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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

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

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

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

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

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

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

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

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

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

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

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

2. Materials and methods

2.1. Experiment 1: Volition

Ethics Statement

All of the 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 = 1.5) and right-handed (Edinburgh handedness inventory (Oldfield, 1971), with normal hearing and no reported history of psychiatric or neurological disorders. Twenty-five participants (including 13 females) participated in this study. Eight participants were eliminated from the analysis due to an extremely weak signal throughout the experiment, thus preventing the capture of grip-force. We used a grip-force mean below 0.13V in combination with the absence of signal changes throughout the experiment as criteria for discarding participants from the analyses.

Stimuli

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

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

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

Nouns	Au printemps, Edmonde aime le bosquet de fleur de son jardin.	*In the spring, Edmonde loves the flower-bush in her garden*

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

Equipment and data Acquisition

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

Procedure

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

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

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

Data analysis

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

(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

in the analysis.

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

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

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

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

In summary, the present study exploited four conditions:

a) action $_{context}$ action $_{verb}$ condition (action verb in action context)
b) action $_{context}$ pseudoverb condition (pseudo-verb in action context)
c) action $_{context}$ non-action $_{verb}$ condition (non-action verb in action context)
d) non-action $_{context}$ non-action $_{verb}$ condition (non-action in non-action context).

Four examples of experimental stimuli are provided in Table 2.

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

Condition	**Sentence**	**English approximate translation**

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

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

Equipment and data Acquisition

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

Procedure

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

Data analysis

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

3. Results

3.1. Results Experiment 1: Volition

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

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

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

The ANOVA revealed significant effects of the conditions in the last two time windows (F(2, 32)=3.4505, p=.043 and F(2, 32)=5.6477, p=.007 respectively). Post hoc comparison (Bonferroni) for the second window showed that the Action condition (M = 0.08 V, SD = 0.1) differed significantly from the Volition condition (M = -0.01 V, SD = 0.1) [p = .05] and just failed to be significantly different from the Noun condition (M = -0.009 V, SD = 0.08) [p = .06 ns)]. In the last window post hoc comparison revealed that the Action condition (M = 0.14 V, SD = 0.19) different from the Volition condition (M = -0.02 V, SD = 0.18) [p =.02] as well as from the Noun condition (M = -0.03 V, SD = 0.8) [p = .007]. Table 3 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 vs. Nouns conditions as well as between the Action vs. Volition conditions.
All together these analyses confirm that the same action words embedded in sentences whose focus is on the mental state of the agent do not increase grip force in the same way as when they are embedded within sentences that focus the action.

Time window 120-320 ms	Nouns	Volition
Action	**0.92**	**0.78**
Volition	0.13	
Time window 320-520 ms	Nouns	Volition
Action	**0.99**	**0.76**
Volition	0.08	
Time window 520-800 ms	Nouns	Volition
Action	**1.26**	**0.92**
Volition	0.08	

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

3.2. Results Experiment 2: Pseudo-verbs

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

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

Time window 120-320 ms	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
Time window 320-520 ms	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**

Time window 520-800 ms	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**

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

4. Discussion

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

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

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

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

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

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

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

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

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

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6. Figure legends

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

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

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

APPENDIX A : Sentences list Experiment 1.

Volition-in-focus Condition

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

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

Action-in-focus condition

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

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

Nouns condition

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

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

English approximate translation

Volition-in-focus Condition

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.

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

Action-in-focus condition

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

21. Through the window, Jacqueline shows the path.
22. In the morning, Mathilde combs her long hair.
23. In the bar, Anne shakes the bottle of juice.
24. In the evening, Vincente waters the plants.
25. In the late afternoon, Karine sweeps the sidewalk.
26. Inside the plane, Laure lifts her luggage.
27. In the kitchen, Madeleine polishes the back of the saucepan.
28. In his grand-mother's house, Stéphane colors the drawings.
29. At the post office, Maël tears the envelop of the received letter up.
30. In the countryside, Rémi draws the outline of the mountains.
31. In the traffic, Patrick drums his fingers on the wheel.
32. In the shower, Pauline soaps her child's hair.
33. This winter, Sabine knits a scarf.
34. At school, Salvador cuts paper men up.
35. In her bedroom, Mathilde combs her doll's hair.

Nouns condition

1. In the mountain sky, Léonard sees the eagle gliding.
2. In the woods, Arthur contemplates the beech dating from 1780.
3. Tonight, Allan awaits his plane to go to Scotland.
4. On the riverbank, Frank chooses a canoe for the day.
5. In the sky, Willylooks at a bright shooting star.
6. Today, Aurélie discovers the cave where the treasure is hidden.
7. At the zoo, Brigitte admires the fleece of the fawn lion.
8. From her window, Chloé appreciates the mulberry tree facing the cabin.
9. At the aquarium, Damien observes the white shark.
10. At the end of the walk, Daniel sees the canyon.
11. Unanimously, Raphaël opens the lock for the boat.
12. On the hill, Aurore looks for the biggest mill.
13. On the phone, Emma books the hotel room.
14. At the solicitor's office, Erick estimates the value of the site.
15. In the shopping center, Léa inspects the shop window before walking in.
16. In the forest, Emile explores the bushy path.
17. In the desert, Abdallah venerates his camel.
18. In spring, Edmonde likes her garden's fower grove.
19. In the theme park, Thierry visits the dragon cave.
20. During the descent, Eléonore thinks about the cliff behind her.
21. In Patagonia, Françoise studies the famous giant iceberg.
22. In her bed, Véronique dreams about a unicorn playing in the grass.
23. At the farm, Victoria takes care of her grand-mother's apple tree.
24. In her dreams, Virginie imagines a peaceful meadow.

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

APPENDIX B: Sentence list Experiment 2.

Action context – Action verb condition (A)

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

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

Action context – Non action verb condition (B)

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

29. Sur un clavecin noir, William compte pianoter une ancienne ritournelle.
30. Avec du gel douche, Claire se propose de savonner les pieds de ses enfants.
31. Dans son cours de tricot, Irène songe à tricoter des chaussettes.
32. Avec un couteau pointu, Jade désire découper son morceau de viande.
33. Avec un crayon à papier, Marc s'apprête à écrire des pense-bêtes sur des post-it.
34. Sur le bouton vert, Paul prétend appuyer de toutes ses forces.
35. D'un tour de poignée, Jacques daigne ouvrir la porte du grenier.
36. Du bout du doigt, Jeanne croit aplatir l'ourlet de son pantalon.
37. Avec une grande cuillère, Pierre conçoit de remuer la pâte à gâteau.

Action context -Pseudo verbs condition (C)

1. A l'aide d'une tronçonneuse, Bruno plucotte les arbres marqués d'une croix rouge.
2. D'un seul bras, Rose enfoupe son adversaire à terre.
3. Avec son poing, Anne hésipère à la porte pour qu'on lui ouvre.
4. Avec un fouet, Jade pièpe les blancs d'œufs en neige.
5. A grands coups de maillet, Jeanne gâne le clou, qui devient inutilisable.
6. Avec une pincette, Alain tellule les feuilles de la partition.
7. A l'aide d'une spatule, Thomas tasempe la nourriture collée au fond du bol.
8. Avec un tournevis, Jacques dève les vis permettant de sa construction.
9. D'un tracé de plume, Henri prache une lettre écrite sur parchemin.
10. Avec un vieux chiffon, Diane sange le meuble ancien.
11. D'un mouvement énergique de la main, Alex ésore la bouteille de jus.
12. Grâce à son épilateur électrique, Pierre se trasanne les jambes rapidement.
13. A l'aide de baguettes chinoises, Irène cétroche un sushi au saumon.
14. Avec une corde, Jean capame de l'eau du puits.
15. Avec une truelle, Lucas gricotte ses bien les plus précieux.
16. A coups de faucille, Max fanse les mauvaises herbes du jardin.
17. D'un coup de batte de baseball, Elise saude la balle qui parcourt plus de cent mètres.
18. A l'aide d'un grattoir, Chloé lore l'encre de chine qui déborde de sa lettre.
19. Avec la théière, Steve quopoud le thé dans les tasses en porcelaine.
20. Avec des boules multicolores, Maud caffre pour le plaisir de ses petits cousins.
21. Avec ses doigts, Marie haloque rapidement ses cheveux avant de sortir.
22. De ses deux mains, Maxime chencre le pommier pour en faire tomber les fruits.
23. A petits coups de balayette, Brice joine la chambre d'amis.
24. A l'aide d'un levier, Anna toupe la trappe qui mène au sous-sol.
25. Avec une brosse spéciale, Lyse britte le meuble ancien.
26. Avec des pastels, Yann achande les personnages de l'histoire.
27. En quelques traits de fusain, Arthur jotige un portrait de sa sœur.
28. Avec la déchiqueteuse, Marc vucle les contrats fallacieux.
29. Sur son synthé neuf, Nina épague en attendant son professeur de piano.
30. A l'aide d'un savon parfumé, Laure tassine ses mains.

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

Non action context – Non action verb condition

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

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

English approximate translation

Action context – Action verb condition (A)

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

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

Action context – Non action verb condition (B)

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

Action context -Pseudo verbs condition (C)

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

Non action context – Non action verb condition

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

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

APPENDIX C: Parameters of lexical control.

VERBS	frequency ranges	Letters	Syllables	Bigrams	Trigrams
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

NOUNS	**frequency 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
chameau	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

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

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

APPENDIX D: Stimuli Validation

Action and non-action words validation

Frequency and the degree of effector specificity of action and nonaction words were controlled.
The frequency of use of target words was evaluated with the Lexique 3 data base (New et al., 2001). All target words presented moderate levels of frequency.
As a measure of "degree of effector specificity of action sentences", 36 subjects were asked to evaluate, on a 1 (this is not a hand action) to 5 (this is a hand action) rating scale, if the action encoded by the sentence was a hand action. All hand actions expressed in the action-action sentences were highly prototypical of their effector (*M*= 4.9, *SD*= 0.05, *M*= 4.8, *SD*= 0.08, *M*= 4.8, *SD*= 0.12 for A, B, and C action context lists, respectively).
To validate that non-action verbs denoted no action performed with the hand or arm we have considered as non-action verbs only those with low degree of effector specificity (under 2) (*M*= 1.1, *SD*= 0.18).

Action context validation

The three lists of action contexts were validated regarding the cloze probability of the hand action verb applying a questionnaire to 36 undergraduate students.
To determine whether context was predictive of the verb, subjects were asked to evaluate how fitting the final verb of the sentence was to the previous context using a 5-point Likert scale. Zero scores indicated that verbs were extremely unpredictable by their contexts and a score of 5 indicated high predictability. To ensure that context was predictive of the verb, sentences with low verb predictability (under 4) were eliminated (*M*= 4.46, *SD*= 0.22).
Pseudo-verbs validation

Thirty-seven pseudo-verbs were created obeying French's phonotactic constraints using the « Lexique Toolbox » of the data base Lexique 3 (New et al., 2001).
They were validated by applying a questionnaire to 36 undergraduate students about the soundness of the verb as a French verb. Subjects were asked to judge yes or no the pseudo-verb sound as a French verb. Pseudo-verbs with a score under 85% were eliminated (*M*= 93.6, *SD*= 4.4).

Figure 1.TIF

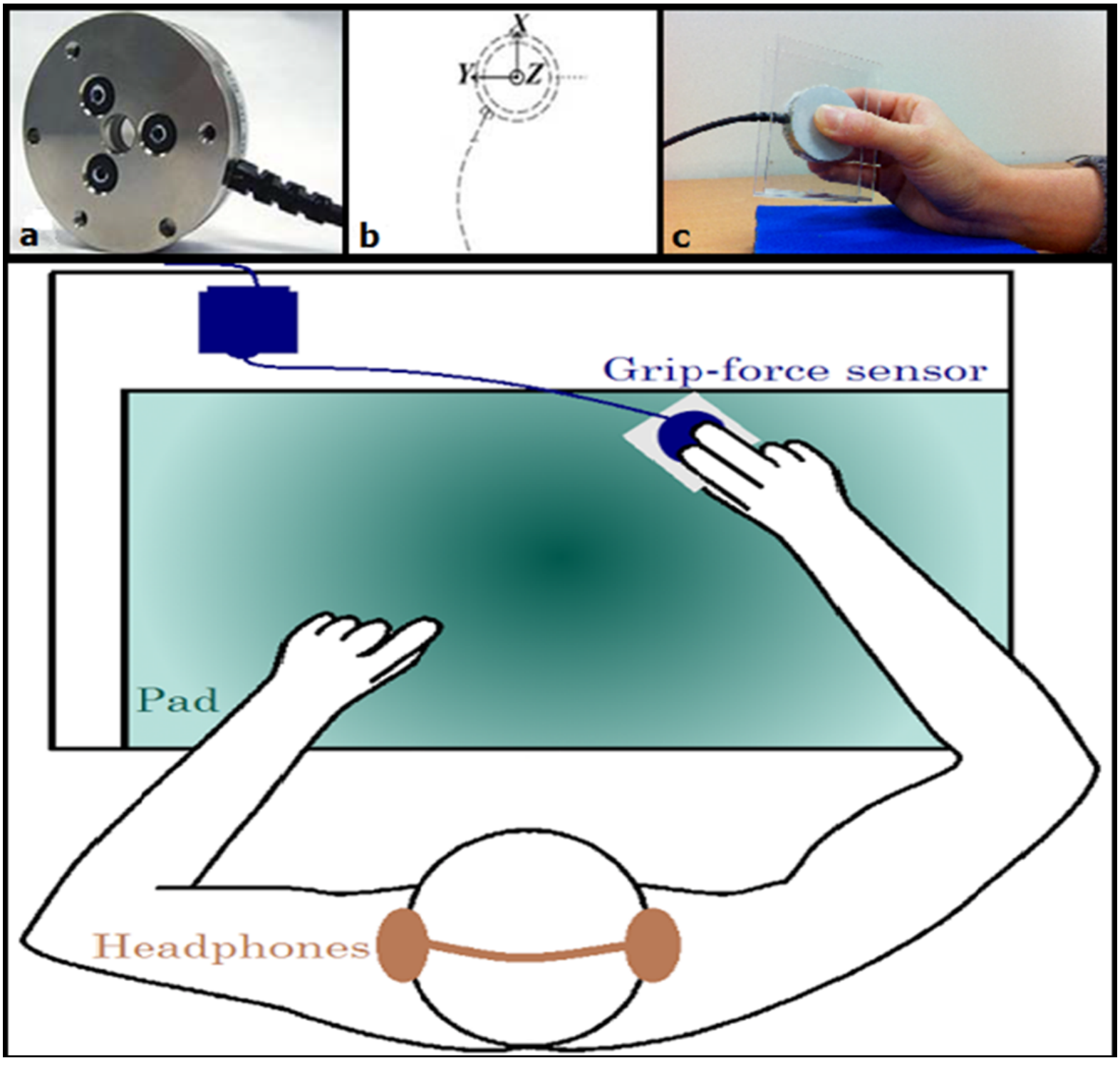


Figure 2.TIF

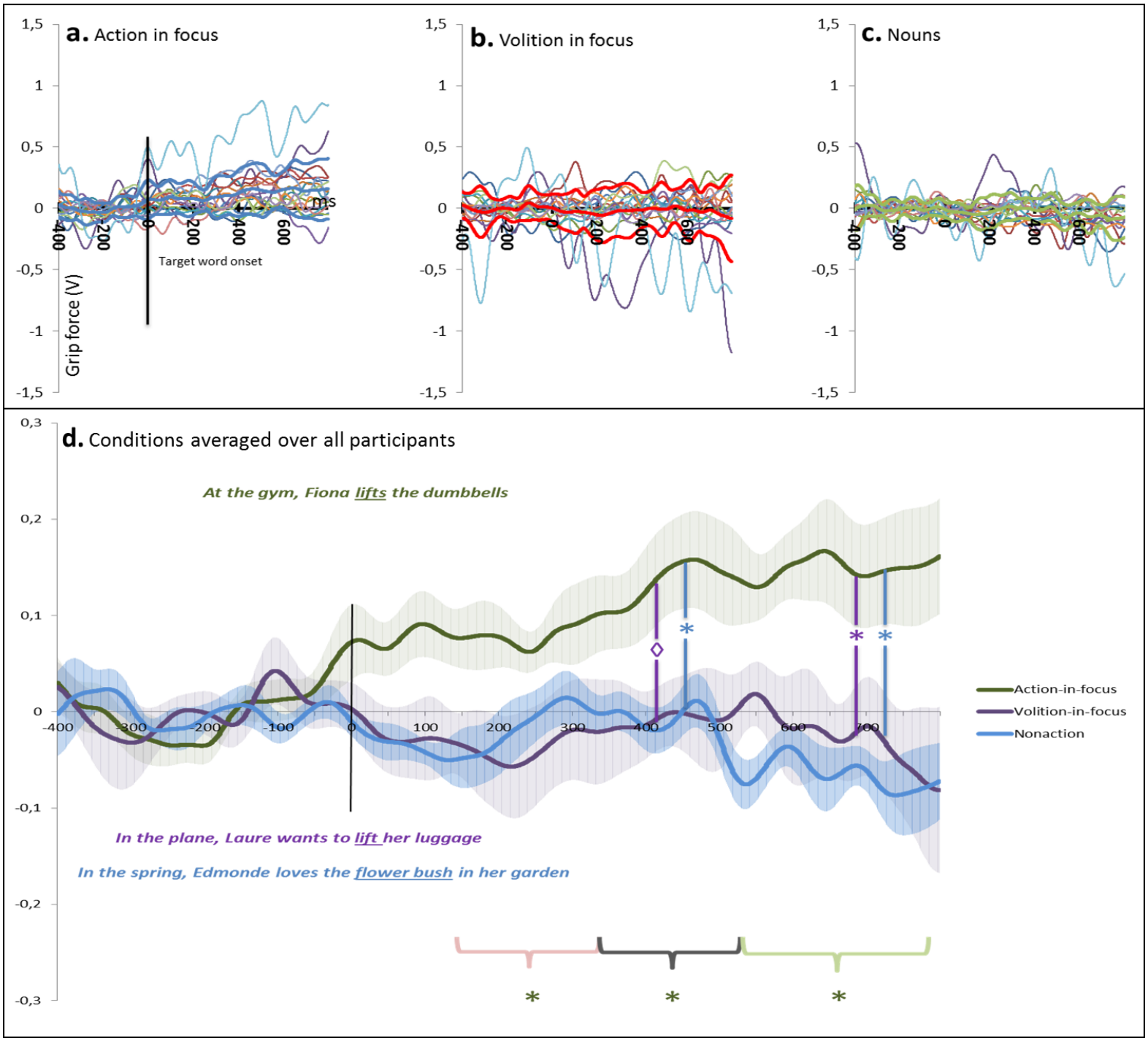
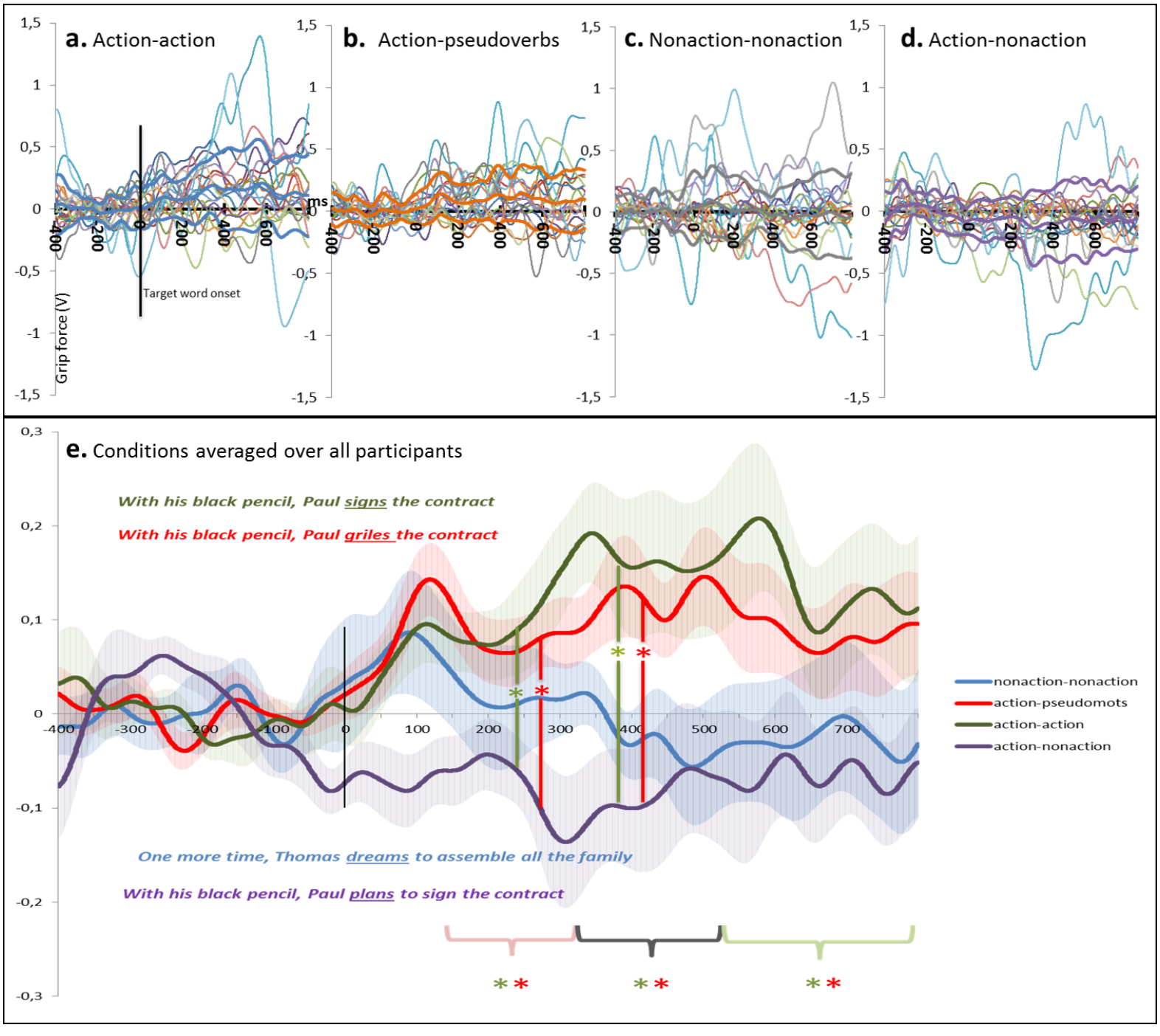

a. Action in focus
b. Volition in focus
c. Nouns
Grip force (V)
Target word onset
ms
d. Conditions averaged over all participants
At the gym, Fiona lifts the dumbbells
In the plane, Laure wants to lift her luggage
In the spring, Edmonde loves the flower bush in her garden
Action-in-focus
Volition-in-focus
Nonaction

Figure 3.TIF


a. Action-action
b. Action-pseudoverbs
c. Nonaction-nonaction
d. Action-nonaction
Grip force (V)
ms
Target word onset
e. Conditions averaged over all participants
With his black pencil, Paul signs the contract
With his black pencil, Paul griles the contract
One more time, Thomas dreams to assemble all the family
With his black pencil, Paul plans to sign the contract
nonaction-nonaction
action-pseudomots
action-action
action-nonaction