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Syntactic structural parallelisms influence processing of positive stimuli: Evidence from cross-modal ERP priming

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ABSTRACT

Language can strongly influence the emotional state of the recipient. In contrast to the broad body of experimental and neuroscientific research on semantic information and prosodic speech, the emotional impact of grammatical structure has rarely been investigated. One reason for this might be, that measuring effects of syntactic structure involves the use of complex stimuli, for which the emotional impact of grammar is difficult to isolate. In the present experiment we examined the emotional impact of structural parallelisms, that is, repetitions of syntactic features, on the emotion-sensitive "late positive potential" (LPP) with a cross-modal priming paradigm. Primes were auditory presented nonsense sentences which included grammatical–syntactic parallelisms. Visual targets were positive, neutral, and negative faces, to be classified as emotional or non-emotional by the participants. Electrophysiology revealed diminished LPP amplitudes for positive faces following parallel primes. Thus, our findings suggest that grammatical structure creates an emotional context that facilitates processing of positive emotional information.

1. Introduction

Language is able to strongly influence our emotions. A broad body of experimental and neuroscientific research has demonstrated that the semantic content of single written words (e.g. Herbert et al., 2006, 2008; Kissler et al., 2009) or short written phrases (Fischler and Bradley, 2006), as well as prosodic information (Kotz and Paulmann, 2007; Schirmer et al., 2002, 2005; Wambacq and Jerger, 2004), contributes to the emotional impact of language. The emotional impact of grammatical structure has been far less studied, which may be due to the fact that syntax and other language influences are difficult to isolate (Caplan and Gow, 2012). Many theories propose that the development of grammar in cultural evolution is strongly related to emotional mechanisms (Perlovsky, 2009), but the neuroscientific evidence for this is still missing.

In the present study we addressed the question of whether a grammatical structure often found in emotional texts and speeches (Wiese, 2007) – namely structural parallelisms – can directly influence our emotions. Structural parallelisms typically involve repetitions of semantic, syntactic, or phonological patterns, and are often found in highly emotional language (Khodadadi and Gründel, 2006; Zima et al., 2009). They are a pervasive feature of ritual language, for instance in prayer texts (e.g. the Paternoster as illustrated below — angular brackets indicate parallel syntactic elements), but also appear in non-secular ritual language, such as football chants, and in persuasive contexts like campaign speeches and commercial ads.

> [Thy kingdom] [come][thy will] [be done]...For thine is [the kingdom]and [the power]and [the glory]

Repetitions of structural patterns are also studied in another actual line of research, investigating the emotional effect of rituals in general. It has been shown that religious rituals can influence emotional well-being, and that ritual behavior is important in health care (see Lee and Newberg, 2005 for a review). Anastasi and Newberg (2008) have shown that reciting the Rosary reduced anxiety in catholic students compared to a student group watching a religious video. The presence of structural parallelisms in such contexts leads to the hypothesis of an emotional impact of these complex verbal expressions (Wiese, 2007).

Repetitions have a further importance in language processing. Even in newborns there is an automatic perceptual mechanism to detect repetitions in speech (Gervain et al., 2008), and repetition suppression effects have already been shown in two month old infants in reaction to music or speech (Dehaene-Lambertz et al., 2010). Psycholinguistic studies have shown facilitated processing of coordinate structures when they are in parallel, both for language comprehension (Frazier et al., 2000) and language production (Dubey et al., 2008). Since direct evidence for the *affective* impact of parallelisms and the underlying cognitive processes is lacking, until now it has only been possible to infer this from their occurrence in emotional language and ritual contexts. Thus,

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the aim of the current study was to measure the emotional impact of linguistic structural parallelisms on psychophysiological processes.

Event-related brain potentials (ERPs) combined with a cross-modal affective priming paradigm appeared to be a well-suited measure for this purpose (Bostanov and Kotchoubey, 2004; Paulmann and Pell, 2010; Schirmer et al., 2002; Zhang et al., 2006). Due to their excellent time resolution, they allow for 'online' measurement of emotion effects during priming. The priming technique was employed because parallelisms obtain their specific structure, and supposedly deploy their emotional impact, through repetition. Thus, there is no exact time point to detect the emotional effect of these complex auditory stimuli. The priming technique represents a well-established paradigm that allows for the measurement of the facilitating effect of different prime stimuli in response to subsequent emotional target stimuli. Originally used in lexical decision tasks, this technique revealed accelerated reaction times to primes and targets that were semantically or conceptually associated, thereby supporting spreading activation theories of memory (Anderson, 1983; Collins and Loftus, 1975; Collins and Quillian, 1969). Since Fazio et al. (1986) demonstrated a similar "affective priming effect" for prime and target words that were congruent with respect to emotional valence, a large body of research has demonstrated similar effects for word classification (Bargh et al., 1996), pronunciation (Hermans et al., 1994, 2001), or non-affective categorization (Spruyt et al., 2007).

Affective priming has also been shown across stimulus domains, e.g., picture primes and written words (Zhang et al., 2006), across modalities, e.g. for affective prosody of spoken sentences on subsequent written words (Schirmer et al., 2002), and with presentation of emotional faces (Paulmann and Pell, 2010). The advantage of cross-modal priming is, that it avoids contamination by perceptual correspondence of prime and target, thereby providing an indication of putatively common aspects of underlying emotion processing (Schneider et al., 2008). Further presenting primes auditorily, variations of reading speed can be bypassed.

While on-line differentiation of spoken language has already been demonstrated with a cross-modal priming task using semantically different sentences (Nicol et al., 1994), the present study aimed at investigating cross-modal *affective* priming of sentences merely differing in grammatical structure. Previous ERP studies have consistently shown that emotional compared to neutral stimuli increase the late positive potential (LPP) that arises around 350–400 ms after stimulus onset and lasts for several hundred milliseconds over centro-parietal electrodes (e.g., Cuthbert et al., 2000; Schupp et al., 2004a, 2004b, 2004c). Because little is known about the underlying psychophysiological processes of language structure on emotions, hypotheses can only be made from what we know about this emotion-sensitive ERP-component, which reflects increased attention to emotional stimuli (Cuthbert et al., 2000) and is modulated by motivational significance (Cuthbert et al., 2000; Schupp et al., 2003). Furthermore, in priming tasks, the LPP is influenced by the evaluative congruence of primes and targets showing diminished amplitudes for evaluative congruent primes and targets (Werheid et al., 2005; Zhang et al., 2010). This has been interpreted as reduced attentional engagement which is needed to process targets when they are emotionally matching to previously presented stimuli. To this point in time, LPP diminution has only been shown for primes and targets congruent in valence. Hence valence effects have not yet been tested for structural parallelisms, we conducted, in addition to the priming task with an independent sample, a valence and arousal rating of the verbal primes. Due to the co-occurrence of structural parallelisms and positive emotional contexts in the church or in football stadiums, they may be highly associated. According to Paulmann and Pell (2010), affective priming effects of speech on face evaluation can be interpreted as evidence for an emotional context established by the affective language primes.

In summary, three mechanisms may underlie an effect of structural parallelisms on emotional information processing. First, if structural parallelisms are judged positively in the valence rating, congruence effects between structural parallelisms and positive faces should result in a reduced LPP amplitude on positive faces after parallel primes (Werheid et al., 2005; Zhang et al., 2010). To ensure that the expected valence specific priming effect is independent from arousal, we used a face stimulus set in which positive and negative faces were balanced for arousal (Czerwon et al., 2011). Second, because little is definitely known about the effect of structural parallelisms, it is also possible that structural parallelisms are related to valence non-specific attentional engagement, which would be related to the arousal dimension. This interpretation is supported by the fact that repetition plays a key role in language processing (Dubey et al., 2008; Frazier et al., 2000; Gervain et al., 2008) and conversation (Tannen, 1987), and may be independent of emotion. This could, in contrast, be reflected in an enhancement of the LPP for both positive and negative faces after parallel primes. Finally, due to the co-occurrence of parallelisms (in language and behavior) and emotionally positive contexts (e.g. Khodadadi and Gründel, 2006), parallelisms may simply act as a contextual cue facilitating the processing of positive information without being themselves judged as positive. No enhanced attentional engagement would be needed. In this case, positive stimuli should rather be expected passively after presentation of parallelisms, reflected in reduced LPP amplitude on positive faces, just depending on context congruency.

2. Materials and methods

2.1. Participants

In the priming study we investigated $n = 23$ (13 female, Mean age = 24.6 +/− 4.2 yrs) participants with a high verbal intelligence (WST-IQ $M = 114.35$, $Min = 98$, $Max = 139$) measured with the German vocabulary test (Wortschatztest, WST, Schmidt and Metzler, 1992). All had normal or corrected-to-normal vision and they all reported being free of neurological and psychiatric diseases.

2.2. Stimulus materials and stimulus selection

Primes consisted of 40 four-lined stanza. In the experimental condition, stanza contained structural parallelisms that were extracted from prayers. We used ten different parallel syntactic patterns for each set of 4 stanzas. For the control condition, we constructed non-parallel versions of the parallel stimuli. In each case, one line from the parallel form was preserved to create a similar control stimulus. The three remaining stanzas of the non-parallel control stimuli were replaced by similar stanza without parallelisms. To assure that possible priming effects could be attributed to *syntactic* structure, content words in both parallel and non-parallel versions were replaced by pseudo words; only function words (articles, pronouns, conjunctions, etc.) were kept, resulting in nonsense sentences. Pseudo words were created by the authors following the phonological constraints in German, yielding phonologically possible, but lexically non-realized, elements. Each pseudo word had only one legal correspondent in the original words and the same number of syllables. Table 1 gives examples for parallel and non-parallel stimulus versions extracted from the same prayer text. Ten different types of parallelisms and ten corresponding stimuli without parallels were used as primes in our experiment (see supplementary material).

The combination of parallel and non-parallel primes with positive, neutral, and negative targets presented in two blocks resulted in six different conditions: (1a) parallel prime–positive target, (1b) non-parallel prime–positive target, (2a) parallel prime–negative target, (2b) non-parallel prime–negative target, (3a) parallel prime–neutral target, (3b) non-parallel prime–neutral target.

For auditory presentation, a female native German speaker produced all primes with neutral intonation. The primes were recorded and sampled at a rate of 44 kHz, and further processed with sound editing

Table 1
Example for one pair of parallel vs. non-parallel primes (English translation in italics), together with a prayer text from which this example of structural parallel was extracted.

Prayer text	Parallel prime (experimental condition)	Non-parallel prime (control condition)
I need the loved one	Ich leube den Gehmen	Ich febel den Tappen
[I PW_V the PW_N]$_1$	*[I PW_V the PW_N]$_1$*	*I PW_V the PW_N*
Who guards when I sleep	Der rellt, wenn ich minse	Der basst, wenn ich narse
Who PW_V, when I PW_N	*Who PW_V, when I PW_N*	*Who PW_V, wenn ich PW_V*
Who beliefs when I doubt	Der stepft, wenn ich rete	Der klaffe Rapf ist minn
Who PW_V, when I PW_N	*Who PW_V, when I PW_N*	*The PW_A PW_N is PW_A*
I need the loved one	Ich leube den Gehmen	Dronnen sete ich Kado
[I PW_V the PW_N]$_1$	*[I PW_V the PW_N]$_1$*	*PW_{AD} PW_V I PW_N*

Abbreviations: PW = pseudo word, syntactic categories as indexes: V — verb, A — adjective, AD — adverb, N — noun.

software (Adobe Audition & Audacity). Each stimulus was saved as an amplitude-normalized sound file of 6.5 s duration. If a stimulus was shorter than that, a silent period was added at the end of the stimulus. The resulting variable prime–target interval of a few milliseconds is advantageous in priming tasks, as it avoids artifacts due to target expectation.

Acoustical analysis of the recorded primes using Praat (Boersma and Weenink, 2009) showed no significant difference in mean pitch value (F0 in Hz: parallel: $M = 258.64$, $SD = 4.60$; non-parallel: $M = 259.6$, $SD = 6.21$; $t(39) = -1.35$, $p > .05$) and intensity between parallel and non-parallel primes (intensity in dB: parallel $M = 76.53$, $SD = 6.16$, non-parallel: $M = 76.96$, $SD = 5.88$; $t(39) = -0.50$, $p > .05$). To assure that the prime conditions did not differ in emotional prosody, the major intonational phrases (IPh, Selkirk, 1984) of the parallel and non-parallel primes were identified and their mean fundamental frequency (F0) was compared. Because the structure of the primes consisted of four lines, four corresponding IPhs could be determined which did not differ in F0, IPh length and overall pause duration, emphasizing that the parallel and non-parallel primes did not differ in emotional prosody (all $ps > .05$).

Targets were 40 positive, 40 negative, and 80 neutral monochrome frontal view portraits of Caucasian faces taken from the Karolinska database (Lundqvist et al., 1998), the Purdue University database (Martinez and Benavente, 1998), the Japanese and Caucasian Facial Expressions of Emotion and Neutral Faces databases (Matsumoto and Ekman, 1988), the NimStim set of facial expressions (Tottenham et al., 2009), the Computer Vision Laboratory Face Database (http://www.lrv.fri.uni-lj.si/facedb.html), the Psychological Image Collection at Stirling (http://pics.psych.stir.ac.uk/), and from our own database (see also Czerwon et al., 2011). The set was edited to a unitary format (768 × 576 pixels), fitted to an egg-frame and presented on a gray background.

To validate the stimulus materials, pilot ratings were conducted with participants other than those who undertook the main experiment. First, to obtain valence and arousal ratings for the auditory primes, 18 participants (11 female, Mean age = 24.2 +/− 2.7 yrs) performed blockwise valence and arousal ratings with 80 trials each (40 parallel and 40 non-parallel primes) on verbally and symbolically labeled 7-step rating scales. The scales were adapted from the Self-Assessment Manikin SAM (Bradley and Lang, 1994), and had been developed in an earlier study (Czerwon et al., 2011). Statistical analysis revealed equivalent valence ratings for parallel ($M = 4.07$, $SD = 0.44$) and non-parallel primes ($M = 4.09$, $SD = 0.39$), $t(17) = -.28$; $p = .77$, $r = .06$. However, parallel primes ($M = 4.23$, $SD = 0.65$) were rated as significantly more arousing than non-parallel primes ($M = 3.39$, $SD = 0.74$), $t(17) = 4.95$; $p < .001$, $r = .77$.

The target rating involved 17 other participants (7 female, Mean age = 24.1 +/− 3.1 yrs), who performed valence and arousal ratings on the same rating scale, for 40 positive and negative faces and 80 neutral faces. As expected, the valence rating of the faces in the three emotional categories did significantly differ, all $ps < .001$. Notably, no difference between positive and negative faces occurred in the arousal rating, $t(16) = -0.65$, $p = .52$, $r = .15$. Hence, positive and negative faces were balanced for arousal, to assure that differences we might observe were due to differences in valence. However, expectedly, neutral and positive, as well as neutral and negative faces did significantly differ in arousal, $t(16) = 7.23$, $p < .001$, $r = .86$, and $t(16) = 6.46$, $p < .001$, $r = .84$, respectively.

2.3. Experimental design

The priming experiment consisted of two blocks. One block comprised 40 positive and 40 neutral target faces, the other 40 negative and 40 neutral target faces not overlapping with the other block. The two valence categories were presented in different blocks, in order to permit dichotomous emotion classification by participants, and to avoid contamination of ERPs by subjectively perceived unequal frequencies of emotional and non-emotional faces.

In each block, the 40 emotional and 40 neutral targets were presented two times, once preceded by a parallel prime and once by a non-parallel prime. Fixed prime–target pairings were used. The first block was preceded by a training run and the order of blocks was counterbalanced across participants. Initially, each participant performed four training trials (with stimuli not otherwise used in the experiment). Each trial began with a fixation cross (300 ms), followed by a prime stimulus (6500 ms), a 300 ms blank, and the target stimulus (2500 ms). Based on pilot experiments and on prior research (Fazio et al., 1986; Hermans et al., 1994), an interstimulus interval of 300 ms between prime and target was chosen. The stimulus pairs were presented in a randomized order for each participant, with a short break after every 40th trial. Altogether, each of the two blocks consisted of 160 trials; the order of the blocks was counterbalanced across participants.

2.4. Procedure

Prior to the experiment, participants performed a short demographic questionnaire, the Positive and Negative Affective Scale (PANAS, Krohne et al., 1996), the Beck Depression Inventory (BDI, Beck et al., 1961; Hautzinger et al., 1995), and a German vocabulary test on verbal intelligence (WST, Wortschatztest Schmidt and Metzler, 1992). Participants sat in a sound- and light-attenuated room, at a distance of 70 cm from the 17-inch computer screen. During the experiment, participants were asked to spontaneously and speedily classify each target face as emotional or non-emotional, by pressing one of the horizontally arranged keys. Furthermore, subjects were told that they should just listen to the auditory stimuli and answer only to the faces. The response-to-hand assignment was counterbalanced across participants. The duration of the experiment was approximately 1 h.

2.5. Electrophysiological recording

During the experiment, the electroencephalogram (EEG) was recorded continuously from 64 electrode sites using BrainAmp EEG-amplifier and BrainRecorder software (Brain Products, Munich, Germany). Two additional electrodes served to control for eye-artifacts. The active Ag–AgCl electrodes were mounted in an electrode cap (actiCap-system) with equidistant electrode sites. The EOG was monitored from FP2 and IO below the right eye. During recording, the TP9 electrode was taken as initial common reference, and AFz served as ground. The data were recorded with a sampling rate of 250 Hz and on-line band-pass filtered at 0.01 to 70 Hz. All electrode impedances were kept below 5 kΩ. The time constant was set at 10 s.

2.6. Data analysis

EEG data were re-referenced offline to average reference, and corrected for eye movement and blink artifacts using the multiple source eye correction method (MSEC, Surrogate Method, Berg and Scherg, 1994) implemented in BESA 5.1 (Brain Electrical Source Analysis, MEGIS

Software GmbH, Gräfelfing, Germany). Then artifacts were rejected using a gradient criterion of 50 μV, a difference criterion of 200 μV and an amplitude criterion of 100 μV. Overall, 9.5% of all trials were discarded. A low-pass filter of 30 Hz was used.

Epochs of 1200 ms were generated offline from the continuous ERP records, starting 200 ms before target onset. ERPs were aligned to a 200 ms baseline. The remaining 90.5% of all trials were averaged separately for each channel and experimental condition and recalculated to average reference, excluding the vertical EOG channels. Only correct trials were analyzed. Average ERP waveforms were calculated separately for each of the eight conditions described above. For visual presentation, grand averages were filtered with a 10 Hz high-cut off.

The LPP amplitude was defined after visual inspection as the mean voltage in the time interval of 350–650 ms post-target picture onset. Eleven regions of interest (ROIs, see Fig. 1) were defined corresponding to Hinojosa et al. (2009), and the average of the selected electrodes was calculated for each of the conditions. For initial analyses of the ERP data, we conducted an ANOVA including the factors prime (parallel, non-parallel), target (positive, neutral, negative) and ROI (11 ROIs), showing highest amplitudes at cluster 11 with a main effect of ROI, $F(10, 210) = 21.47$, $p < .001$, $\eta_p^2 = .51$, Power = 1. This is also the typical region for LPP effects as shown in other studies (Cuthbert et al., 2000; Herring et al., 2011; Schupp et al., 2004a, 2004b, 2004c). Moreover, a trend for a prime × target interaction was found, $F(2, 42) = 2.67$, $p = .07$, $\eta_p^2 = .12$, Power = .52. Accordingly, for brevity, further ERP analyses included only the parietal cluster 11 and a repeated measurement ANOVA with the factors prime (parallel, non-parallel) and target (positive, neutral, negative) was conducted. In case of significance Bonferroni-corrected post-hoc tests were conducted. For effects involving repeated measures, the Greenhouse–Geisser epsilon was utilized where appropriate to correct for violations of sphericity.

Behavioral data were analyzed by calculating mean reaction times for correct responses for each of the conditions. Only trials with correct classifications and reaction times in the range of 250–1500 ms (a time window which is typically used in affective priming studies) (e.g. Hermans et al., 2001) were analyzed (86.5%). Differences in reaction times and error rates between the conditions were assessed using repeated measures 2 (Prime: parallel, nonparallel) × 3 (Target: positive, neutral, negative) ANOVAs.

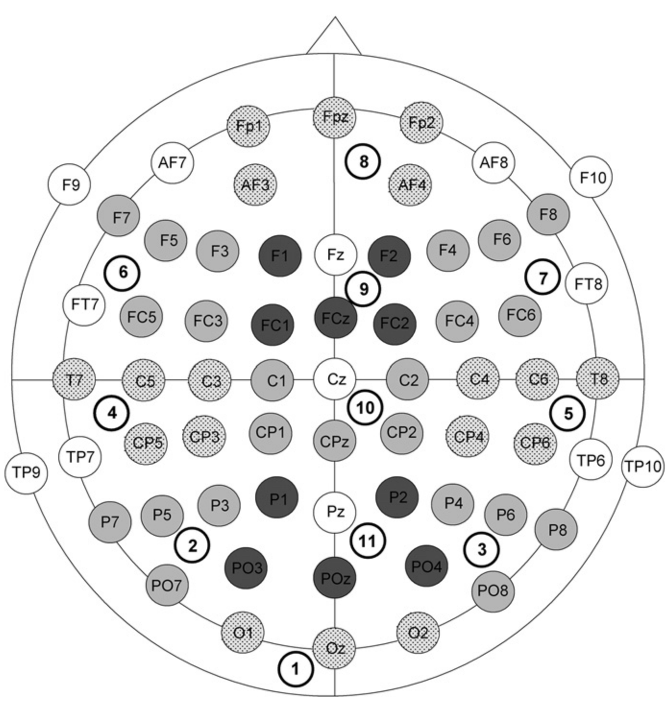

Fig. 1. Eleven regions of interest in which ERPs were grouped for the analyses.

3. Results

3.1. Behavioral data

Accuracy of behavioral responses (emotional vs. non-emotional) did not differ for positive (91.5%), negative (89.47%) and neutral faces (86.0%), $p > .25$, and no prime × target interaction was obtained, $p > .32$.

Analysis of reaction times revealed a main effect of target, $F(2, 44) = 15.78$, $p < .001$, $\eta_p^2 = .42$, Power = .99. Post-hoc comparisons showed that reaction times on positive (581 ms) and neutral targets (695 ms) and negative (616 ms) and neutral targets differed significantly, with slower reactions on neutral targets, $ps < .01$. No prime × target interaction was obtained, $p > .31$, with the following reaction times in each condition: (1a) parallel prime–positive target ($M = 581$ ms), (1b) non-parallel prime–positive target ($M = 580$ ms), (2a) parallel prime–negative target ($M = 609$ ms), (2b) non-parallel prime–negative target ($M = 621$ ms), (3a) parallel prime–neutral target ($M = 694$ ms), and (3b) non-parallel prime–neutral target ($M = 695$ ms).

3.2. Event-related brain potentials

The 2 × 3 ANOVA revealed a trend for prime, $F(1, 22) = 3.50$, $p = .07$, $\eta_p^2 = .14$, Power = .42, with reduced LPP amplitudes after parallel primes. Further a significant prime × target interaction was obtained, $F(2, 44) = 3.54$, $p < .05$, $\eta_p^2 = .14$, Power = .63. Post-hoc tests of this interaction showed a reduced LPP amplitude for positive faces following parallel compared to non-parallel primes, $F(22) = 7.19$, $p = .014$, $\eta_p^2 = .25$, Power = .73. No differences were found for negative faces, $ps > .74$, and for neutral faces after parallel versus non-parallel primes, $ps > .77$. The results are demonstrated in Fig. 2.

Looking at the effect of face valence for both parallel and non-parallel structures separately, positive and neutral faces preceded by parallel primes differed by trend, $p = .065$, positive and negative faces did not differ, $p = .26$, but the effect showed the same direction with a smaller mean amplitude on positive faces. Negative and neutral faces preceded by parallel primes did not differ, and after non-parallel primes positive, neutral and negative face targets did not differ as well, all $ps = .1$. Hence, only the congruent condition parallel–positive shows a difference in comparison to the other conditions.

4. Discussion

The main finding of the current study was a reduced LPP amplitude on positive target faces preceded by parallel compared to non-parallel primes. This finding is in accordance with the hypothesis that structurally parallel spoken language facilitates the processing of subsequently presented positive information. While emotion effects of syntactic structure have previously been noted anecdotally (e.g. for commercial ads) this finding represents, to our knowledge, the first experimental evidence for such an effect on subsequent processing of positive stimuli. Parallelisms in grammatical structure seem to be strongly associated to positive emotional faces.

Reduced LPPs in affectively congruent compared to incongruent conditions have at least been reported by two ERP priming studies, a study of our own group on priming of emotional facial expression (Werheid et al., 2005), and a recent study by cross-domain picture–word affective priming by Zhang et al. (2010). The LPP effect was explained as a modulation of attention processes related to perceived inconsistency in valence. This interpretation might also apply to our data, as the effect found here might likewise be taken as enhanced LPP in the incongruent condition, interpreted as increased attentional involvement after non-parallel primes on positive targets. Nevertheless, in the present priming paradigm one has to doubt whether non-parallel primes and positive targets

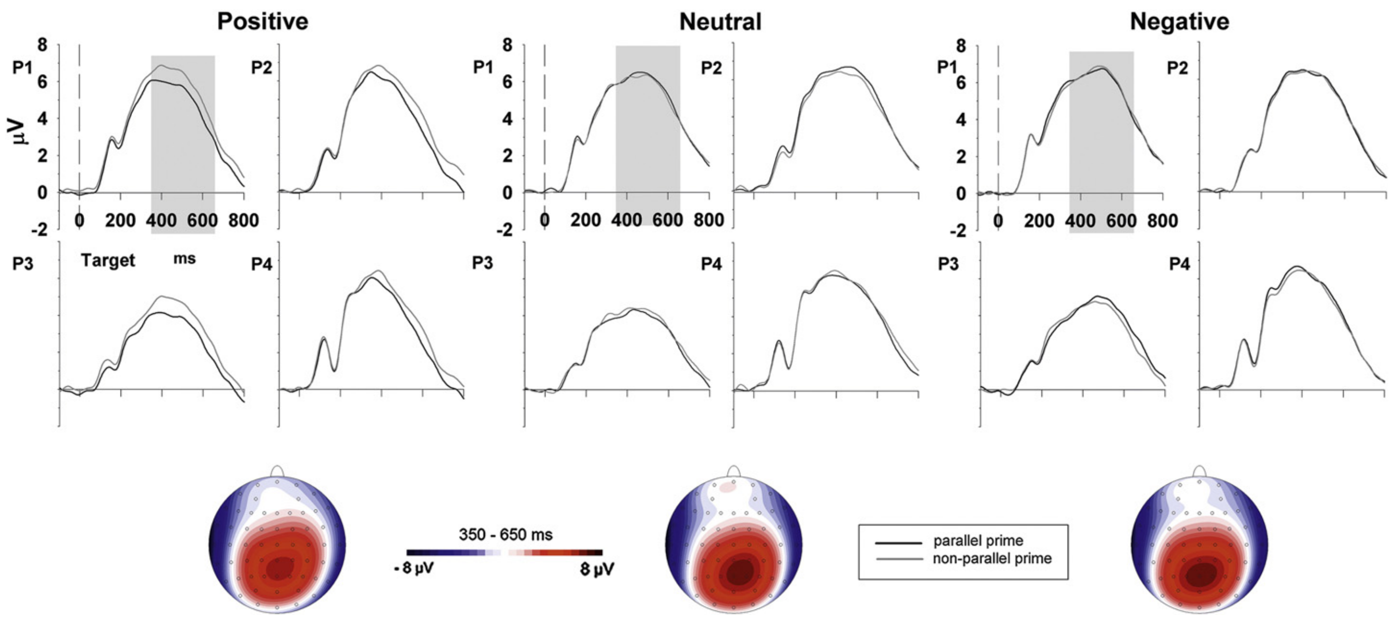

Fig. 2. Target-locked ERPs on selected electrodes for positive, neutral and negative face targets and their topographic distributions.

can be seen as so strongly affectively incongruent with the impact to produce an enhanced LPP amplitude. In contrast to structural parallelisms, utterances without parallelisms represent rather everyday language that is not per se incongruent with positive emotional contents. Further, the statistical analysis rather supports the view of diminished LPP amplitude after parallel primes on positive faces, showing only a significant difference on positive faces preceded by parallel compared to non-parallel primes and a by trend reduced amplitude on parallel–positive compared to parallel–neutral prime target combinations. On the other hand no significant difference of non-parallel–positive compared to non-parallel–neutral or non-parallel–negative has been found. This supports the view that the LPP amplitude is reduced in the parallel–positive condition, hence no enhancement of the incongruent conditions could have been shown.

Finally, while the exact direction of the effect is difficult to determine with the ERP method, our interpretation of a positive context created by syntactic structural parallelisms would apply for both result patterns — an enhancement in the incongruent or a reduction in the congruent condition. They are also in accordance with a study of Paulmann and Pell (2010) reporting ERP priming effects for positive emotional prosody on subsequently presented positive emotional faces. Although their study focused on the N400 (Kutas and Hillyard, 1980) component, which is usually considered a measure of semantic context rather than emotion, they interpreted their findings as evidence for meaningful emotional context established by prosodic primes, and influencing subsequent emotional processes.

Supposing a positive context established by parallel primes, they should be incongruent to negative target faces, but we found no LPP enhancement in none of the conditions assumed as incongruent (e.g. parallel primes–negative targets and parallel primes–neutral targets). This may be explained by two factors. On the one hand we found no main effect of target valence for which the LPP amplitude is sensitive (Schupp et al., 2004a, 2004b, 2004c), indicating only a slight valence differentiation on the electrophysiological level, which argues for the fact that incongruence between prime and target might have also been less obvious due to a floor effect on negative faces and – as described above – only the congruent condition parallel–positive sets oneself apart from the other conditions. Second we used a blockwise presentation of positive and negative targets to circumvent the problem of unequal frequencies of emotional and non-emotional targets, which influences LPP amplitudes. Consequential, in the block with negative targets, no congruent trials which could have served as reference, occurred, this should be ruled out in future studies.

Our finding that the ERP priming effect occurred in the absence of accelerated behavioral responses differs from several other ERP studies reporting behavioral affective priming effects (Paulmann and Pell, 2010; Schirmer et al., 2002; Zhang et al., 2006). However, there are many other ERP studies showing evaluative or affective priming effects in ERPs but not in behavioral data (Gibbons, 2009; Hinojosa et al., 2009; Kissler and Koessler, 2011; Lu et al., 2011). Even from behavioral research it is known that reaction time effects in affective priming are generally smaller compared to semantic priming (Carroll and Young, 2005), and seem to be strongly influenced by task type and task characteristics. Whereas reaction time effects have been reported, for example for valence categorization (Carroll and Young, 2005) or affective semantic priming in a lexical decision task (Rossell and Nobre, 2004), they have not been found in pronunciation tasks (e.g., Bargh et al., 1996) or arousal categorization of emotional stimulus material in affective priming (Hinojosa et al., 2009). Thus, as a possible explanation, variation of syntactic structure of our stimuli may be a very subtle change, as supported by our pilot ratings, in which direct valence judgments of parallel and non-parallel primes did not differ. The syntactic structure of sentences is in everyday life never deliberately judged in valence like happy or angry faces, emotional words or odors are. Taken together the diverging results of the rating and priming study argue for the context hypothesis and against an affective priming effect based on the same emotional evaluation of primes and targets. On the other hand our results extend findings of prior priming studies in the way that prime characteristics, which are despite supraliminal presentation not apparent to the subjects, may nevertheless affect the processing of emotional targets on a neurophysiologic level. If this is strengthened by future research, affective priming theories as theory of spreading activation or affective matching (for review see Klauer and Musch, 2003) should take this into account. However, the study was not designed to differentiate between these approaches.

As has been shown for behavioral data (Bargh et al., 1996; Hinojosa et al., 2009), LPP effects are also modulated by task demands (Eimer et al., 2003; Hajcak et al., 2006; Schacht et al., 2008). Thus, in the present task, the priming effect might have been minimized by the fact that the participants were completely unaware of the hypothesized emotional effect of the primes. Although earlier research has established that stimuli do not have to be perceived consciously to influence processing of subsequently presented stimuli (Hermans et al., 2003; Murphy and Zajonc, 1993; Winkielman et al., 2005), conscious processing of relevant stimulus dimensions increases LPP effects (Schacht et al., 2008). As another possible explanation, the absence of a behavioral priming effect might result from the long duration of the primes of 6500 ms (cf. Bensafi et al., 2002). It is known that behavioral priming effects increase until a maximal SOA of 300 ms and then decrease, and are hard to observe at intervals longer than 1000 ms (De Houwer and Hermans, 1998; Fazio et al., 1986). Little is known about the optimal timing in priming tasks with primes of extensively long duration. The timing in our task is not comparable with other affective priming tasks since repetitions of syntactic patterns require the primes to be presented for duration longer than 1 s. However, it would be a valuable enterprise to investigate whether language stimuli with a somewhat shorter duration than those used here, would elicit similar ERP effects along with behavioral acceleration in supposedly congruent conditions.

Another question that deserves consideration is the relationship of our finding to dichotomous models of arousal and valence (Lang et al., 1998). The LPP has often been related to the arousal dimension, as LPP enhancement has been demonstrated both for positive and negative stimuli (Cuthbert et al., 2000; Schupp et al., 2004a, 2004b, 2004c). In an earlier study, Hinojosa et al. (2009) reported decreased LPP amplitudes when prime words and target words were congruent in arousal. The finding that LPP reduction was only observed for positive targets following parallel primes does, however, contradict the idea of a mere arousal-based effect. According to our behavioral pilot ratings, structurally parallel primes were perceived as more arousing than non-parallel primes, while positive and negative faces were balanced with respect to arousal. If structural parallelisms affected the processing of emotional faces exclusively at the arousal level, the LPP should have been influenced for positive as well as negative faces. However, as elaborated above, the results show that structurally parallel primes facilitated specifically the processing of positive faces. This pattern is rather compatible with a broader interpretation of the LPP component as reflecting an evaluative processing stage, or enhanced attentional engagement (Cuthbert et al., 2000). According to the context based account, reduced LPP on positive faces after parallel primes shown in our data might reflect a reduced amount of attention needed to process stimuli matching the positive context.

Nevertheless, our results are limited by the fact that the stimuli are high in complexity, and auditory repetition effects and effects of syntactic parallelisms can't be fully dissociated. Human language is complex and using complex language stimuli with higher ecological validity leads inevitably to the confounding of different language characteristics. These effects should be systematically excluded in future research. A main problem is the confounding of grammatical parallelisms and auditory repetition effects. One possibility might be to control them statistically in future research, using a condition with repeated versus randomly presented series of auditory pseudo words as primes to assess the amount of repetition, and then controlling statistically for repetition effects in the priming task with structural parallelisms.

In a broader view, our finding that structural parallelisms might create a positive evaluative context relates to research investigating the effect of rituals and parallelisms on the behavioral level and is associated with positive emotions and social bonding within a community, such as fan chants at sport events or church services (Khodadadi and Gründel, 2006; Zima et al., 2009). For example, reciting the rosary was shown to have a positive emotional impact in younger adults (Anastasi and Newberg, 2008) and is related to health and well-being in families (Bouisson and Swendsen, 2003; Fiese et al., 2002). It is a question for future studies to investigate how the findings of our study are related to this earlier research. Pre–post assessment of mood and the comparison of experts and novices may be useful approaches to further investigate the emotional impact of structural parallelisms. Without any doubt word meaning and prosody of speeches may influence the recipients emotionally, but this study shows that also the grammatical structures used, have an own part on the positive emotional effect of verbal utterances.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ijpsycho.2012.10.014.

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