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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