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Musical Chords as Affective Priming Context in a Word-Evaluation Task

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Using an affective priming paradigm, we demonstrated that the affective tone of musical chords influences the evaluation of target words. In Experiment 1, participants heard either consonant chords with three tones or dissonant chords with four tones as primes and then saw a positive or a negative word as target. Even participants who were unaware of the hypothesis of the experiment evaluated target words faster if the words were preceded by a similarly valenced chord (e.g., consonant-holiday) as compared to affectively incongruent chord-word pairs (e.g. dissonant-humor). In Experiment 2, results of Experiment 1 were replicated even when chord density was held constant at three tones per chord. Results suggest that the affective tone of single musical elements is automatically extracted and might therefore be viewed as a basic process contributing to the strong connection between music and affect.

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From everyday experience, it is obvious that music can elicit affective responses. In the past few years, a growing body of research has provided scientific evidence for the strong influence of music on affect. Several studies have shown effects of music on self-reports of mood (e.g., Eich, 1995; Pignatiello, Camp, & Rasar, 1986), emotions (e.g., Sloboda, 1999),

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and preferences (e.g., Kenealy, 1988). On the other hand, several studies that were not based on self-reports have demonstrated affective effects of music. For example, Witvliet and Vrana (1996) reported differential effects of music varying in valence (positive versus negative) and intensity on psycho-physiological responses such as facial electromyography (EMG) data, heart rate, and skin conductance. In a study by Schmidt and Trainor (2001), valence and intensity of musical emotions were found to result in differences in electrical activity in the frontal lobe of the brain as shown by electroencephalography (EEG). These authors reported higher EEG activity in the left than the right frontal cortex during the presentation of positively valenced musical excerpts and higher EEG activity in the right than the left frontal cortex during the presentation of negatively valenced musical excerpts. In a positron emission tomography study, Blood, Zatorre, Bermudez, and Evans (1999) identified activity in paralimbic and neocortical regions correlated with musical dissonance. These regions have been shown before to be associated with the distinction between pleasantness and unpleasantness. Gottselig (2000) conducted experiments that yielded evidence that patients with bilateral amygdala lesions, in comparison to control participants, tended to perceive unpleasant music and unpleasant sounds as more pleasant. The amygdala plays a crucial role in emotional processing (LeDoux, 1995).

Despite this increase in research on music and emotion in the past few years, no research has yet been done on automatic affective responses that single musical elements might trigger. As Peretz (2001) stresses, it might be very fruitful to study musical affects indirectly by the way they influence other tasks or behaviors without awareness. Following this idea, we were interested in investigating whether musical elements with positive and negative valence could lead to an automatic activation of the evaluative channels for positive and negative information in the affect system and thereby influence the processing of forthcoming information. We tested this hypothesis by using consonant and dissonant chords as primes in an affective priming paradigm.

The Affective Priming Paradigm

The affective priming paradigm follows the idea that the superordinate division concerning the organization of affect is between positivity and negativity (e.g., Lang, Bradley, & Cuthbert, 1990). In typical affective priming studies, a series of affectively positive (e.g., holiday) or negative (e.g., war) target words are presented, and participants have to respond to them as quickly as possible. Each target word is preceded by a prime stimulus, which can be either positive (e.g., love) or negative (e.g., disgust). Of crucial importance in these studies is the affective relation between the prime and the target. Prime-target pairs can be either affectively congruent (positive-positive, e.g., love-holiday or negative-negative, e.g., war-disgust) or affectively incongruent (positive-negative, e.g., love-disgust or negative-positive, e.g., war-holiday). The affective relationship between the prime and the target mediates responses to the target word. Response latencies are shorter when a target word is preceded by a prime with the same valence than when it is preceded by a prime with different valence (e.g., Bargh, Chaiken, Govender, & Pratto, 1992; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Hermans, De Houwer, & Eelen, 1994; see Fazio, 2001; Klauer, 1998, for overviews).

Typically, participants in affective priming studies are instructed to evaluate (e.g., Hermans, Baeyens, & Eelen, 1998) or pronounce (e.g., Bargh, Chaiken, Raymond, & Hymes, 1996; Duckworth, Bargh, Garcia, & Chaiken, 2002; Hermans, De Houwer, & Eelen, 2001) the targets. In addition, priming has been demonstrated in lexical decision tasks in which participants had to decide whether the target is a word or a nonword (e.g., Kemp-Wheeler & Hill, 1992; Wentura, 2000).

Conscious evaluation of the primes is not required for affective priming to occur because evaluation of the primes is assumed to be an automatic process (e.g., Fazio, 2001). Indeed, effects have been reported in studies in which participants had to ignore (e.g., Hermans et al., 2001) or remember (e.g., Fazio et al., 1986) the primes. Recent evidence for the automatic nature of the affective priming effect stems from studies in which primes were presented subliminally (Draine & Greenwald, 1998; Greenwald, Draine, & Abrams, 1996; Greenwald, Klinger, & Schuh, 1995).

The idea that affective priming is the result of automatic processes is further supported by the fact that usually effects of affective activation are reported when the interval between the onset of the prime and the onset of the target, or the stimulus onset asynchrony (SOA), is 300 ms or less (e.g., Hermans et al., 2001). These SOAs are assumed to be too brief for participants to develop controlled response strategies (Neely, 1977). If so, affective priming effects obtained with short SOAs can be attributed to automatic processes. This suggestion received support by the finding that the priming effect disappeared when the SOA was prolonged to 450 ms (Hermans et al., 2001) or 1000 ms (Fazio et al., 1986) and even reversed at 1200 ms (Klauer, Rossnagel, & Musch, 1997). Furthermore, long presentation of the prime (1000 ms) resulted in lower priming than very short presentation (10 ms), presumably because controlled processes interfered with automatic evaluation of the prime (Rotteveel, de Groot, Geutskens, & Phaf, 2001).

According to Fazio (2001), there are two explanations for how the automatic evaluation of the prime stimulus affects responses to targets in affective priming: The first assumption, proposed by Klauer et al. (1997), is that despite short SOAs, participants have some amount of control in affective priming experiments, which means that expectancies concerning the valence of the target are generated once a prime is presented. If the valence of prime and target are not congruent in a given trial, participants have to correct their initial response tendency and therefore, reaction times are slower than in congruent trials. However, this response competition account does not easily explain affective priming effects obtained with nonevaluative tasks (e.g., Bargh et al., 1996; Chen & Bargh, 1999; Duckworth et al., 2002). In such tasks, the evaluation activated by the prime does not compete with the participants' response. Consistent with this idea, the "spreading evaluation" account (Bargh et al., 1996) assumes that affective priming occurs because a short-lived activation of the prime automatically spreads to all concepts sharing the same valence in the semantic network, facilitating responses to affectively congruent targets, irrespective of the task at hand.

The generality of the affective priming effect has been demonstrated using different types of stimulus materials, such as words (Bargh et al., 1992; Chaiken & Bargh, 1993; Fazio et al., 1986; Hermans et al., 1994), simple line drawings (Giner-Sorolla, Garcia, & Bargh, 1999), and complex real-life color pictures (Hermans et al., 1994). Additional empirical support for the idea that the affective valence of afferent stimulus information is automatically extracted stems from a study involving event-related brain potentials (ERPs) by Ito and Cacioppo (2000). They have shown that photographs of affectively negative scenes (e.g., graveside) elicited larger late positive brain activation potentials (signaling an alerting response) than affectively positive pictures (e.g., chocolate bar), although participants did not have to evaluate these pictures explicitly.

Most affective priming effects reported so far were obtained with visual stimuli. One exception is the study by Hermans et al. (1998), who used one positive and one negative odor as affective primes that served as processing context for word evaluation. Recently, Duckworth et al. (2002) used auditory verbal stimuli as primes. As assumed by all models in the context of affective priming (see Klauer, 1998, for an overview), these findings suggest that the effect might not be restricted to the visual domain but applies to all sensory modalities. In our study on cross-modal affective priming, we aimed at answering the question whether musical chords elicit an automatic affective response that in turn influences processing of visually presented target words.

Affective Priming with Musical Chords

Even short sequences of tones (building up melodies) or chords (building up harmonies) can differ in the affective reactions they evoke. In this respect, the distinction between consonance and dissonance is an important feature (Blood et al., 1999). Because we needed primes with short exposure duration, we decided to use consonant and dissonant chords to test if they result in an automatic activation of positive or negative affect. Chords were recorded using a typical piano sound (which therefore include all overtones of the single tones) and with equal tempered tuning, just as chords are heard in everyday music (see, e.g., Bigand & Pineau, 1997).

A musical chord usually consists of two or more tones sounding together. The distinction between consonant and dissonant chords as important building stones of music in general is based on the finding that two (or more) tones sounding together can vary in the relation of their frequencies; this relation can be expressed in numerical terms. It is assumed that consonant, pleasing-sounding combinations of musical tones consist of simple frequency ratios, an idea that goes back to Pythagoras (see Schellenberg & Trehub, 1996). Typical consonant intervals are the octave, in which the frequency of the lower tone is half the frequency of the higher tone, resulting in a frequency ratio of 1:2; the perfect fifth, consisting of a frequency ratio of 2:3; and the perfect fourth (3:4). On the other hand, very dissonant intervals such as the minor second (15:16) or the augmented fourth (32:45) consist of much more complex frequency ratios. The augmented fourth is known as the tritone and was called the "devil in music" in the Middle Ages (Seay, 1975, p. 83). Psychological research supports the notion that consonance is preferred over dissonance. Several studies have shown that in self-reports, affective responses to dissonant intervals and chords are more negative than response to their consonant counterparts (e.g. Costa, Bitti, & Bonfiglioli, 2000; Gabrielsson & Lindström, 2001; Gottselig, 2000; Smith & Williams, 1999). Zentner and Kagan (1996) were able to show that even 4-month-old infants preferred consonant to dissonant versions of melodies and suggested that the human infant may possess a biological preparedness that renders consonance perceptually more attractive than dissonance. In another study, Blood et al. (1999) demonstrated that cerebral blood flow in paralimbic brain regions, as measured with positron emission tomography, depended on the degree of dissonance of a novel musical passage. Results of this study provided evidence that music may recruit neural mechanisms similar to those associated with pleasant and unpleasant emotional states, but different from those underlying more cognitive aspects of music processing. Moreover, the notion of processing dispositions for simple frequency ratios is entirely consistent with the dominance of musical scales with simple frequency ratios throughout history and across cultures (Schellenberg & Trehub, 1996).

The consonant chords in Experiment 1 and Experiment 2 consisted of three tones with very simple frequency ratios, the dissonant chords of four (Experiment 1) and three tones (Experiment 2) with very complex frequency ratios. Therefore, these stimuli were at the extreme poles of the consonance-dissonance distinction.

Participants in our experiments had to evaluate positive and negative words as quickly and correctly as possible. Before each target, either a consonant or a dissonant chord was presented to participants. Pairing primes with targets resulted in congruent prime-target pairs (consonant prime—positive target or dissonant prime—negative target) and incongruent prime-target pairs (consonant prime—negative target or dissonant prime—positive target). We predicted that reaction times would be shorter for congruent prime target pairs than for incongruent prime target pairs because the auditory primes are automatically evaluated concerning their positive versus negative affective character (e.g., Davidson, 1993; Duckworth et al., 2002; Ito & Cacioppo, 2000; Zajonc, 1980). Furthermore, if this evaluation was indeed automatic, we expected that this priming effect emerged independently of whether participants guess the correct hypothesis after the experiment. In addition, priming should be independent of musicality of participants because the links between consonance and positive affect and between dissonance and negative affect are assumed to be stored in memory regardless of the extent of formal musical knowledge (e.g., Zentner & Kagan, 1996).

Experiment 1

METHOD

Participants

Forty-three psychology students (13 males, 30 females) at the University of Bern participated in the experiment in partial fulfillment of undergraduate course requirements.

Materials

Primes were two consonant and two dissonant chords synthesized with equal tempered tuning in which 1 semitone corresponded to a frequency factor of $2^{1/12}$ (see, e.g., Tekman & Bharucha, 1992). In order to minimize possible effects of tone height (Maher, 1980), one consonant and dissonant chord shared the same lowest and highest tone (root and octave), only the tones between them varied: The first consonant chord consisted of the root (the tone D, 146.83 Hz), a perfect fifth (A, seven half-steps above, frequency = root $\times\ 2^{7/12}$ = 220 Hz) and the octave (D_1, 12 half-steps above, frequency = root $\times\ 2^{12/12}$ = 293.66 Hz), resulting in the three frequency ratios 1:2 (root – octave), 2:3 (root – perfect fifth), and 3:4 (perfect fifth – octave = perfect fourth). The dissonant chord built up by the root (D, 146.83 Hz), the minor second (D♯, one half-step above, frequency = root $\times\ 2^{1/12}$ = 155.56 Hz), the augmented fourth/the tritone (G♯, six half-steps above, frequency = root $\times\ 2^{6/12}$ = 207.65 Hz) and the octave (D_1, 12 half-steps above, frequency = root $\times\ 2^{12/12}$ = 293.66 Hz), resulting in an dissonant chord including the frequency ratios 1:2 (root – octave), 3:4 (minor second – augmented fourth = perfect fourth), 8:15 (minor second – octave = major seventh), 15:16 (root – minor second = minor second) and twice 32:45 (root–augmented fourth and augmented fourth – octave = augmented fourth). The second consonant and dissonant chords differed in tone height. The root tones of these two chords were two octaves above the root tones of the first two chords (D_2, 587.33 Hz), but all frequency ratios—the feature we suggest to have an effect on the automatic activation of affect—were exactly the same as in the lower chords.

The primes were originally recorded on Cubase VST Score Music Creation and Production System software using a Yamaha QY20 synthesizer and then transformed into Wave (.wav) sound files using WaveLab 3.0 software. In a validation study, we assessed whether the consonant chords used in our study indeed had a positive valence and the dissonant chords, a negative valence. Each of these four chords was presented twice in random order to 13 participants who did not participate in the affective priming study. After hearing each chord, participants were asked to rate how much they liked it on a scale ranging from 0 (don't like it at all) to 10 (like it very much). As in the priming study, each chord was presented through Sennheiser HD 25 SP headphones for 800 ms with 65 dB (measured with a Brüel & Kjaer Impulse Precision Sound Level Meter Type 2204).

In line with our assumption, the mean liking rating of the consonant chords (M = 5.42) was significantly higher than of the dissonant chords (M = 3.71), $t(12) = 2.79$, $p = .008$, one-tailed.

A set of 80 nouns were used as targets. All of these words were selected from a word evaluation study at the University of Bern (Burri, 1999) in which 31 participants who did not participate in the priming study had to rate the affective connotation of 210 German nouns on scales ranging from 1 (= very negative) to 5 (= very positive). Based on their mean affective rating, the 40 most positive and 40 most negative words were selected for the target-evaluation task (see Appendix). Primes were randomly assigned to target words for each participant, with the restriction that there were 40 affectively congruent (20 consonant-positive and 20 dissonant-negative) and 40 affectively incongruent (20 dissonant-positive and 20 consonant-negative) prime-target pairs. The experiment, including instructions, was programmed and run on MEL Professional software (Schneider, 1989) on an IBM-compatible computer.

Procedure

Participants were tested individually. They were seated in front of the computer screen at a distance of about 50 cm. Participants were told that positive and negative words would appear on the computer screen. They were instructed to evaluate these words as quickly and as correctly as possible by pressing one of two marked keys on the computer keyboard ("negative" and "positive"). Participants were told that shortly before the presentation of each word, an "acoustic signal" from the headphones would indicate the onset of the target. In order to make this cover story more credible, the intertrial intervals, which denote the duration between a participant's response and the onset of the prime in the next trial, were set at 2000, 3000, 4000, or 5000 ms. During this intertrial interval, a fixation point appeared on the screen, preventing participants from guessing when exactly the next target word would appear. Intertrial intervals were balanced across prime and target valence. Each trial started with the presentation of a fixation cross in the center of the screen, which was followed by the prime chord. Target words were presented in upper case 200 ms after onset of the prime. Since prime chords were presented for 800 ms, there was an overlap in time between prime and target. If a participant evaluated a target before prime-presentation was finished (i.e., within 600 ms), the chord automatically stopped sounding.

The experiment started with four practice trials that were not included in data analysis. Then, each of the 40 positive and negative words was presented once, preceded by a consonant or a dissonant prime chord. Tone height was balanced across prime and target valence. For example, there were 10 trials in which the low consonant chord was followed by a positive target and 10 trials in which the high consonant chord was followed by a positive target. Presentation order of the 80 trials was randomized.

After the affective priming task, a manipulation check followed. First, participants were asked to guess the hypothesis tested in this study. Participants' answers were noted and assigned either to the *accurate hypothesis* group or to the *inaccurate hypothesis* group.

They were assigned to the accurate hypothesis group if they saw a connection between the affective connotation of the chords (consonant versus dissonant) and their facilitating influence on the processing of congruent versus their inhibiting influence on the processing of incongruent target words. Participants who did not provide any guess or mentioned some other, inaccurate hypothesis were assigned to the inaccurate hypothesis group. This distinction was made because priming might be the result of expectancies participants generated after prime presentation (e.g., Neely, 1991). However, we were interested in whether affective priming can be shown even if participants are not aware of the influence of the primes. Then, participants were asked to rate their musicality along a rating scale ranging from 1 (very unmusical) to 7 (very musical). Participants were told that musicality depends on their knowledge about music theory and on whether or not they currently play an instrument. Finally, participants were thanked, debriefed, and dismissed.

RESULTS

Data for one participant were excluded from data analysis because of problems with the data recording. As in other affective priming studies (e.g., Hermans et al., 1994), response latencies higher than 1500 ms (1.96%) were excluded from analyses to minimize the effects of outlier responses; there were no latencies below 300 ms. In addition, wrong answers were also excluded (1.49%); we will present a separate analysis for errors in order to exclude a speed-accuracy trade-off.

Response Latencies

Mean latencies for both hypothesis groups are shown in Table 1. The response latencies were analyzed in a 2 (Hypothesis Group) × 2 (Prime) × 2 (Target) analysis of variance (ANOVA). The first factor was manipulated between participants, the other two factors were manipulated within participants. A significant main effect of target valence, $F(1, 40) = 9.96$; $p = .003$, was qualified by a significant two-way Prime by Target interaction,

TABLE 1

Mean Evaluative Response Latencies (in Milliseconds) for Target Words (Positive/Negative) as a Function of Primes (Consonant/Dissonant) and Results of the Manipulation Check (Experiment 1)

	Target	
	Positive	Negative
Accurate hypothesis (n = 16)		
Consonant primes	686 (92)	735 (102)
Dissonant primes	699 (88)	693 (92)
Inaccurate hypothesis (n = 26)		
Consonant primes	706 (97)	754 (98)
Dissonant primes	727 (109)	735 (101)

NOTE—Numbers in parentheses are standard deviations.

$F(1, 40) = 21.46$; $p < .001$ (Figure 1, upper panel). Positive target words were evaluated faster if preceded by a consonant ($M = 699$ ms) as compared to a dissonant chord ($M = 716$ ms), $t(41) = 2.92$, $p = .003$, one-tailed. In contrast, negative targets were evaluated significantly faster if preceded by a dissonant ($M = 719$ ms) rather than a consonant chord ($M = 747$ ms), $t(41) = 3.33$, $p = .001$, one-tailed.

Importantly, the three-way interaction between hypothesis group, prime, and target was not significant, $F(1, 40) = 0.66$, $p = .422$. This means that

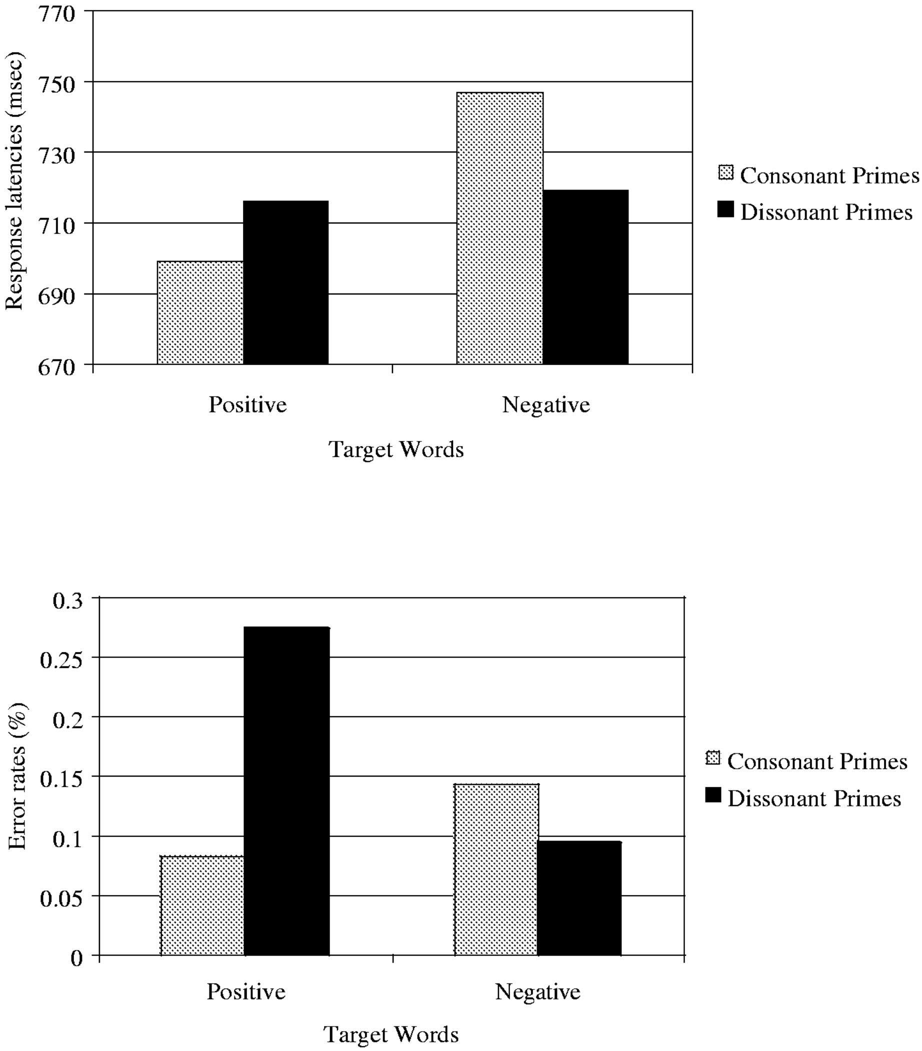

Fig. 1. Mean evaluative response latencies (upper panel) and mean number of errors (lower panel) for positive and negative target words (Positive/Negative) as a function of the consonant and dissonant primes, Experiment 1.

the affective priming effect does not depend on whether or not a participant guessed the accurate hypothesis. Indeed, the critical two-way interaction between prime and target was significant for both the accurate hypothesis group, $F(1, 15) = 8.35$; $p = .011$ and the inaccurate hypothesis group, $F(1, 25) = 12.96$; $p = .001$.

Errors

Error data for both hypothesis groups are shown in Table 2. Errors were analyzed in a 2 (Hypothesis Group) × 2 (Prime) × 2 (Target) ANOVA. The first factor was manipulated between participants, the other two factors were manipulated within participants. This analysis yielded a significant two-way interaction between Prime and Target, $F(1, 15) = 5.81$; $p = .021$ (Figure 1, lower panel). On average, participants made fewer errors on trials with positive targets if the preceding chord was consonant ($M = 0.063$) rather than dissonant ($M = 0.281$), $t(15) = 2.78$, $p = .007$, one-tailed. In contrast, participants made nonsignificantly fewer errors on trials with negative targets if the preceding chord was dissonant ($M = 0.095$) rather than consonant ($M = 0.143$), $t(15) = 1.00$, $p = .175$, one-tailed.

The three-way interaction between hypothesis group, prime, and target was not significant, $F(1, 40) = 0.12$, $p = .735$. Despite the nonsignificant three-way interaction, the two-way interaction between prime and target was significant for the accurate hypothesis group, $F(1, 15) = 9.57$; $p = .007$, but not for the inaccurate hypothesis group, $F(1, 25) = 1.99$; $p = .170$. However, the means of the latter group showed the pattern of an affective priming effect so that any speed-accuracy trade-off can be excluded.

TABLE 2

Mean Number of Errors for 40 Positive and 40 Negative Target Words as a Function of Primes (Consonant/Dissonant) and Results of the Manipulation Check (Experiment 1)

	Target	
	Positive	Negative
Accurate hypothesis (n = 16)		
Consonant primes	0.063 (0.171)	0.156 (0.301)
Dissonant primes	0.281 (0.364)	0.094 (0.202)
Inaccurate hypothesis (n = 26)		
Consonant primes	0.096 (0.246)	0.135 (0.267)
Dissonant primes	0.269 (0.406)	0.096 (0.246)

NOTE—Numbers in parentheses are standard deviations.

Correlational Analyses

In this analysis, priming was defined as the response latency difference between incongruent and congruent trials. The correlation between participants' ratings of their own musicality and both the priming-measure and hypothesis accuracy were not significant, $r(42) = .043$; $p = .79$, and $r(42) = -.025$; $p = .87$, respectively.

DISCUSSION

Experiment 1 yielded an affective priming effect, as expressed by the significant prime × target interaction: Target words were evaluated faster when preceded by an affectively congruent rather than an incongruent prime chord. This effect was replicated for both groups: Participants who provided the accurate hypothesis showed the same kind of affective priming effect as did the participants who provided an inaccurate hypothesis, supporting the "spreading-evaluation" account (Bargh et al., 1996), which posits that conscious expectancy generation after prime presentation is not a necessary precondition for the occurrence of the effect. The prime × target interaction for error rates reached significance only for the group of participants who guessed the correct hypothesis during the experiment, bolstering the affective priming effect obtained with reaction time measures; the same interaction was not significant for participants who were unaware of the hypothesis. In sum, reaction time effects were genuine and not due to a trade-off between speed and accuracy.

However, the affective priming-effect obtained in Experiment 1 might be confounded with chord density because the consonant chords consisted of three tones, whereas the dissonant chords were built of four tones. It might be argued that priming in Experiment 1 was driven by this difference in the number of tones processed, since research has shown that stimuli that are easier to process result in more positive affective reactions (e.g., Reber, Winkielman, & Schwarz, 1998; Winkielman & Cacioppo, 2001). In order the exclude this possibly confounding factor, we conducted Experiment 2, which had one difference in comparison to Experiment 1: the minor second of the dissonant chords was removed. As a consequence, the density of the chords used was held constant. Additionally, it should be noted that apart from the intended manipulation of consonance and dissonance, the two types of chords used in Experiment 2 were only minimally different: They shared the same root and octave, and the fifth of the consonant chords and the augmented fourth of the dissonant chords were only a semitone apart, minimizing a possible confound with tone height (Maher, 1980).

Experiment 2

METHOD

Participants

Seventy-six psychology students (20 males, 56 females) at the University of Bern participated in the experiment for partial fulfillment of undergraduate course requirements.

Materials

Materials and procedure were exactly the same as in Experiment 1, with the only exception that the minor second of the two dissonant chords was removed in Cubase VST Score Music Creation & Production System Software, before these chords were again transformed into Wave sound files using WaveLab 3.0 Software.

RESULTS

Response latencies higher than 1500 ms (1.96%) were again excluded from analyses to minimize the effects of outlier responses, and there were again no latencies below 300 ms. As in Experiment 1, wrong answers were also excluded (1.25%) and analyzed separately.

As in Experiment 1, we present separate analyses, first for latencies and then for errors. For each dependent variable, we present a 2 (Hypothesis Group) × 2 (Prime: consonant versus dissonant) × 2 (Target: positive versus negative) factorial ANOVA for the reaction time data, then for the error data, with the first factor manipulated between participants and the two other factors manipulated within participants.

Response Latencies

Mean latencies for both hypothesis groups are shown in Table 3. The 2 × 2 × 2 factorial ANOVA yielded a marginally significant main effect of hypothesis group, $F(1, 74) = 3.56$; $p = .063$, and significant effects of Prime valence, $F(1, 74) = 5.08$; $p = .027$ and of Target valence, $F(1, 74) = 8.30$; $p = .005$. The latter two main effects were qualified by a significant two-way Prime by Target interaction, $F(1, 74) = 11.96$; $p = .001$ (Figure 2, upper panel). Positive target words were evaluated slightly faster if preceded by a consonant ($M = 722$ ms) rather than a dissonant chord ($M = 726$ ms), but this difference was not significant, $t(75) = 0.84$, $p = .200$, one-tailed. In contrast, negative targets were evaluated significantly faster if preceded by a dissonant ($M = 729$ ms) rather than a consonant chord ($M = 752$ ms), $t(75) = 3.48$, $p = .001$, one-tailed.

Importantly, the three-way interaction between hypothesis group, prime, and target was not significant, $F(1, 74) = 0.72$, $p = .398$. This means that the affective priming effect does not depend on whether or not a partici-

TABLE 3
Mean Evaluative Response Latencies (in Milliseconds) for Target Words (Positive/Negative) as a Function of Primes (Consonant/Dissonant) and Results of the Manipulation Check (Experiment 2)

	Target	
	Positive	Negative
Accurate hypothesis (n = 32)		
Consonant primes	684 (85)	724 (112)
Dissonant primes	685 (82)	690 (107)
Inaccurate hypothesis (n = 44)		
Consonant primes	750 (177)	772 (173)
Dissonant primes	757 (170)	757 (187)

NOTE—Numbers in parentheses are standard deviations.

pant guessed the accurate hypothesis. Indeed, the critical two-way interaction between prime and target was significant for both the accurate hypothesis group, $F(1, 31) = 7.28$; $p = .011$, and the inaccurate hypothesis group, $F(1, 43) = 4.36$; $p = .043$.

Errors

Error data for both hypothesis groups are shown in Table 4. Although the means showed the pattern expected by an affective priming effect (Figure 2, lower panel), a 2 (Hypothesis Group) × 2 (Prime) × 2 (Target) ANOVA did not yield any significant effects.

Despite nonsignificant results over all participants, a 2 (Prime) × 2 (Target) ANOVA for the group who provided an inaccurate hypothesis yielded a significant interaction of Prime and Target, $F(1, 43) = 4.24$; $p = .046$. Participants made fewer errors for positive targets if they followed consonant ($M = 0.341$) rather than dissonant ($M = 0.466$) primes, $t(43) = 1.81$; $p = .039$, one-tailed. On the other hand, participants made slightly fewer errors for negative targets after the presentation of dissonant ($M = 0.330$) versus consonant ($M = 0.375$) chords, but this difference was not significant, $t(43) = 0.645$; $p = .262$, one-tailed.

Correlational Analyses

Again, priming in these correlational analyses was defined as the response latency difference between incongruent and congruent trials. As in Experiment 1, the correlation between participants' ratings of their own musicality and both the priming-measure and hypothesis accuracy were not significant, $r(76) = -.042$; $p = .721$, and $r(76) = -.061$; $p = .60$, respectively.

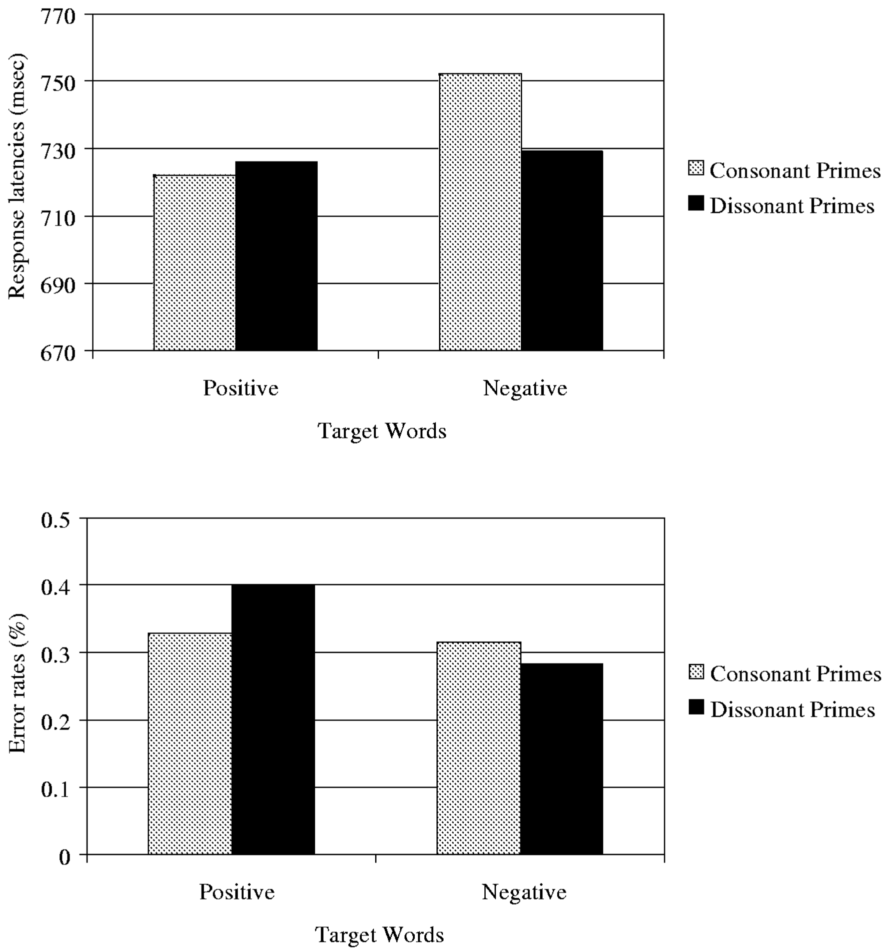

Fig. 2. Mean evaluative response latencies (upper panel) and mean number of errors (lower panel) for positive and negative target words (Positive/Negative) as a function of the consonant and dissonant primes, Experiment 2.

DISCUSSION

In Experiment 2, the affective priming effect of Experiment 1 was replicated: Again, target words were evaluated faster when preceded by an affectively congruent chord rather than an incongruent chord, independently of whether participants were aware of the hypothesis tested. Most importantly, we used consonant and dissonant chords with equal density, ruling out the possibility that priming in Experiment 1 was driven by the amount of tones processed. In contrast to Experiment 1, the prime × target interaction for errors was only significant in the inaccurate hypothesis group. Thus, affective priming was observed with error rates even in those partici-

TABLE 4
Mean Number of Errors for 40 Positive and 40 Negative Target Words as a Function of Primes (Consonant/Dissonant) and Results of the Manipulation Check (Experiment 2)

	Target			
	Positive		Negative	
Accurate hypothesis (n = 32)				
Consonant primes	0.313	(0.435)	0.234	(0.381)
Dissonant primes	0.313	(0.397)	0.219	(0.335)
Inaccurate hypothesis (n = 44)				
Consonant primes	0.341	(0.526)	0.375	(0.947)
Dissonant primes	0.466	(0.659)	0.330	(1.017)

NOTE—Numbers in parentheses are standard deviations.

pants who did not see the accurate connection between the primes and the targets presented.

In the next section, we summarize and discuss the main findings of both experiments in the light of the theoretical predictions.

General Discussion

In two experiments, we observed affective priming using consonant and dissonant chords as primes and words as targets: Target words were evaluated faster and more correctly if an affectively congruent chord was presented as prime. In both experiments, priming was independent of participants' self-rated musicality and their awareness of a possible effect of prime-presentation on target evaluation. In Experiment 2, affective priming occurred even when chord density of the primes was held constant, ruling out the possibility that the effect observed in Experiment 1 was simply due to the number of tones in the two types of chords. Our results are in line with the main findings of affective priming research (see Klauer, 1998, for an overview), which have repeatedly demonstrated that the affective valence of the prime influences the speed of responses to affectively congruent or incongruent target stimuli. Hermans et al. (1998) have interpreted these results as evidence for the assumption that humans possess an evaluative decision mechanism that enables them to evaluate afferent stimulus information automatically (Zajonc, 1980). The generality of this affective priming effect is now well established and has been validated using different types of stimuli and procedural variations. Nevertheless, one aspect shared by most published studies (with the exception of Duckworth et al., 2002, and Hermans et al., 1998) on affective priming is the visual nature of the priming stimuli. The present experiments extend the basic observation of prior affective priming studies by showing that musical primes led to faster evaluative response latencies for affectively congruent targets than for affectively incongruent targets.

The reaction time data of both experiments demonstrated that the strong interconnection between music and affect might be rooted in single musical elements, since consonant and dissonant chords possess the quality to activate affect automatically. In both experiments, participants who did not guess the correct hypothesis showed a significant affective priming effect, as did those who provided the correct hypothesis. Furthermore, there was no difference in Experiment 1 between self-reports and assessment of priming. This finding is in line with existing theoretical and empirical work that demonstrated the emotional significance of music: First, even infants prefer consonant to dissonant melodies (Zentner & Kagan, 1996), suggesting that no explicit musical knowledge is needed for such preferences. Second, there is evidence that the degree of dissonance in music recruits neural mechanisms associated with different pleasant and unpleasant emotional states (Blood et al., 1999). Third, Tillmann, Bharucha, and Bigand (2000) reviewed evidence that culture-specific musical knowledge is acquired as the product of passive exposure to a culture's music and therefore becomes mentally represented. Indeed, emotional responses to the music of one's culture are relatively homogeneous across individuals, being shared by all members of that culture (e.g., Peretz, Gagnon, & Bouchard, 1998). This assumption is supported by the fact that both the ratings in the validation study of Experiment 1 and the assessment of priming of the affective connotation of consonant and dissonant chords yielded the same results, although theoretically, these two types of responses to emotional stimuli might be different (e.g., Frijda, 1986, p. 356). For example, Peretz, Blood, Penhune, and Zatorre (2001) have shown that I.R., who is amusic due to bilateral lesions in the auditory cortex, was unable to distinguish between the affective tone of consonant and dissonant versions of musical excerpts by pleasantness ratings, although she was able to rate the same excerpts as happy or sad, just as a control group did. This finding suggests that there are at least two kinds of affective qualities tied to musical elements, and it remains to be examined which of those account for the affective priming effect with chord primes. It is not clear to what extent the effects observed in our experiments are the result of automatic or even unconscious emotional processes (e.g., Winkielman, Zajonc, & Schwarz, 1997) or of automatic cognitive processes (e.g., Hermans et al., 2001).

In our study, we observed that the affective priming phenomena could be extended to the musical domain. Most importantly, results suggest that the affective tone of single musical stimuli is automatically extracted. Therefore, our investigation is a further step toward the experimental study of implicit connections between single musical stimuli and affective processes they may trigger.[1]

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Appendix

Mean Affective Ratings of the German Target Words Used in Our Study (1 = Very Negative, 5 = Very Positive)

Positive Words		Negative Words	
Liebe (love)	4.91 (0.29)	Mörder (murderer)	1.15 (0.35)
Freude (joy)	4.89 (0.31)	Gewalt (violence)	1.16 (0.43)
Glück (fortune)	4.86 (0.43)	Folter (torture)	1.17 (0.56)
Lachen (laugh)	4.85 (0.36)	Inzest (incest)	1.19 (0.48)
Urlaub (holyday)	4.80 (0.43)	Hass (hatred)	1.22 (0.42)
Spass (fun)	4.77 (0.51)	Unfall (accident)	1.23 (0.55)
Sonne (sun)	4.77 (0.42)	Qual (torment)	1.25 (0.53)
Humor (humor)	4.74 (0.46)	Horror (horror)	1.26 (0.53)
Lob (praise)	4.74 (0.46)	Elend (misery)	1.26 (0.47)
Lust (lust)	4.72 (0.48)	Seuche (epidemic)	1.27 (0.47)
Kuss (kiss)	4.71 (0.52)	Verrat (betrayal)	1.28 (0.49)
Ferien (holyday)	4.64 (0.58)	Leid (injury)	1.30 (0.46)
Reise (journey)	4.63 (0.55)	Unheil (mischief)	1.31 (0.48)
Musik (music)	4.62 (0.68)	Strafe (punishment)	1.34 (0.59)
Genuss (pleasure)	4.61 (0.60)	Not (need)	1.35 (0.55)
Natur (nature)	4.61 (0.56)	Geiz (stinginess)	1.35 (0.58)
Schatz (treasure)	4.59 (0.58)	Zwang (compulsion)	1.37 (0.48)
Dank (thanks)	4.59 (0.55)	Trauma (trauma)	1.37 (0.67)
Wunder (miracle)	4.58 (0.61)	Opfer (victim)	1.42 (0.63)

(Continued)

Positive Words		Negative Words	
Leben (life)	4.58 (0.65)	Ekzem (eczema)	1.43 (0.56)
Oase (oasis)	4.56 (0.61)	Sklave (slave)	1.44 (0.72)
Wärme (warmth)	4.54 (0.52)	Gier (greed)	1.45 (0.69)
Charme (charm)	4.53 (0.52)	Akne (acne)	1.46 (0.58)
Blume (flower)	4.52 (0.63)	Rache (rage)	1.47 (0.70)
Herz (heart)	4.51 (0.66)	Kotzen (puke)	1.47 (0.74)
Party (party)	4.46 (0.67)	Übel (evil)	1.48 (0.54)
Erfolg (success)	4.45 (0.54)	Hölle (hell)	1.48 (0.69)
Spiel (game)	4.44 (0.59)	Panzer (tank)	1.48 (0.69)
Jubel (jubilation)	4.42 (0.63)	Geisel (hostage)	1.49 (0.76)
Trost (consolation)	4.42 (0.79)	Betrug (deceit)	1.52 (0.66)
Kraft (power)	4.38 (0.64)	Armut (poverty)	1.53 (0.60)
Fest (party)	4.38 (0.70)	Ekel (disgust)	1.54 (0.68)
Gewinn (winning)	4.37 (0.63)	Satan (satan)	1.54 (0.75)
Meer (sea)	4.35 (0.78)	Frust (frustration)	1.54 (0.55)
Licht (light)	4.32 (0.72)	Sucht (addiction)	1.56 (0.59)
Geburt (birth)	4.32 (0.80)	Pein (pain)	1.57 (0.57)
Reife (maturity)	4.31 (0.65)	Kot (mud)	1.58 (0.63)
Ruhe (silence)	4.29 (0.69)	Ruin (ruin)	1.62 (0.78)
Gefühl (feeling)	4.28 (0.76)	Feind (enemy)	1.62 (0.58)
Perle (pearl)	4.28 (0.64)	Lüge (lie)	1.63 (1.13)

NOTE—Numbers in parentheses are standard deviations.