiver, Thomas déteste avoir froid.
 1154 12. Une fois de plus, Alain se résout à écouter au lieu de parler.
 1155 13. Par principe, Jade répugne à céder aux caprices de son fils.
 1156 14. Par moments, Laure conçoit d'oublier le travail.
 1157 15. Pour le petit-déjeuner, Brice choisit de rester au lit.
 1158 16. L'année prochaine, Yann ambitionne de suivre une formation d'ingénieur.
 1159 17. Au marché, Bruno hésite à acheter des carottes.
 1160 18. Devant le gendarme, Maxime prétend qu'on lui a volé ses papiers.
 1161 19. Pour ses enfants, Rose aspire à être la meilleure mère possible.
 1162 20. Pour les vacances, William pense naviguer sur le Nil.
 1163 21. Cette fois-ci, Julie accepte de considérer des études en médecine.
 1164 22. Avec tristesse, Paul se résigne à rentrer chez lui bredouille.
 1165 23. A cause de ces rumeurs, Maud se tâte à commander des plats chinois.
 1166 24. Régulièrement, Claire rêve de faire le tour du monde.
 1167 25. Pour son mari, Diane souhaite organiser une soirée d'anniversaire.
 1168 26. Pour le championnat de saut en hauteur, Lyse tente de passer la barre des 2 mètres.
 1169 27. Au bout de vingt ans de carrière, Alex songe à changer de profession.
 1170 28. La semaine prochaine, Jeanne compte demander une augmentation.
 1171 29. En rentrant de l'école, Marie désire raconter sa journée.
 1172 30. Pour le bal de fin d'année, Anna s'imagine danser toute la nuit.
 1173 31. Ce soir, Jacques prévoit de surprendre sa femme avec des fleurs.
 1174 32. Depuis plus d'un an, Jean cherche à entrer dans cette entreprise.

- 1175 33. Le dimanche matin, Louis préfère regarder la télévision.
 1176 34. Cet après-midi, Max essaye de plaire à ses beaux-parents.
 1177 35. En observant son cousin, Chloé croit savoir ce qui le tracasse.
 1178 36. Le week-end, Henri a besoin de s'évader de son quotidien.
 1179 37. La veille de l'interrogation, Pierre s'applique à réciter sa poésie.

1180

1181 **English approximate translation**

1182

1183 Action context – Action verb condition (A)

1184

- 1185 1. With his beautiful tools, Jean saws thin wooden planks.
 1186 2. In a rapid movement of the hand, William throws the paper in the dustbin.
 1187 3. On her keyboard, Anne types a letter of motivation.
 1188 4. With a broom, Chloé beats the Persian carpet.
 1189 5. With his two hands, Marc wrings the towel that fell in the water.
 1190 6. With his two fingers, Alex pinches his classmate's arm.
 1191 7. With a spoon, Claire scrapes the bottom of the saucepan.
 1192 8. With a monkey wrench, Anna tightens the bolt on her bicycle.
 1193 9. With his black pen, Paul signs the renewal contract.
 1194 10. With his paintbrush, Thomas varnishes the ancient piece of furniture.
 1195 11. With her two arms, Diane waves the flag to call for help.
 1196 12. With small pliers, Emma waxes her legs for summer.
 1197 13. With rubber gloves, Pierre takes the sticky mollusc.
 1198 14. With his bow, Lucas shoots at the target.
 1199 15. With a big shovel, Laure buries her treasure in the back of her garden.
 1200 16. With her pruning knife, Elise mows the weed with her father.
 1201 17. With his hammer, Louis hits the nail repeatedly.
 1202 18. With the sponge, Alain scrapes the dirty plate until it is shiny.
 1203 19. With a jug, Jeanne pours water in the glasses.
 1204 20. Single-handedly, Irène juggles four balls.
 1205 21. With her pink brush, Lyse combs her Barbie's hair with care.
 1206 22. With a cocktail shaker, Julie shakes the ingredients of a delicious cocktail.
 1207 23. With a long-handled scrubbing brush, Bruno sweeps the floor of his manor.
 1208 24. With a jack, Maud lifts the car to change a puncture.
 1209 25. With an old cloth, Marie polishes her grand-mother's chest.
 1210 26. With his beautiful felt-tip, Yann colors the farm animals.
 1211 27. With a paper-knife, Henri tears the envelop of the long awaited letter.
 1212 28. Thanks to his color pencils, Brice draws an erupting volcano.
 1213 29. With her ten fingers, Nina drums on the table following her favorite song's rhythm.
 1214 30. With a flannel, Steve soaps his child before putting him to bed.
 1215 31. With long needles, Maxime knits a red scarf.
 1216 32. With scissors, Sonia cuts paper en up.
 1217 33. With her fountain pen, Rose writes a beautiful letter to her lover.
 1218 34. With the tip of his finger, Max presses the red button.

- 1219 35. With the right key, Jacques opens the cupboard.
 1220 36. With a rolling pin, Jade flattens the pastry.
 1221 37. With big flatware, Arthur shakes the green salad.

1222

1223 Action context – Non action verb condition (B)

1224

- 1225 1. With an electric saw, Alain is reluctant to saw the tree trunk.
 1226 2. In a rapid gesture, Lucas pretends to throw the sheet in the dustbin.
 1227 3. With her tennis racket, Maud applies to hit the ball.
 1228 4. With an electric whisk, Emma balks at beating the butter into cream.
 1229 5. With her fingers, Marie struggles to twist a small rod.
 1230 6. With pliers, Anne grows tired of pinching electric wires.
 1231 7. With a fork, Bruno aspires to scraping the bottom of the saucepan.
 1232 8. With a pair of pincers, Julie chooses to tighten the loose bolt.
 1233 9. A pen in the hand, Rose resolves to sign the contract without reading it.
 1234 10. With small paintbrush strokes, Elise strives to varnish her nails in blue.
 1235 11. In the bottle, Chloé thinks about shaking the vinegar sauce before pouring it on the salad.
 1236 12. With a hair-removing cream, Louis agrees to wax his back.
 1237 13. Through his mittens, Jean tries to take the snow to shape it into a ball.
 1238 14. With his revolver, Thomas plans to shoot on the running bandits.
 1239 15. With a pickaxe, Sonia hesitates to bury her loot in broad daylight.
 1240 16. With a scythe, Henri fumes at the idea of mowing the wheat in the traditional way.
 1241 17. With a punch, Steve tries to hit his opponent in the face.
 1242 18. With her nails, Diane resigns herself to scraping the bottom of her plate.
 1243 19. With a watering can, Max plans to pour water on the plants.
 1244 20. With eight circus balls, Maxime considers juggling one hour straight.
 1245 21. With to a hair-conditioner, Anna wishes to comb her fuzzy hair.
 1246 22. With to wooden flatware, Lyse hesitates to shake the salad.
 1247 23. With to a blue broom, Nina decides to sweep the terrace.
 1248 24. With one arm, Brice likes to lift his wife's big luggage.
 1249 25. With a special brush, Arthur has the ambition to polish the living room floor.
 1250 26. With his color pencils, Yann dreams of coloring the drawings in his notebook.
 1251 27. With a sudden gesture of the hand, Alex attempts to tear his old jeans.
 1252 28. With her beautiful felt-tips, Laure recommends to draw what she sees through the window.
 1253 29. On a black harpsichord, William intends to tinkle away an old tune.
 1254 30. With a shower gel, Claire proposes to soap her children's feet.
 1255 31. In a knitting class, Irene thinks about knitting socks.
 1256 32. With a sharp knife, Jade wants to cut her loaf of meat.
 1257 33. With a black pencil, Marc gets ready to write reminders on post-its.
 1258 34. On a green button, Paul pretends to press with all his strength.
 1259 35. With a turn of the handle, Jacques deigns to open the attic door.
 1260 36. With the tip of her finger, Jeanne believes she is flattening her trousers hem.
 1261 37. With a big spoon, Pierre designs to stir the pastry.

1262

1263 Action context -Pseudo verbs condition (C)

1264

- 1265 1. With a chain saw, Bruno plucottes the trees that are marked with a red cross.
- 1266 2. With one arm, Rose enfoupe her opponent to the ground.
- 1267 3. With her fist, Anne hesiperes on the door for someone to open it.
- 1268 4. With a whisk, Jade piepes the eggs whites until stiff.
- 1269 5. With heavy mallet blows, Jeanne ganes the nail, making it unusable.
- 1270 6. With a pair of tweezers, Alain tellules the score pages.
- 1271 7. With a spatula, Thomas tasempes the food stuck at the bottom of the bowl.
- 1272 8. With a screwdriver, Jacques deves the screws allowing for the construction.
- 1273 9. With a nib, Henri praches a letter on parchment.
- 1274 10. With an old cloth, Diane sanges the old piece of furniture.
- 1275 11. With a dynamic hand gesture, Alex esores the juice bottle.
- 1276 12. With his electric epilator, Pierre trasames his legs quickly.
- 1277 13. With chopsticks, Irène cetroches a salmon sushi.
- 1278 14. With a rope, Jean capames water from the well.
- 1279 15. With a trowel, Lucas gricottes his most precious goods.
- 1280 16. With a sickle, Max fanses the garden weed grass.
- 1281 17. With a baseball bat blow, Elise saudes the ball, which covers over a hundred meters.
- 1282 18. With a scraper, Chloé lores the Indian ink overflowing her letter.
- 1283 19. With the teapot, Steve quopouds the tea in porcelain teacups.
- 1284 20. With multicolored balls, Maud caffres to amuse her little cousins.
- 1285 21. With her fingers, Marie quickly haloques her hair before going out.
- 1286 22. With his two hands, Maxime chencres the apple tree to make the fruits fall.
- 1287 23. With small brush strokes, Brice joins the guest room.
- 1288 24. With a lever, Anna toupes the trap door leading to the basement.
- 1289 25. With a special brush, Lyse brittes the ancient piece of furniture.
- 1290 26. With pastels, Yann achandes the great men of history.
- 1291 27. With a few lines of charcoal, Arthur jotiges a portrait of his sister.
- 1292 28. With the shredder, Marc vucles the fallacious contracts.
- 1293 29. On her new synthesiser, Nina epagues while waiting for her piano teacher.
- 1294 30. With a perfumed soap, Laure tassines her hands.
- 1295 31. With the crochet technique, Louis salatits slippers for his godchild.
- 1296 32. With a cutter, Sonia shemes sewing patterns in cardboard.
- 1297 33. With an ink pen, Julie firres poems in her notebook.
- 1298 34. With her thumb, Emma pirimits on the window to open it.
- 1299 35. With a scalpel, Claire grittes the abdomen of her patient.
- 1300 36. With a paperweight, Paul vraités the leaves he wants to add to herbarium.
- 1301 37. With a wooden spoon, William commores the onions that are cooking in the pan.

1302

1303 Non action context – Non action verb condition

1304

- 1305 1. This afternoon, Lucas decides to take a walk in the country.
- 1306 2. In August, Nina loves to bathe in the sea.

- 1307 3. Every six months, Elise calls her grand-parents.
 1308 4. Every morning, Irene gets ready to look at herself in the mirror.
 1309 5. At the airport, Anne offers to welcome the travelers.
 1310 6. In the park, Marc plans to daydream all afternoon.
 1311 7. At eleven in the morning, Sonia likes to take a coffee break.
 1312 8. For once, Steve agrees to letting others speak.
 1313 9. In the afternoon, Arthur envisages to fall asleep in his deckchair.
 1314 10. For Easter, Emma hopes to receive a lot of chocolate.
 1315 11. In winter, Thomas hates to be cold.
 1316 12. One more time, Alain resolves to listen instead of speaking.
 1317 13. On principle, Jade is reluctant to give in to her son's whims.
 1318 14. From time to time, Laure plans to forget about her work.
 1319 15. For breakfast, Brice chooses to stay in bed.
 1320 16. Next year, Yann has the ambition to follow an engineering course.
 1321 17. At the market, Bruno hesitates to buy carrots.
 1322 18. In front of the policeman, Maxime pretends he was stolen his papers.
 1323 19. For her children, Rose aspires to be the best mother.
 1324 20. For the holidays, William thinks about sailing the Nile.
 1325 21. This time, Julie accepts to consider studies in medicine.
 1326 22. With sadness, Paul resigns himself to go home empty-handed.
 1327 23. Because of the rumors, Maud hesitates to order the Chinese dishes.
 1328 24. On a regular basis, Claire dreams of traveling around the world.
 1329 25. For her husband, Diane wishes to organize a birthday party.
 1330 26. For the high-jump championship, Lyse tries to jump the 2 meters bar.
 1331 27. After a carrier of twenty years, Alex thinks about starting a new profession.
 1332 28. Next week, Jeanne plans to ask for a raise.
 1333 29. Back from school, Marie wishes to tell about her day.
 1334 30. For the prom, Anna imagines herself dancing all night.
 1335 31. Tonight, Jacques plans to surprise his wife with flowers.
 1336 32. Since last year, Jean tries to enter this company.
 1337 33. Sunday morning, Louis prefers to watch television.
 1338 34. This afternoon, Max tries to please his parents-in-law.
 1339 35. While observing her cousin, Chloé thinks she knows what is bothering him.
 1340 36. On weekends, Henri needs to get away from his routine.
 1341 37. The day before the test, Pierre applies to recite his poem.

1342

APPENDIX C: Parameters of lexical control.

1344

VERBS	frequency	Letters	Syllables	Bigrams	Trigrams
	ranges				
scier	2,39	5	1	2053,7	232,24
jeter	38,77	5	2	6096,66	563,97
râper	0,23	5	2	1759,06	99,85
Saler	0,39	5	2	6306,76	471,06

Tordre	2,9	6	1	5814,48	338,09
Pincer	2,35	6	2	3354,96	277,8
Racler	1,06	6	2	3989,2	227,73
Serrer	13,42	6	2	8611,9	1106,28
signer	9,23	6	2	3330,94	544,8
vernir	0,39	6	2	3561,04	660,46
agiter	6,68	6	3	4791,1	466,91
épiler	0,68	6	3	3463,74	210,76
prendre	256,16	7	1	5136,04	955,6
brosser	1,65	7	2	4158,96	599,1
enfouir	1,9	7	2	4528,46	371,87
faucher	2,06	7	2	3594,3	728,2
frapper	21,19	7	2	2929,02	354,41
gratter	4,94	7	2	4152,75	744,68
griffer	1,39	7	2	2372,61	141,21
jongler	0,94	7	2	6503,16	289,8
mendier	1,81	7	2	4827,74	908,19
montrer	66,61	7	2	10581,79	2856,44
peigner	0,81	7	2	3148,86	288,22
secouer	8	7	2	5271,19	540,37
arroser	2,55	7	3	2497,37	412,32
balayer	4,19	7	3	2455,48	246,47
soulever	11,45	8	2	9276,43	1187,34
astiquer	1,16	8	3	3880,11	594,07
colorier	0,32	8	3	5898,38	615,55
déchirer	5,16	8	3	3705,59	572,54
dessiner	9,74	8	3	16644,66	3172,44
pianoter	0,19	8	3	2788,21	149,2
savonner	0,77	8	3	3341,17	403,38
tricoter	1,77	8	3	2900,61	193,54
découper	3,81	8	3	3043,4	486,1
	13,9	6,8	2,3	4765	629

1345

	frequency				
NOUNS	ranges	Letters	Syllables	Bigrams	Trigrams
aigle	9	5	1	3627,42	194,03
hêtre	3,1	5	1	4917,89	1667,96
avion	34,71	5	2	3791,62	237,67
canoë	1,29	5	3	4856,14	159,17
grotte	12,35	6	1	4013,74	424
étoile	32,42	6	2	3838,43	227,65
toison	3,42	6	2	8015,57	1263,44
mûrier	0,35	6	2	2879,87	288,44
requin	1,29	6	2	3741,16	159,44
canyon	0,58	6	2	4775,36	98,74

écluse	1,9	6	2	1672,2	184,56
moulin	14,52	6	2	11156,36	676,74
chambre	231,23	7	1	3132,07	1005,93
terrain	61,87	7	2	4704,97	969,53
vitrine	11,42	7	2	4474,5	532,88
sentier	16,39	7	2	7737,99	1324,38
chateau	3,52	7	2	3897,52	1058,85
bosquet	1,77	7	2	2248,54	599,46
caverne	4,9	7	2	2999,25	412,82
falaise	9,74	7	2	4701,2	798,53
iceberg	0,77	7	2	1188,83	31,97
licorne	1,1	7	2	2571,27	397,42
pommier	5,35	7	2	7236,32	1767,02
prairie	9,29	7	2	6623,51	663,49
tempête	17,42	7	2	2971,79	562,34
oseraie	0,29	7	3	2658,04	311,02
grillage	5	8	2	1899,71	319,69
banquise	1	8	2	3695,2	282,94
barrière	12,48	8	2	4371,53	391,89
moquette	7,97	8	2	2650,77	339,62
penderie	1,39	8	2	4693,45	765,49
rambarde	1,32	8	2	1494,19	156,91
monument	8,61	8	3	6753,73	1246,29
cerisier	1,68	8	3	6076,53	479,05
chevalet	3,35	8	3	2509,06	544,19

15,2 6,8 2,0 4245 587

1346

FQ OCCU	F(1, 142)=.0006; p = .9798	0,90
SYLL	F(1, 142)=1.7373; p = .1897	0,09
BIGR	F(1, 142)=1.8422; p = .1769	0,39
TRIG	F(1, 142)=.5321; p = .4670	0,76

1347

	NOUNS	VERBS
FRQ	13,92	15,22
LETT	6,80	6,80
SYLL	2,26	2,03
BIGR	4765	4245
TRIG	629	587

1348

1349 **APPENDIX D: Stimuli Validation**

1350 Action and non-action words validation

1351

1352 Frequency and the degree of effector specificity of action and nonaction words were controlled.
1353 The frequency of use of target words was evaluated with the Lexique 3 data base (New et al., 2001).
1354 All target words presented moderate levels of frequency.
1355 As a measure of “degree of effector specificity of action sentences”, 36 subjects were asked to
1356 evaluate, on a 1 (this is not a hand action) to 5 (this is a hand action) rating scale, if the action
1357 encoded by the sentence was a hand action. All hand actions expressed in the action-action sentences
1358 were highly prototypical of their effector ($M= 4.9$, $SD= 0.05$, $M= 4.8$, $SD= 0.08$, $M= 4.8$, $SD= 0.12$
1359 for A, B, and C action context lists, respectively).
1360 To validate that non-action verbs denoted no action performed with the hand or arm we have
1361 considered as non-action verbs only those with low degree of effector specificity (under 2) ($M= 1.1$,
1362 $SD= 0.18$).
1363
1364 Action context validation
1365
1366 The three lists of action contexts were validated regarding the cloze probability of the hand action
1367 verb applying a questionnaire to 36 undergraduate students.
1368 To determine whether context was predictive of the verb, subjects were asked to evaluate how fitting
1369 the final verb of the sentence was to the previous context using a 5-point Likert scale. Zero scores
1370 indicated that verbs were extremely unpredictable by their contexts and a score of 5 indicated high
1371 predictability. To ensure that context was predictive of the verb, sentences with low verb
1372 predictability (under 4) were eliminated ($M= 4.46$, $SD= 0.22$).
1373 Pseudo-verbs validation
1374
1375 Thirty-seven pseudo-verbs were created obeying French’s phonotactic constraints using the «
1376 Lexique Toolbox » of the data base Lexique 3 (New et al., 2001).
1377 They were validated by applying a questionnaire to 36 undergraduate students about the soundness of
1378 the verb as a French verb. Subjects were asked to judge yes or no the pseudo-verb sound as a French
1379 verb. Pseudo-verbs with a score under 85% were eliminated ($M= 93.6$, $SD= 4.4$).
1380

Figure 1.TIF

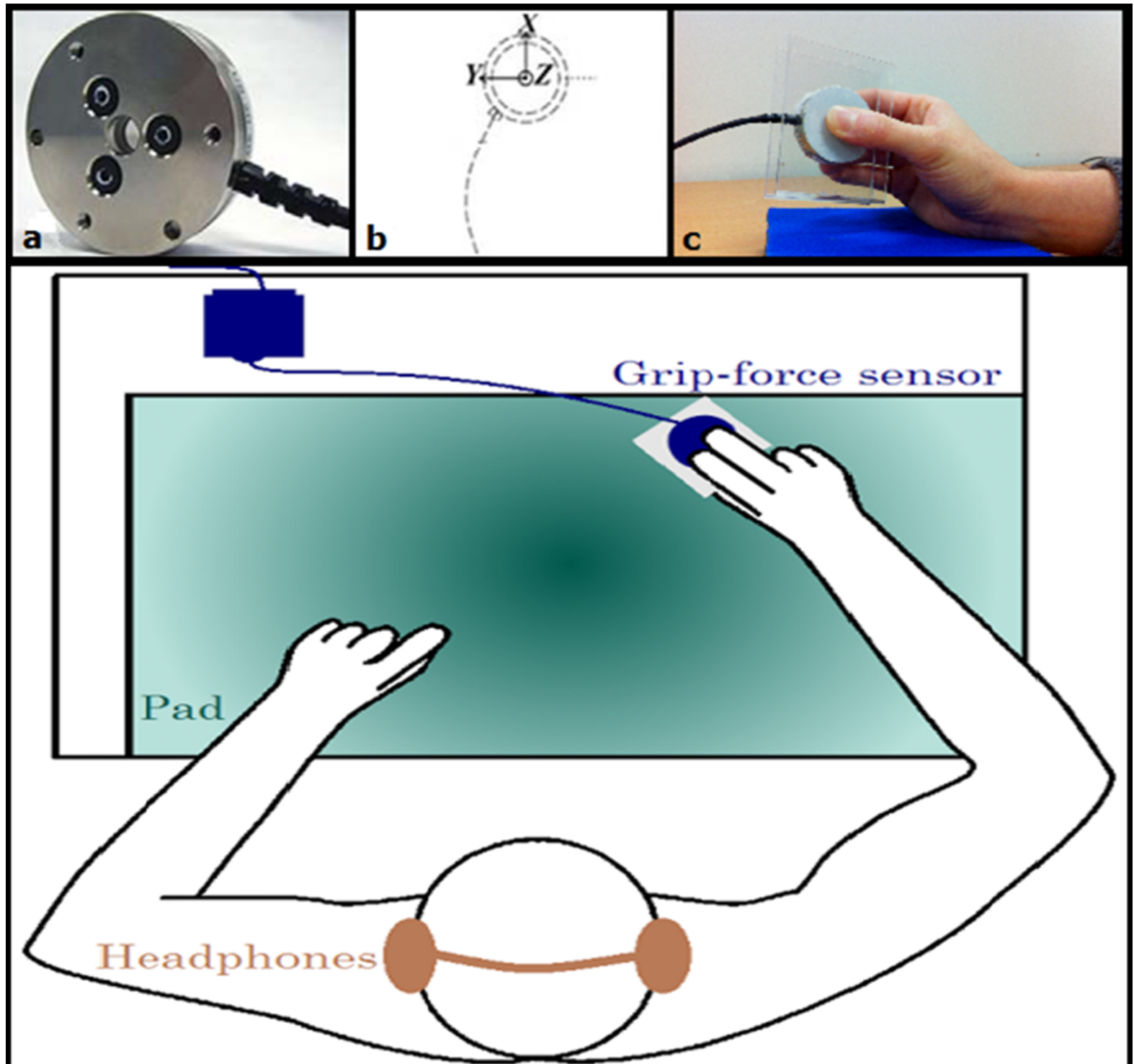


Figure 2.TIF

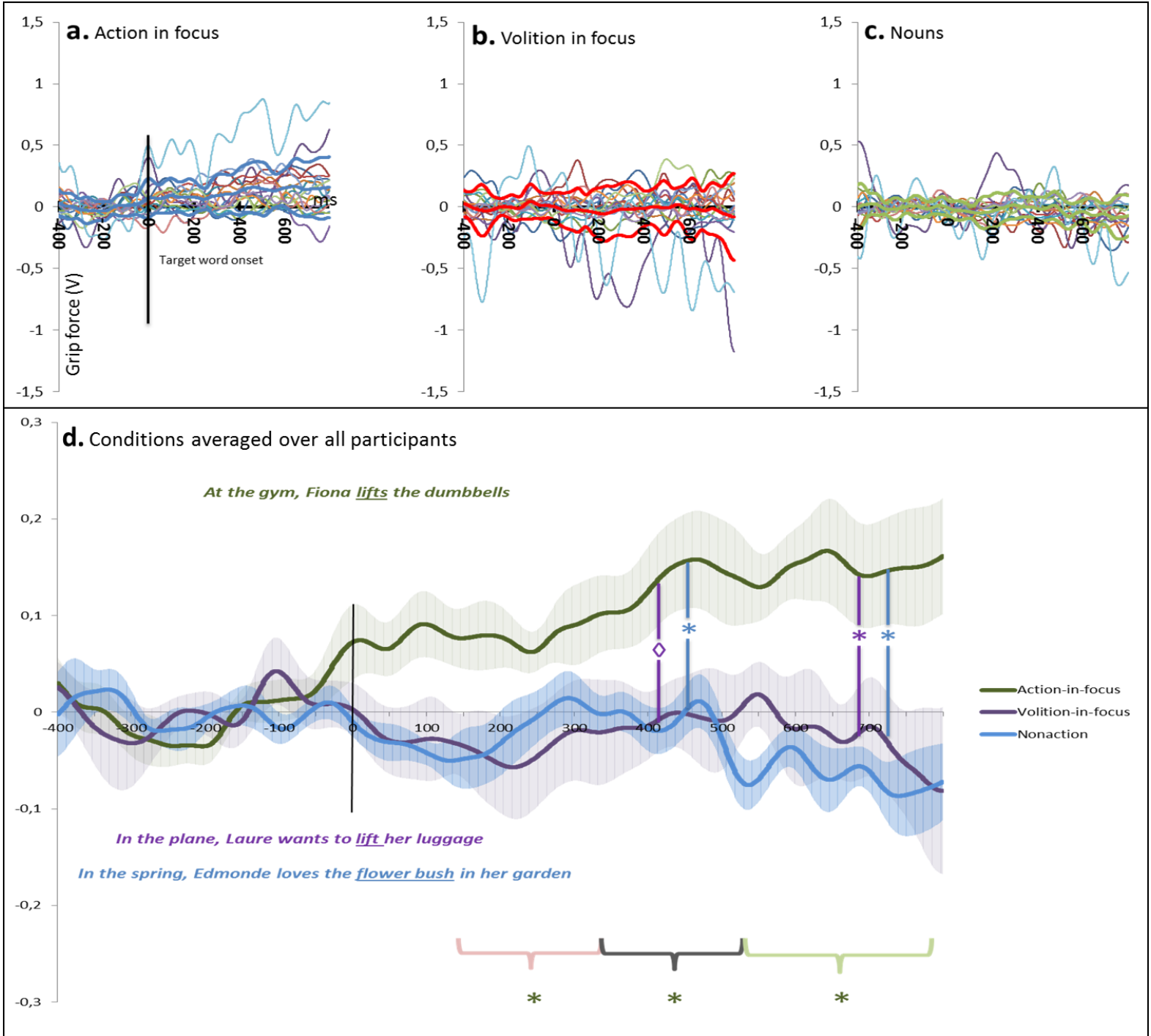


Figure 3.TIF

