Language that puts you in touch with your bodily feelings: The Multimodal Responsiveness of Affective Expressions.

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Running head: MULTIMODAL RESPONSIVENESS OF AFFECTIVE EXPRESSIONS

Language that puts you in touch with your bodily feelings: The Multimodal Responsiveness of Affective Expressions.

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Abstract

Observing a smile activates the very same facial muscles in a perceiver (e.g., Dimberg, Thunberg, & Elmehed, 2000). In experiment 1, we predicted and revealed that verbal stimuli (verbs of action) that map emotional expressions elicit the same facial muscle activity (facial EMG) as visual stimuli do. This furnished evidence that language mapping facial muscular activity is not amodal as traditionally assumed, but bodily grounded. These findings were extended in exp. 2, in which subliminally presented verbal stimuli were shown to drive muscle activation and shape our judgments, but not when muscle activation was blocked. These findings provide an important bridge between research on the neurobiological basis of language and related behavioral research. The implications of these findings for theories of language and other domains in cognitive psychology (e.g., priming) are discussed.

WORD COUNT (abstract): 132 words

Language that puts you in touch with your bodily feelings: The Multimodal Responsiveness of Affective Expressions.

It is well documented that registering a smile or a frown activates the corresponding facial muscles in a perceiver (e.g., Dimberg & Petterson, 2000; Dimberg, Thunberg, & Elmehed, 2000). Such mirroring in motor movements is assumed to guide our understanding of the other in general (cf. Gallese, 2006; Rizollatti & Craighero, 2004) as well as our own and others' emotional states (Niedenthal, 2007), and to influence emotional experience, and to shape our judgments (e.g., Ekman, Levenson, Friesen, 1983; Winkielman, Niedenthal, Oberman, 2008).

A question that arises in this context is: does emotion language induce *motor resonance* (e.g., Rüschemeyer, Lindemann, van Elk, & Bekkering, in press; Zwaan, in press; Zwaan & Taylor, 2006)? In other words: when you read or hear a word representing an emotional expression (e.g., to smile), then do these words recruit the neutral substrates and the muscles that are active when the person is performing the emotional expression represented in the sentence (i.e., smiling)? Furthermore, does motor resonance mediate our linguistic comprehension? An answer to these questions would contribute to our understanding of how affective communication is grounded.

Such a question could not be posed in the traditional view of language that has regarded language as an amodal symbolic system (e.g., Fodor, 1983). However, recent developments from an embodiment perspective (e.g., Barsalou, 2008; Glenberg, 2008; Semin & Smith, 2008) suggest that language comprehension involves the simulation and the recruitment of neural systems used for perception, action, and emotion (Pulvermuller, 2005; Buccino, Riggio, Melli, Gallese, & Rizzolatti, 2005; Hauk, Johnsrude, & Pulvermüller, 2004; Zwaan & Taylor, 2006). Neurophysiological conceptualizations of language understanding point to mental simulation processes driven by the mirror neuron system (e.g., Fischer & Zwaan, 2008; Gallese & Lakoff, 2005; Tettamanti et al., 2005; Rizzolatti, Fogassi, & Gallese, 2001; Rizzolatti & Arbib, 1998; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996).

Findings from behavioral studies converge with this perspective. For instance, Havas, Glenberg, and Rinck (2007) have covertly manipulated the expression of positive and negative emotions and shown that the match between facial posture and sentence valence contributed to a speed advantage in judgments of sentence valence and sensibility when compared to mismatches. More recently, Niedenthal, Winkielman, Mondillon, and Vermeulen (in press) have revealed that the conceptual processing of emotions involves somatic responses, as indicated by facial expressions of emotion and that such responses are situated and context dependent.

Notably, no experimental work has investigated if *semantic* stimuli induce a motor resonance of facial muscular activity comparable to what has been demonstrated in the case of the production and perception of facial expressions of emotion.

Thus, the objective of the first study was to examine not only whether semantic stimuli induce motor resonance of specific facial expressions of affect, but also to specify the characteristics of the semantic stimuli that are likely to do so (i.e., verbs mapping facial expression directly such as ‘to smile’ versus abstract representations of emotion-related states such as ‘happy). Such a demonstration would establish, for the first time, that verbal stimuli induce motor resonance comparable to what has been demonstrated in the case of facial expressions of emotion (e.g., Dimberg et al., 2000). Moreover, it would suggest not only that verbal stimuli have somatic consequences, but also that they are somatically commensurable to visual stimuli of emotional expressions.

The second study extrapolates from the first by examining how subliminally presented *semantic* stimuli influence affective judgments by inducing motor resonance of facial expressions and thereby shaping affective judgments. This study relies on a paradigm developed by Strack and his colleagues (Strack, Martin, & Stepper, 1988) that has revealed that mechanically activating smiling muscles (zygomatic major) influences our judgments of how funny a cartoon is. Such evidence would demonstrate how verbally induced motor resonance is used in the understanding of emotional states and emotional experience as well as its contribution to how our judgments are shaped as argued by other authors (e.g., Ekman et al., 1983; Winkielman et al., 2008).

Experiment 1

To investigate whether verbal stimuli of emotional expressions induce the same facial muscle activation in a reader/perceiver and for optimal comparability with the facial mimicry literature we focused on positive and negative emotional words representing the facial expression of two specific emotions (i.e., to smile, to frown) or states associated with these expressions (i.e., happy, angry; see e.g., Dimberg, et al., 2000). We measured motor resonance of emotional expressions to related verbal stimuli in the reader/perceiver by means of EMG measurement of the *zygomatic major* and *corrugator supercilii* muscle region. As verbal stimuli, we selected a set of *action verbs* that preserve the perceptual features of an emotional expression unambiguously (e.g., to smile, to frown) and a second set consisting of *adjectives* (e.g., happy, angry) that refer to a state but do not have an unambiguous or direct reference to a specific expression. We expected that concrete verbs mapping facial expressions directly should induce motor resonance in the reader/perceiver more strongly, compared to adjectives expressing emotional states, since abstract emotion terms (e.g., happy, angry) do not directly refer to specific behaviors or movements (e.g., Semin & Fiedler, 1988).

Method

Participants and Stimulus Material

Thirty students (23 females; 26 right-handed; mean age: 21.2) participated in this experiment on a paid voluntary basis. The stimulus material consisted of 12 words (6 verbs and 6 adjectives) related to positive and negative emotional expressions'.[1] Earlier research using facial stimuli (e.g., Dimberg et al., 2000) showed distinct facial reactions between 500-1000 ms after stimulus onset. We expect critical effects to occur between 1000-2000 ms because of the slower processing of verbal material (e.g., Snodgrass & McCullough, 1986).

Procedure, Apparatus and Data acquisition

The verbal stimuli were sequentially presented on a monitor in a soundproofed experimental chamber. Each trial started with a fixation point (500 ms) followed by a baseline interval of 3 seconds after which the stimulus word was presented (6 sec.) followed by a inter-trial interval of 3 seconds. Participants received 5 blocks of words. Each block consisted of 12 test words and 15 fillers. Facial muscle activity was measured using miniature Ag/AgCl electrodes attached on the left side of the face, over the zygomatic major and the corrugator supercilii muscle regions (Fridlund, & Cacioppo, 1986). The skin was cleaned and prepared to reduce electrode site impedance to less than 11 kV. The raw EMG activity was measured with a Neuroscan Synamps amplifier at a sampling rate of 1000Hz using two bipolar channels and a gain of 1000. The digitized signal was filtered using a notch filter at 50Hz and a bandpass filter from 10 to 200 Hz.

Data Preparation and Results

Phasic facial EMG responses (in microvolts) were scored and averaged over intervals of 250 ms during the first two seconds of exposure. The EMG responses were expressed as change in activity from the pre-stimulus level (i.e., 1000 ms before stimulus onset). Separate ANOVAs were performed for the zygomatic and corrugator muscle regions. As suggested by others (e.g., Dimberg, Thunberg, & Grunedal, 2002; Kirk, 1968), Geisser–Greenhouse conservative *F* tests were used to reduce likelihood of positively biased tests. A priori comparisons between means (e.g., verbs vs. adjectives) were evaluated by *t*-tests.

The data were analyzed in a three factorial design with emotional expression (positive vs. negative), linguistic category (action verbs vs. adjectives), and period (eight intervals of 250 ms each) repeated-measure variables.

Zygomatic major muscle. Figure 1 shows the outcomes for the *zygomatic major* muscle. Our main hypothesis was confirmed by the significant 3-way interaction between linguistic category, emotional expression *over* time, $F(3,97) = 2.78$, $p_{rep} = .93$, $\eta_p^2 = .09$. Participants showed a significant increase of activation of the zygomatic major muscle when presented with words related to positive emotion. However, this was qualified by linguistic category. This activation was significantly stronger for action verbs (e.g., 'to smile') than adjectives (e.g., funny) after 1000 ms, all $p_{rep} > .92$. This result is paralleled by the relatively larger inhibition produced by action verbs in the frowning group compared to the one produced by the adjectives. The negative verbs produced a significant inhibition of the zygomatic mayor (after 1000 ms, all $p_{rep} > .88$) while the adjectives did not (ns). In general, the overall zygomatic major EMG activity increased over time, ($F[2,45] = 4.26$, $p_{rep} = .94$, $\eta_p^2 = .13$) and was larger for positive words compared to negative words, $F(1,29) = 4.09$, $p_{rep} = .91$, $\eta_p^2 = .12$. As can be also seen and indicated by the emotional expression X period interaction ($F[1,38] = 4.75$, $p_{rep} = .94$, $\eta_p^2 = .14$), negative words showed no increase in EMG activity over time, while positive words did so significantly.

Corrugator supercilii muscle. Figure 2 shows the outcome for the *corrugator supercilii* muscle and reveals the expected pattern. Participants registered a larger activation of the *corrugator supercilii* when presented with negative verbs rather than adjectives *over* time ($F[4,116] = 2.38$, $p_{rep} = .91$, $\eta_p^2 = .08$). They showed a significant inhibition of the *corrugator sopracilii* muscle when presented with positive words both for action verbs (after 500 ms, all $p_{rep} > .91$) and adjectives (all but at 1750 ms after 500 ms $p_{rep} > .92$) . Overall EMG activity showed a significant change over time, $F(2,49) = 4.93$, $p_{rep} = .96$, $\eta_p^2 = .14$. Moreover, positive words, in general, yielded a larger inhibition compared to negative words, $F(1,29) = 4.37$, $p_{rep} = .92$, $\eta_p^2 = .13$. Negative words showed no change over time, while positive words inhibited the corrugator supercilii progressively as revealed by the interaction between emotion type X period (F[3,81] = 2.92, p_{rep} = .92, η_p^2 = .09).

Discussion

The results clearly demonstrate motor resonance to verbal expressions of emotion that map these expressions unambiguously (action verbs: e.g., to smile, to frown) by recruiting the corresponding muscles (i.e., *zygomatic major, corrugator supercilii*) after reading them. Such motor resonance is present for abstract terms. In the case of adjectives representing corresponding emotional states, however, the resonance is in most cases significantly weaker in intensity. This pattern of results parallel nearly perfectly those reported using facial expression as stimuli (e.g., Dimberg & Petterson, 2000; Dimberg et al., 2000). The findings speak unequivocally to the argument advanced here, namely the commensurability between linguistic and visual stimuli. These results also demonstrate that verbal stimuli of emotional expressions are clearly embodied. Furthermore, they suggest that the communicative potency of language is not merely symbolic but also somatic.

Experiment 2

Experiment 2 was designed to extend the findings of the first study by examining the impact of subliminally presented verbal stimuli (action verbs versus adjectives) upon social judgments and the role that motor resonance may play in this process. To this end, participants were presented subliminally with verbal stimuli (verbs vs. adjectives) and asked to rate the degree to which a series of cartoons they saw were funny. Motor resonance was either inhibited (i.e., participants held a pen with their lips, see

Winkielman, et al., 2008) or not. We predicted that in the uninhibited condition motor resonance would occur as a function of the linguistic category. If motor resonance is responsible for shaping such judgments (e.g, Strack et al., 1988) then the results of experiment 1 would suggest that verbs to do with positive expressions (e.g., to smile) would enhance funniness ratings, whereas verbs representing negative expressions (e.g., to frown) would depress these ratings. This was not expected for adjectives which have been shown to induce weak motor resonance. Moreover, if language is embodied then an inhibition of the relevant muscles should nullify these effects. These predictions were examined in the present experiment.

Method

Participants, Stimuli, Procedure, and Hypothesis

Hundred-sixty-four students (105 females, mean age: 20.7) participated in this experiment on a paid voluntary basis.

Two sets of stimulus material were used. The first consisted of 24 cartoons, selected on the basis of a pretest from a larger pool with comparable average funniness ratings (M=5.75, SD = 0.18). The second set was the 12 stimulus words from Experiment 1.

Each trial started with a fixation point and after a variable interval (between 500-1500 ms.) a stimulus word appeared (for 30 ms.) forward and backward masked by a series of 'X's' (each for 30 ms). Participants were instructed to press the space bar as soon as they saw a flash (i.e., mask). As post-experimental debriefing determined, participants were unaware of the fact that they were subliminally presented with words. A cartoon appeared next and stayed on the screen until participants read the caption and registered their funniness judgment (on a 9-point scale anchored from ‘not at all funny’ to ‘extremely funny’). There were 24 trials. Each trial consisted of one of the verbal stimuli and one of the 24 cartoons randomly combined for each participant. Each participant was randomly assigned to one of 8 between participants’ conditions of the 2x2x2 design: linguistic category (action verbs vs. adjectives) X emotional expression (positive vs. negative) X muscle condition (no inhibition vs. inhibition). Participants in the inhibition condition held a pen between their lips. This position is known to inhibit facial muscle activity and to avoid the possibility of muscle resonance as has been indicated by other authors (e.g., Niedenthal, 2007).

Data Reduction and Results

Funniness ratings were aggregated for each participant to yield a funniness score.[2] These ratings are presented in Figure 3. The predicted 3-way interaction between linguistic category, emotional expression, and muscle condition was significant, F (1,156) = 4.31, p_{rep} = .92, η_p^2 = .03. As hypothesized, uninhibited participants (no inhibition condition) showed the expected 2-way interaction between linguistic category and emotional expression, F (1,74) = 4.49, p_{rep} = .93, η_p^2 = .06. Participants’ judgments showed no systematic difference, when presented with adjectives in the positive (M = 4.49, SD = .94) and negative conditions (M = 4.63, SD = 1.13); t (20) = ns. In contrast, as hypothesized, participants in the ‘positive’ verbs condition rated the cartoons significantly funnier (M = 4.88, SD= .80) than in the ‘‘negative’ verbs condition (M = 4.09, SD = 1.00), t (35) = 2.69, p_{rep} = .96, η_p^2 = .88. As expected, when participants’ motor resonance was inhibited, the 2-way interaction ($F < 1$) was not significant and neither were the other comparisons (ts < 1).

Discussion

The second experiment revealed that even when *verbal stimuli* are presented subliminally, they influence affective ratings as shown by the funniness ratings of cartoons. Notably, and as predicted these outcomes were obtained only when there was a potential for motor resonance and not when this possibility is blocked. This particular comparison further underlines the motoric impact of verbal stimuli and grounds earlier work and theorizing (e.g., Strack, et al., 1988) in terms of a verbally mediated motor resonance. The type of verbal stimulus that is used qualifies this process. This finding suggests that although motor resonance is present for verbs mapping emotion expressions and to some extent for adjectives mapping emotional states, the intensity difference found in experiment 1 appears to influence judgments. It could be argued that a certain threshold of motor resonance is necessary to have an impact on judgments.

Finally, this pattern of data cannot be explained by a simple evaluative difference between positive versus negative emotional words (i.e., affective priming). First, verbs and adjectives within each emotional expression were matched in valence (see footnote 1). Second, the differential effects of the two linguistic categories (verbs vs. adjectives) in the no-inhibition condition and the lack of any effects in the muscle inhibition condition cannot be accounted for by a simple evaluative priming account.

General Discussion

The studies reported here were designed to cast the linguistic representation of specific affective expressions into a socially embodied framework. To this end, we build on earlier research showing that: (1) observing a smile (or frown) induces a smile (or frown) response in an observer (e.g., Dimberg & Petterson, 2000; Dimberg et al., 2000); and (2) research arguing that a mechanically induced smile influences evaluative judgments (Strack et al., 1988), as it was argued, via proprioceptive feedback.

We have shown that the very same motor resonance induced by exposure to facial expressions (e.g., Dimberg et al., 2000) is also induced by exposure to verbs that unambiguously map affective facial expressions of smiling and frowning and to some extent by exposure to abstract emotional expressions. Next, we have shown that the subliminal presentation of these verbs also shape our evaluation of cartoons. This was not found in the case of adjectives. Finally, this differential pattern of judgments is not found when participants' facial muscle movement is blocked. The results reported here have a number of implications.

One of the implications is for some of the current work in neuroscience that has furnished new insights about the neural mapping of language and in particular verbs of action (Pulvermuller, 2005). In a recent functional magnetic resonance imagery (fMRI) study, Hauk et al. (2004) have shown that listening to verbs referring to leg actions activates regions of the motor cortex responsible for the control of the leg, in the case of verbs referring to hand actions, regions responsible for hand control in the motor cortex are activated, and so on. Using fMRI, Tettamanti et al. (2005) have demonstrated somatotopic representation of actions with simple sentences (e.g., "I kick the ball").

Whereas the fMRI research constitutes a fascinating illustration of the neural grounding of action verbs, the data remain ambiguous and can indicate either an association, which reflects simulation of action after hearing action verbs, or alternatively, that activity in motor areas of the brain is important for understanding these verbs. Although recent research by Buccino and his colleagues (2005) suggests a strong connection between action and language originating in the brain and extending to the periphery of the body, the evidence we have presented provides a clear answer to the open issues in earlier research.

Second, we show clearly that not only do action verbs give rise to the same motor resonance that has been demonstrated earlier for faces, which complements the neuroscientific findings noted above, but such a resonance of muscular activity contributes to the shape of affective judgments. The two experiments presented here therefore constitute an important bridge by providing an embodied grounding for neuroscientific research on language (e.g., Pulvermuller, 2005), psycho-physiological work (e.g., Dimberg et al., 2000), and findings in the field of social cognition and affective processes (e.g., Strack et al., 1988). The evidence reported here is clearly in line with theoretical perspectives of language comprehension such as Indexical Hypothesis (Glenberg & Robertson, 1999, 2000). These authors suggest that language comprehension (i.e., understanding the verb 'to smile') would lead to physical simulation of the events to be comprehended. In fact, it is argued that such simulations are necessary components for comprehension. We show here that such simulation occurs during language comprehension and extend this by showing how it shapes our judgments.

Finally, the differential results obtained using the two linguistic categories (verbs that map muscle activity and abstract adjectives) speak to other central research fields. For example, our findings provide a novel look on, for instance, affective priming (e.g., Musch & Klauer, 2003). In this large body of research, stimulus material has carefully controlled for valence, semantic meaning and other features (e.g., word length, frequency of occurrence). However, the distinction between different categories of linguistic expressions has never been attended. As we show here, not all linguistic expressions have the same consequences. Certain categories (i.e. verbs) induce motor resonance more than others and contribute differentially to the shape of our judgments. The implications of these findings for affective priming in particular and priming research in general are considerable. They suggest that factors aside from valence or affective loading influence judgments. The findings of our second study suggest that judgments are influenced by a certain level of motor resonance (respectively for action verbs and adjectives) and not by the positivity or negativity of these words.

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Footnotes

1. *Stimulus Words as a Function of Condition*. Words are presented here in English and were in Dutch in the experiments (translations in some cases are approximate, as no precise correspondence is available). *Positive Emotional Expressions (1) verbs*: to smile (glimlachen), to laugh (lachen), to grin (grinniken). *(2) Adjectives*: comical (komisch), funny (grappig), entertaining (lollig). *Negative Emotional Expressions (1) verbs*: to frown (fronsen), to cry (huilen), to squeal (janken). *(2) Adjectives*: irritating (irritant), frustrating (frustrerend), annoying (vervelend). In Dutch the infinitive form of verbs is distinct from the adjectival form. The stimuli have been pre-tested for valence. Participants rated each stimulus word on a 7-point scale ranging from very negative to very positive. The data were analyzed in a two factorial design with emotional expression (positive vs. negative) and linguistic category (action verbs vs. adjectives) as repeated-measure variables. Positive emotion words (M = 6.94; SD = .91) were rated as more positive than negative emotion words (M = 2.76; SD = 1.06), $F(1,14) = 96.78$, $p_{rep} = .99$. No other effect was significant.
2. To ensure the use of only those trials where priming procedure was performed correctly, ratings for which the RT on the simple reactance parallel task were too slow (RTs> 1600 ms) indicating no attention to the prime were excluded (excluded trials in total 11.7%). Results including those trials show similar pattern of results but slightly reduced statistical power.

Figures Captions

Figure 1. Mean facial electromyographic response for the zygomatic major muscle region, plotted in intervals of 250 ms during the first 2 seconds of exposure. Responses are a function of linguistic category and emotional expression over time.

Figure 2. Mean facial electromyographic response for the corrugator supercilii muscle region, plotted in intervals of 250 ms during the first 2 seconds of exposure. Responses are a function of linguistic category and emotional expression over time.

Figure 3. Funniness ratings as a function of linguistic category, emotional expressions, and muscle condition.

Figure 1

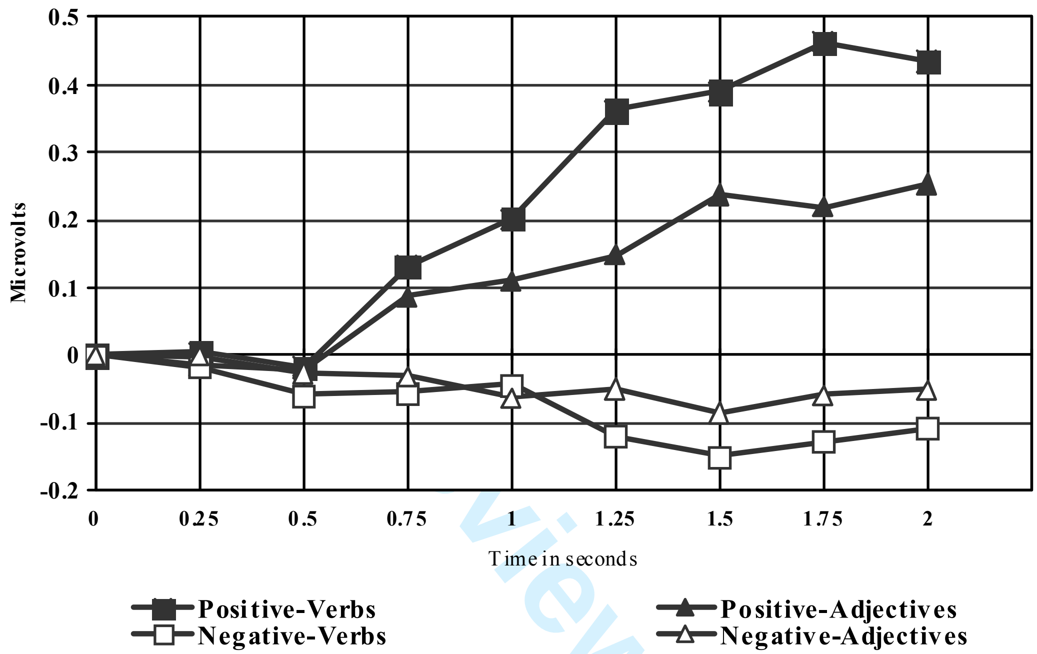

0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Microvolts
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
Time in seconds
Positive-Verbs
Negative-Verbs
Positive-Adjectives
Negative-Adjectives

Figure 2

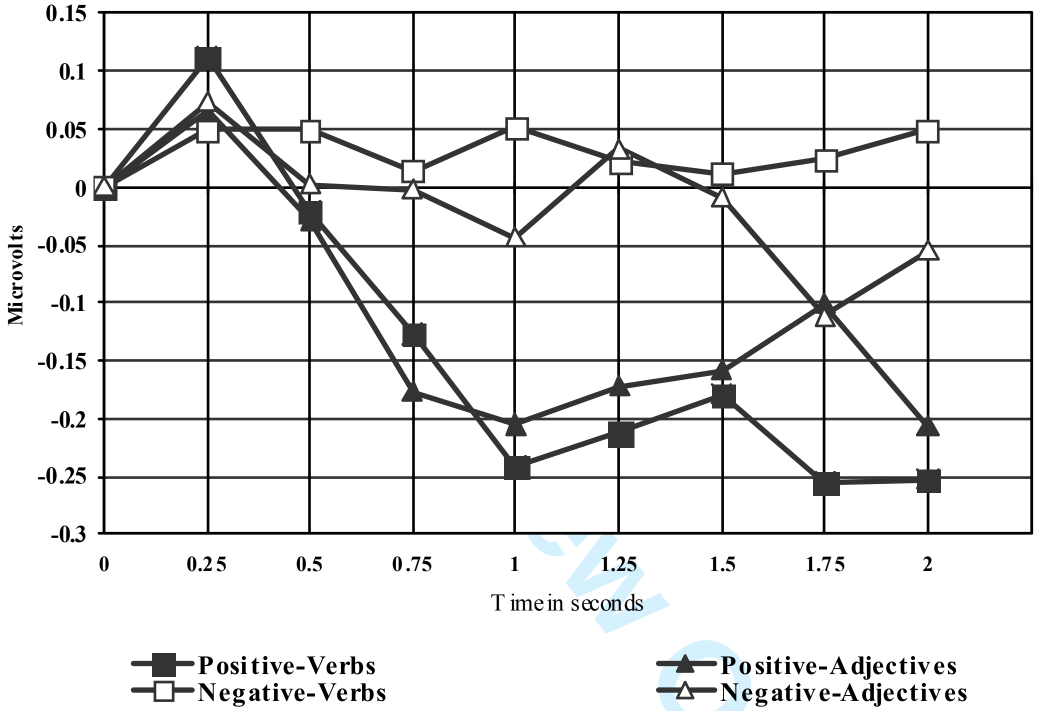
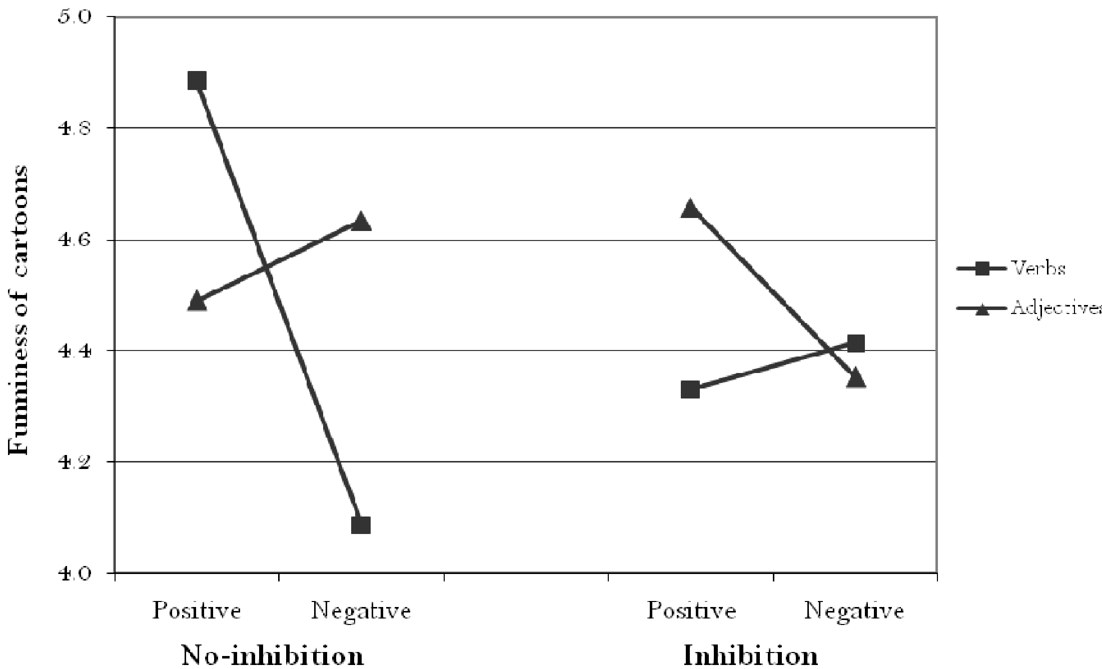

0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Microvolts
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
Time in seconds
Positive-Verbs
Negative-Verbs
Positive-Adjectives
Negative-Adjectives

Figure 3


5.0
4.8
4.6
4.4
4.2
4.0
Funniness of cartoons
Verbs
Adjectives
Positive
Negative
Positive
Negative
No-inhibition
Inhibition