Automaticity and affective responses in valence transfer: Insights from the crossmodal auditory-visual paradigm

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Automaticity and affective responses in valence transfer: Insights from the crossmodal auditory-visual paradigm

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Abstract

The current study examined valence transfer in the crossmodal paradigm in order to test the generalizability of the phenomenon and to contribute to a better understanding of the underlying processes. Western European participants evaluated Asian ideographs to be more visually pleasant when in the presence of pleasant sounds than when in the presence of neutral or unpleasant sounds (Experiment 1). Experiment 2 was conducted to reduce the demand characteristics, and to investigate the involvement of affective responses. We measured facial electromyography (EMG) and skin conductance responses (SCR) from participants evaluating ideographs while a piece of music was playing in the background. Evaluative judgments of the ideographs reflected subtle variance of valence *within* the piece of music. The extent of this valence transfer depended on the extent of SCRs within the respective trial. In addition, ideograph judgments were accompanied by concordant affective responses within facial EMG. The findings suggest that valence transfer from brief stimuli can be generalized to the crossmodal paradigm, occurs even if the experimental procedure obscures the purpose of investigation (i.e., automatically), and that affective responses are involved.

Keywords

affective responses, EMG, music, SCR, sounds, valence transfer

Many studies (e.g., Oikawa, Aarts, & Oikawa, 2011) have reported that valence from visual stimuli (primes) can transfer and influence evaluative judgments concerning other, temporally close visual stimuli (targets). Valence transfer has mainly been examined in the unimodal paradigm, in particular in the Affect Misattribution Procedure (AMP; Payne, Cheng, Govorun, &

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Stewart, 2005). In each trial of the AMP, participants are exposed to an Asian ideograph. Participants (who are not familiar with the meaning of these ideographs) are asked to evaluate the visual pleasantness of each ideograph. Each of these ideographs is preceded (or accompanied) by a briefly presented visual prime, for example, a picture from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008)[1]. The order of primes in the AMP is random, so that valence varies unpredictably from trial to trial. Valence transfer refers to the observation that participants are more likely to evaluate the ideographs to be pleasant in trials with pleasant rather than unpleasant and neutral visual primes, respectively. These findings indicate that valence transfer can be observed from briefly presented visual primes. However, no study has yet examined valence transfer from brief auditory primes in a crossmodal paradigm.

In the current studies we are not primarily interested in the examination of theories and mechanistic processes that are in particular inherent to "crossmodality" per se. With this respect, there is a lot of research, for example on crossmodal integration (Maiworm, Bellantoni, Spence, & Röder, 2012) and crossmodal correspondence (Spence & Deroy, 2013), and highly elaborated models and theories have been developed (Spence, 2011). However, an exhaustive review of such findings and their empirical examination goes beyond the scope of the current study. When using the term "crossmodal" in the current study, we merely want to describe valence transfers from primes that are of a different modality than the target (in particular, auditory–visual).

It is quite surprising that no study has yet investigated crossmodal valence transfer from brief auditory stimuli. Such an investigation would offer important insights into the generalizability of the phenomenon. Furthermore, if valence transfer from brief primes generalizes to the crossmodal paradigm, new methodological approaches would be possible that may offer new insights into the mechanistic underpinnings of valence transfer in general.

Concerning these mechanistic assumptions in particular, many researchers assume that misattribution is involved in valence transfer (e.g., Gawronski & Ye, 2014; Payne et al., 2005); the primes induce valence-concordant changes in core affect (Russell, 2003), which in turn is misattributed by the participants to evolve from the target. Evaluative judgments of these are thus affected accordingly. Importantly, it has been argued that these processes proceed automatically (i.e., unintended; De Houwer, 2006). Evidence supporting the proposition of automaticity comes from the observation that valence transfer in the unimodal paradigm can be observed even if participants are instructed to do their best not to let their evaluations of the ideographs be influenced by the primes (Payne et al., 2005). However, Bar-Anan & Nosek (2012) propose that valence transfer is driven by strategic processes. They assume that due to the blatant obvious nature of the procedure participants easily become aware of the purpose of the investigation and thus behave accordingly. In particular, participants are assumed to strategically evaluate the primes instead of the ideographs, even if they were explicitly told to ignore these. As there is considerable evidence in favor of both propositions (e.g., Payne et al., 2013; Teige-Mocigemba, Penzl, Becker, Henn, & Klauer, 2015), the discussion is yet unresolved. One approach to contribute to this discussion is the development of procedures that cover the purpose of investigation. If valence transfer can occur from even brief auditory stimuli in the crossmodal paradigm, less obvious procedural approaches would be possible. Such procedures may allow for a more conclusive investigation of the involvement of strategic processes. The second aim of the current study, therefore, is to examine whether crossmodal valence transfer can be observed if the purpose of the experimental procedure is less obvious to the participants.

A similarly unresolved mechanistic discussion concerns the question whether "affective" responses are indeed involved in the formation of valence transfer. While some researchers propose that the primes elicit affective responses (e.g., expressivity), which in turn influence evaluative judgments (Payne et al., 2005; see also Pfister & Böhm, 2008 and Stanton, Reeck, Huettel,

& LaBar, 2014 for similar approaches), others doubt that affective responses are involved in valence transfer at all (e.g., Blaison, Imhoff, Hühnel, Hess, & Banse, 2012). A third aim of the current study, therefore, is to investigate whether affective responses are involved in valence transfer.

Taken together, there is considerable evidence for robust valence transfer from briefly presented visual primes in the unimodal paradigm. In contrast, no study has yet examined valence transfer from brief auditory primes in the crossmodal (auditory–visual) paradigm. A positive result would suggest a certain generalizability of the phenomenon and, furthermore, allow for new methodological approaches that may offer further insights into the automaticity of the processes involved. Apart from that, little is known about the involvement of affective responses in the formation of valence transfer.

The current study aims to contribute to the clarification of these points. In a first experiment we examined whether—similar to the unimodal paradigm—crossmodal valence transfer can be found from brief auditory primes. In the second experiment, we examined whether valence transfer can be observed if the purpose of the experimental procedure is less obvious to the participants, and whether affective responses are involved.

With respect to the first aim one has to note that there is already evidence that our evaluative experience of the visual world can be influenced by the emotional quality of longer auditory stimuli (Hanser & Mark, 2013; Hanser, Mark, Zijlstra, & Vingerhoets, 2015; Yamasaki, Yamada, & Laukka, 2015; Ziv, Hoftman, & Geyer, 2012). For example, in a study by Logeswaran & Bhattacharya (2009) participants were asked to rate the happiness (vs. sadness) of visual facial expressions that were preceded by happy and sad musical excerpts. The authors found that happy faces were rated as more happy after happy music and sad faces were rated as more sad after sad music. The findings suggest that the emotional quality of an auditory stimulus (e.g., a piece of music) can transfer and influence judgments of subsequent visual stimuli. As participants were to judge the targets with respect to basic emotions (fear vs. anger), we do not know, whether this may also occur with respect to their general valence (pleasant vs. unpleasant). More importantly, auditory stimuli were quite long (15 seconds) and targets were presented at the offset of these. No study to date examined valence transfer from brief auditory stimuli and nearly simultaneously presented targets. It is possible that such procedural conditions do not evoke valence transfer. This would reflect an interesting limitation to the robustness of valence transfer, and would imply important information for our understanding of the mechanisms involved. One goal of the current study, therefore, was to examine whether evaluative judgments of visual stimuli can be influenced by the valence of brief and nearly simultaneously presented primes. With this respect, valence of the primes is the independent variable and evaluative judgment concerning the ideographs is the dependent variable.

Experiment 1

In Experiment 1 we examined the generalizability of valence transfer in a crossmodal paradigm. We asked participants to evaluate the pleasantness of Asian ideographs that were accompanied by brief unpleasant, neutral, or pleasant sound from the IADS (Bradley & Lang, 2007). Each of the IADS sounds was only 2 seconds long.

Method

Participants. Twenty-nine psychology students from Humboldt-Universität zu Berlin (Germany) ranging from 19 to 31 years of age (M = 23.00, SD = 3.53) took part in the experiment (21 females). Participants were required to have normal vision and hearing. Each participant signed an informed consent form before beginning the experiment.

Materials. Thirty-six sounds from the IADS (Bradley & Lang, 2007) were used as primes.[2] In their original version the IADS sounds are 6 seconds long. As we intended to examine valence transfer from brief stimuli, we used only the first 2 seconds of each sound for the current experiment. With respect to the normative database of the IADS, 12 of the sounds were pleasant, 12 were neutral, and 12 were unpleasant.[3] As cropping the sounds may have changed their valence, we asked a group of independent participants ($N = 32$) to rate these brief sounds according to their valence and arousal. These ratings followed those of the normative data base and confirmed the validity of the categorization.[4]

For the targets we used Asian ideographs drawn from a Windows® standard font that were printed in black against a grey background (Figure 1). In a pretest study we asked 51 participants to rate the pleasantness of 400 of these ideographs. Based on these data we selected those 72 ideographs that were rated to be most neutral.

Procedure. Upon arriving in the laboratory each participant signed an informed consent form. Participants were told that the experiment was designed to investigate how people intuitively make quick and simple judgments. Participants were then led to a quiet room and seated approximately 70 cm in front of a computer screen in a comfortable chair. They were asked to put on stereo headphones through which the sounds were delivered. Participants were instructed as follows:

> In the following experiment we will show you some Asian ideographs. Each of these ideographs will be visible very briefly. Please decide whether you find the respective ideograph to be visually pleasant or unpleasant. If you find the ideograph to be pleasant, please press the right arrow key. If you find the ideograph to be unpleasant, please press the left arrow key. During the experiment you will also hear brief sounds. These sounds will signal the appearance of the ideographs. Note that these sounds might influence your decision. However, it is very important, to avoid this influence.

Each trial started with a black fixation point that was shown for 1 second. Directly after the fixation point a sound was played for 2 seconds. With a short delay of 0.1 seconds following the *onset* of the sound the ideograph appeared for 0.1 seconds. The ideograph was than masked by a pattern of black and white "noise" until the participant responded with either the left ("rather unpleasant") or right ("rather pleasant") arrow key. This procedure is nearly identical to the unimodal paradigm of Payne et al. (2005). Ideographs were presented centrally in black against a grey background (RGB: 162, 162, 162).

Altogether 144 trials were completed so that each prime was used four times, while each ideograph was used twice. The sequence and pairing of primes and ideographs was randomized with the restrictions that each prime had to be presented twice in the first and twice in the second half of trials, and that each ideograph had to be shown once in the first and once in the second half of trials. Furthermore, any particular stimulus could only recur after at least three trials.

At the end of the experiment participants were thanked, given course credit, and debriefed. Including preparation and instructions the entire experiment took approximately 30 minutes to complete.

Apparatus. Ideographs were presented on a 24-inch liquid crystal display (LCD) using a 100 Hz refresh rate and a resolution of 1680 × 1050 pixels. Sounds were played on AKG K 272 stereo

Figure 1. Example of the Asian ideographs that have been used in the study.

headphones. Stimulus presentation and timing were controlled using MATLAB (The Mathworks Inc.) and the Psychophysics Toolbox version 3 (Brainard, 1997) running on a standard computer.

Results

For the analysis "pleasant" evaluations of the visual stimuli were coded with 1, and "unpleasant" evaluations of the visual stimuli were coded with -1. For each participant and valence category we calculated the mean of these evaluations and entered these into a one factor (prime valence) ANOVA with three factor steps (pleasant, neutral, and unpleasant). This analysis revealed a main effect of valence $F(2,56) = 6.63$, $p < 0.01$, $\eta^{p2} = 0.19$. The mean evaluation of the ideographs was more pleasant ($t(28) = 2.32$, $p = .028$) following pleasant primes ($M = 0.14$) compared to neutral ($M = -0.01$), and compared to unpleasant primes ($M = -0.11$; $t(28)= 2.78$, $p = .01$). Likewise the difference between evaluations following neutral and unpleasant sounds was significant ($t(28)= 2.19$, $p = .037$). See Figure 2 for an overview.

Discussion

In Experiment 1 we observed that valence of brief IADS sounds (Bradley & Lang, 2007) influences the evaluative judgments of nearly simultaneously presented visual Asian ideographs. This suggests that immediate valence transfer from briefly presented primes generalizes to the crossmodal paradigm. Evidently, auditory stimuli can alter evaluative judgments concerning visual stimuli on a moment-to-moment basis.

Experiment 2

Similarly valence transfer effects have been reported within the unimodal paradigm (Payne et al., 2005). These findings have been explained by proposing that even brief visual stimuli elicit affective responses that in turn influence evaluative judgments, for example via (automatic) misattribution (Gawronski & Ye, 2013; Oikawa et al., 2011). Indeed there is evidence that visual stimuli can elicit immediate affective responses (e.g., Codispoti, Bradley, & Lang, 2001; Dimberg, Thunberg, & Grunedal, 2002; Gibbons, 2009). Similarly immediate affective responses can also be elicited by auditory stimuli (Eerola & Vuoskoski, 2013; Eich, Ng, Macaulay,

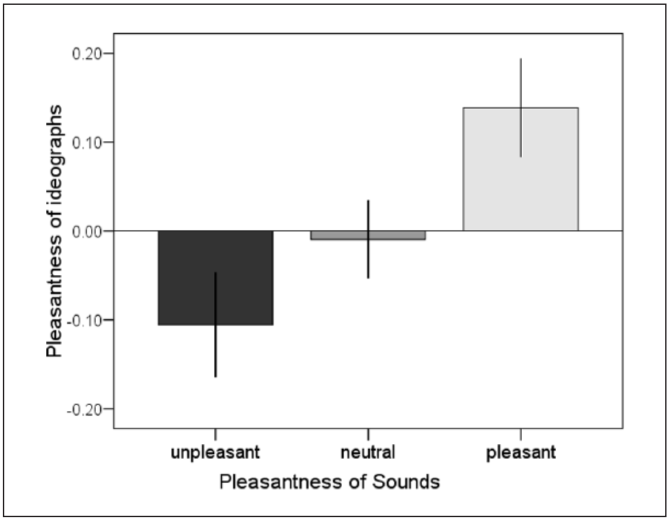

Figure 2. Mean pleasantness judgments concerning the ideographs plotted against sound valence in Experiment 1. Error bars represent +/- 1 SE.

Percy, & Grebneva, 2007; Ilie & Thompson, 2011; Larsen, Norris, & Cacioppo, 2003; Müller, Klein, & Jacobsen, 2011). Some researchers, however, assume that affective responses are not involved in valence transfer at all (Blaison, Imhoff, Hühnel, Hess, & Banse, 2012).[5] Thus the question for the involvement of affective responses in the formation of valence transfer is yet not resolved.

Another important discussion on the mechanistic underpinnings of valence transfer refers to the extent of automaticity of the processes. While some researchers argue that transfer (e.g., in terms of misattribution) proceeds automatically (i.e., unintended), others (e.g., Bar-Anan & Nosek, 2012) propose that valence transfer is rather driven by strategic processes. They assume that the blatant nature of the procedure allows participants to gain insight into the purpose of investigation and thus to behave accordingly. In particular, participants are assumed to strategically evaluate the primes instead of the ideographs. One approach to contribute to this discussion is the development of procedures that cover the purpose of investigation. We argue that the crossmodal paradigm allows for the development of less obvious procedural designs. Both issues (automaticity and involvement of affective responses) were targeted in Experiment 2.

It has been argued that in typical valence transfer studies (e.g., the AMP) participants may easily become aware of the purpose of investigation. Usually, primes with strong valence polarization are used, which may contribute to the blatancy of a typical valence transfer study. Furthermore, primes and targets are temporally close and in the unimodal paradigm they are of the same modality. As participants are asked to attend to the visual targets, the primes must inevitably receive a lot of attention, too. As a result, participants may very easily become aware of the purpose of investigation and thus be more likely to intentionally rate the primes instead of the ideographs—even if they were explicitly told to ignore these. As prime and target of the crossmodal paradigm are of different modalities, attention to the primes is reduced, rendering participants less likely to become aware of the purpose of investigation.

Furthermore, the crossmodal paradigm offers the potential to further reduce the demand characteristics of the procedure. While it is obvious that a distinct song may induce a feeling of certain pleasantness, valence can subtly vary *within* a song. We argue that such variation in valence is much less obvious than the global valence of a distinct stimulus per se. Furthermore, it is less obvious that these subtle variations may influence evaluative judgments of visual targets, rendering participants less suspicious about the purpose of investigation.

In order to reduce the obviousness of the investigation, we asked participants to evaluate visual targets while music was playing in the background. We assessed valence transfer by analyzing the covariation of the evaluative judgments and the valence of the respective moment within the music. With these conditions any valence transfer (i.e., covariation) can more credibly be attributed to automatic (i.e., unintended) processes.

A second aim concerns the involvement of affective responses in valence transfer. As outlined above, pleasant stimuli are assumed to increase the hedonic quality of the organism's affective state (core affect), and unpleasant stimuli result in an affective state of decreased hedonic quality (Russell, 2003). Importantly, responses in facial expressivity have been suggested to reflect these affective changes (Dimberg, Thunberg, & Elmehed, 2000; Larsen et al., 2003). For example, participants in a study by Cacioppo, Petty, Losch, and Kim (1986) evaluated the pleasantness of emotional pictures. This study revealed that activities over the muscles corrugator supercilii (involved in frowning) and zygomaticus major (involved in smiling) systematically vary with picture valence; activity of the muscle corrugator supercilii decreased with pleasantness and the reversed pattern has been found for the muscle zygomaticus major. These findings have repeatedly been replicated, and have also been extended to other stimulus material and modalities (Cacioppo, Bush, & Tassinary, 1992; Dimberg, 1986; Larsen et al., 2003; Weinreich & Funcke, 2014; Weinreich, Strobach & Schubert, 2015). These findings indicate that expressive facial reactions reliably indicate affective responses across a broad range of modalities.

Furthermore, a study of Codispoti et al. (2001) reported that pleasant and unpleasant stimuli elicit higher skin conductance responses (SCRs) when compared to neutral pictures suggesting that the extent of SCRs reflects the intensity of affective responding (see also Bradley, Codispoti, Cuthbert, & Lang, 2001).

In order to examine whether affective responses were involved in valence transfer, we measured SCR and facial EMG while the participants were engaged in judging the ideographs. If affective responses were involved in valence transfer, we expected a positive relation between EMG activity over the muscle zygomaticus major and the pleasantness of evaluations. A reversed pattern is expected for the muscle corrugator supercilii. As SCRs are indicative of the intensity of affective responses (Codispoti et al., 2001) we, furthermore, expected higher valence transfer in trials with larger affective responses, that is, in trials with relatively higher than compared to lower SCRs.

Method

Participants. Thirty-two psychology students from Humboldt-Universität zu Berlin (Germany) took part in the experiment. We excluded five participants as they claimed to be familiar with the Asian ideographs at the end of the experiment. Age and gender of two of the remaining participants cannot be reported due to a recording error. The mean age of the 25 participants (20 females) was 25.1 years ($SD = 8.09$). Participants were required to have normal vision and hearing.

Apparatus. EMG was recorded using Ag/AgCl miniature surface electrodes. In accordance with the standard electrode placements recommended by Fridlund & Cacioppo (1986), two electrodes were placed over the left eyebrow (*corrugator supercilii*), and two electrodes were placed over the left cheek region (*zygomaticus major*). A reference electrode was placed on the upper right forehead over a region that contains relatively few muscles. Electrodes were filled with high conducting water-soluble electrolyte gel. Electrode sites were cleaned and rubbed with prep-pads dampened with alcohol to decrease skin resistance. The raw electromyography signal was amplified by a factor of 50,000 at a bandpass of 8 Hz–10 kHz (Coulbourn V75-04), rectified and integrated (Coulbourn V76-23; time constant 0.1 seconds). Skin conductance electrodes were placed adjacently on the hypothenar eminence of the left palmar surface, using standard electrodes filled with water-soluble electrolyte gel. The signal was acquired with a Coulbourn S71-22 skin conductance coupler. The output voltage of both, the EMG and SCR signal was digitized at 16bit and 1000 Hz (USB 1608 FS by Measurement Computing). With all other respects the apparatus was identical to Experiment 1. Ideographs were presented on a 24-inch LCD using a 100 Hz refresh rate and a resolution of 1680 × 1050 pixels. Sounds were played on AKG K 272 stereo headphones. Stimulus presentation and timing were controlled using MATLAB (The Mathworks Inc.) and the Psychophysics Toolbox version 3 running on a standard computer.

Materials. Two pieces of music were used as auditory stimuli: “Stereo Love” by Edward Maya &Vika Jigulina (electronic) and “A Little Night Music” by Wolfgang Amadeus Mozart (classical). Twenty seven Asian ideographs served as target stimuli. For each participant these ideographs were randomly drawn from the pool of 72 ideographs that were used in Experiment 1.

Procedure. Participants were instructed to evaluate the visual pleasantness of Asian ideographs by clicking on a point on a visual judgment scale below the respective ideograph and confirming this evaluation by clicking on an “OK” button displayed below. The scale was labelled with the endpoints “not at all pleasant” and “very pleasant.” There were no visual divisions between these endpoints, making the scale continuous and meaning that participants were able to click anywhere in between these endpoints. For the analysis the scale was divided into 100 equally sized units. The value 1 was assigned to the endpoint “not at all pleasant.” The endpoint “very pleasant” was assigned the value 100. The music was explained as a perceptual distractor. After confirming that they understood these instructions, participants started the experiment by pressing any keyboard button. When the button was pressed the music started to play. After 10 seconds the first fixation point appeared. After 1.5 seconds this fixation point was replaced by the first ideograph. At the same time the judgment scale including the “OK” button was presented below the ideograph. When the participant clicked the “OK” button both the ideograph and the scale disappeared. This was also the case if participants did not make their judgment within 8 seconds of ideograph presentation. The interval between the onsets of two consecutive ideographs was exactly 10 seconds. Altogether 27 ideographs had to be judged. The sequence of ideographs was randomized. The genre of the music pieces was manipulated between participants.

When the song had ended, after 280 seconds an instruction screen appeared, informing participants about an unexpected second task. Participants were instructed to evaluate the pleasantness of sections of the song by clicking a point on a visual judgment scale identical to the ideograph rating scale, and confirming this evaluation by clicking an “OK” button below. “Now you will hear the music again. While the music is playing you will repeatedly be asked to evaluate how pleasant you personally feel at the respective moment in time.” After these instructions the participant started the task by pressing any keyboard button. The same piece of music from the ideograph judgment task started to play again. After 10 seconds the first fixation point appeared. After 1.5 seconds this fixation point was replaced by the judgment scale including the “OK” button. When the participant clicked the “OK” button the scale disappeared.

This was also the case if participants did not make their judgment within 8 seconds from fixation point offset. The interval between the onsets of two consecutive judgment scales was exactly 10 seconds again. Altogether the pleasantness of 27 passages (moments) within the music piece had to be judged. No ideographs were shown.

At the end of the experiment participants were asked to evaluate the pleasantness of the song as a whole on a five-point Likert scale. Finally, they rated whether they were familiar with Asian ideographs in general. Then they were thanked, paid, and debriefed. Including preparation and instruction the experiment took approximately 30 minutes to complete.

Results

Preliminary analysis. Genre did not have an effect on the global evaluation of the music pieces ($M = 2.93$, $SD = 1.20$), nor the averaged ideograph ($M = 50.78$. $SD = 7.7$) or music passage judgments ($M = 57.01$. $SD = 24.2$). Mean reaction times for the ideograph evaluation was 3.14 seconds ($SD = 0.8$).

Primary analysis. For the analysis we examined the covariation of ideograph evaluations and the individually assessed valence of the respective moment within the piece of music. For each participant we z-transformed the evaluations concerning both, the ideographs and the music passages. Then we calculated a correlation (i.e., an estimate of covariation) between both for each participant. In a next step we transformed the resulting correlation coefficients to Fisher-z values. We tested the resulting distribution of the Fisher-z transformed correlation values against zero. This analyses revealed that the mean of the distribution of the Fisher-z transformed correlation values ($M = 0.11$, $SD = 0.18$) significantly differed from zero ($t(26) = 3.14$, $p < .005$).[6]

To examine whether affective responses are involved in valence transfer, we calculated the SCRs in a time window of 1 to 5 seconds following the onset of the ideograph. From these values we subtracted the baseline, namely the mean of SCR in a time window of 1 second immediately preceding the ideograph. For each participant we then calculated the median of these values and split the trials accordingly. Then we calculated intra-individual correlations of ideograph evaluation and music passage evaluations for trials with lower and higher SCRs, respectively, calculated Fisher-z transformations of these values and compared both distributions of the Fisher-z transformed correlation coefficients with a *t*-test. This analysis revealed that the correlation between ideograph evaluations and music passage ratings was significantly larger ($t(26) = 2.07$, $p < .05$) in high ($M = 0.24$, $SD = 0.34$) than compared low SCR trials ($M = 0.02$, $SD = 0.33$).[7]

Then we analyzed whether the ideograph ratings were accompanied by affective responses as indicated by facial EMG. For each participant and trial we calculated the EMG activity over the muscles corrugator supercilii and zygomaticus major in a time window of 1 to 5 seconds following the onset of the ideograph. From these values we subtracted the baseline activity, namely the median of activity across the entire experiment. For each participant we then calculated the correlation of ideograph evaluations and EMG activity over the muscles corrugator supercilii and zygomaticus major, respectively, and tested both distributions of the Fisher-z transformed correlation coefficients against zero. This analysis revealed that the correlation between ideograph evaluation and affective responding of the zygomaticus major muscle ($M = 0.11$, $SD = 0.21$) was significantly larger than zero ($t(26) = 2.72$, $p < .05$). Likewise, the correlation between ideograph evaluation and affective responding of the corrugator supercilii ($M = -0.12$, $SD = 0.26$) was significantly different from zero ($t(26) = 2.45$, $p < .05$).[8]

Discussion

Experiment 2 offered evidence that valence transfer proceeds in a rather automatic (unintended) way, and that affective responses are involved in the formation of valence transfer. Evaluative judgments of Asian ideographs reflected subtle moment-to-moment variations in valence within a piece of music that was played in the background, suggesting that subtle variation of valence within auditory stimulation can influence evaluative judgments of items of the visual domain. This finding is in line with results from Lebrecht, Bar, Barrett, and Tarr (2012) who found that small variance in valence ("micro-valences") has behavioral effects.

Our findings suggest that valence transfer is not restricted to emotionally strong stimuli. Furthermore, they are informative for the recent discussions on the nature of the processes involved in the formation of valence transfer.

First, they reflect evidence for the notion that valence transfer (e.g., via misattribution) can proceed without the participants' intention. It has been argued that the blatant procedural situation of typical valence transfer studies facilitates insight into the purpose of investigation. As a result, valence transfer may solely depend on strategic effects. In particular, it has been argued that participants may in general evaluate the prime rather than the ideograph. Our procedure covered the purpose of the investigation. In particular, our procedure reduced the obviousness of the role of the primes. While evaluating the ideographs, participants focused on the visual modality, while the "primes" were intruding on the unattended auditory channel. Furthermore, variation of valence of the "primes" was unobtrusive. Finally, all participants rated the music passages *after* they had rated the ideographs. Thus, it is less likely that participants became aware of the subtle variation of valence within the music, and its potential influence on ideograph evaluation. Altogether the procedural properties allow that the observed valence transfer is less likely based on strategic than automatic processes (e.g., Bar-Anan & Nosek, 2012).

Second, our findings suggest that affective responses are involved in the formation of valence transfer. We found that the evaluative judgments were accompanied by concordant affective responses within facial EMG. In particular, the activity of the corrugator supercilii muscle decreased with increasing pleasantness of the evaluative judgments. Accordingly, the activity of the zygomaticus major muscle increased with increasing pleasantness of the evaluative judgment. Finally, we found that valence transfer was significantly greater in trials with higher affective responding compared to those with lower affective responding within SCR. These findings add evidence to the proposition that affective responses are involved in valence transfer.

To sum up, the findings of both experiments suggest that (1) nearly immediate crossmodal valence transfer from brief auditory stimuli can be observed; (2) affective responses are involved; and (3) valence transfer is less likely to be exclusively based on strategic processes.

Yet, the implications of the presented results are limited. Participants were recruited from psychology students. At least in Germany females are considerably overrepresented in this population (around 80%). Randomly drawing from this population results in a similarly unbalanced sample. With this in mind, one has to be careful with generalization of the results. Yet removing the males from the sample does not profoundly change the pattern of results. Furthermore, the aim of balancing the sample from the population of psychology students can also introduce new problems that may seriously harm representativeness.

Another limitation concerns the target stimuli. Drawing on previous research we used emotionally ambiguous Asian ideographs as visual target stimuli (Payne et al., 2005). Thus the implications of the current study are limited to such material. It would be interesting to see whether the findings generalize to other visual target stimuli, like faces, brands, or pictures of everyday items (e.g., food). Such a generalization would increase the implications of the phenomenon. For example, valence transfer may be involved in evaluative conditioning (Jones & Fazio, 2009). Future studies may examine whether brief auditory stimuli can cause *durable* changes in valence of visual stimuli (e.g., brand logos) as well, and, in addition, whether this has an effect on overt approach behavior like consumption and choice (e.g., Gibson, 2008; Knutson, Wimmer, Kuhnen, &Winkielman, 2008; Veltkamp, Custers, & Aarts, 2011). If this was the case, a split second of music or a sound could potentially impact your entire day. For example, a pleasant jingle incidentally perceived could improve your evaluation of a person you are interacting with, and, as a result, cause your behavior towards this person to be more positive in the long run.

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Notes

1. Valence norms exist for these IAPS pictures; thousands of people rated how pleasant they felt while watching each of these pictures. Valence is strongly linked with the appraisal of pleasantness (Smith & Ellsworth, 1985), and has also a nearly one-to-one relationship with intrinsic pleasantness (Scherer, Dan, & Flykt, 2006), both appraisal criteria evaluating the amount of pleasantness conveyed by a particular stimulus (Dan-Glauser & Scherer, 2011).
2. The IADS is a collection of sounds that have been evaluated by a large number of people with respect to their pleasantness. Based on these norms (which are freely available) researchers may select subsets of auditory stimuli with certain valence. Using IADS sounds allows for a better comparability of the studies.
3. A list of the sounds from each category—unpleasant: 130, 424, 287, 712, 502, 115, 106, 116, 261, 730, 501, 706; neutral: 702, 708, 322, 358, 251, 310, 320, 425, 704, 325, 410, 726; pleasant: 216, 360, 200, 226, 352, 820, 220, 353, 215, 201, 110, 815.
4. Sounds with pleasant content were rated to be more pleasant than sounds with neutral content, and sounds with neutral content were rated to be more pleasant than sounds with unpleasant content (all ts > 3.45, ps < .002). As expected, sounds with unpleasant and pleasant content were more arousing than sounds with neutral content, (all ts > 4.17, ps < .001). In contrast, arousal did not differ between sounds with unpleasant and pleasant content ($t = 1.38$, $p = .18$).
5. Blaison et al. (2012) used angry and fearful faces as primes and asked their participants to rate the degree to which Asian ideographs (the targets) were visually evoking rather anger or fear. The authors found that ideographs were judged to evoke more anger (vs. fear) following angry (vs. fearful) primes (pictures of facial expressions). The authors took this result as evidence for the notion that non-affective information is transferred from the prime to the target. They argued that angry faces should evoke fearful affect. If affective responses were involved in the transfer process, targets following angry faces should thus be judged as visually evoking fear (especially in fearful participants). The authors based their (interesting) rationale on indirect evidence, but did not gather direct judgments on the facial expressions. Pilot data from our lab did not reveal any evidence for the notion that angry faces elicit fearful affect.
6. This analysis captures the whole variance that is inherent to the data. We also ran an alternative procedure that might yet appear more prevalent in the literature. This analysis confirmed the primary analysis. In this alternative analysis we categorized the music passages for each participant into three categories. Passages that have been rated at least 0.5 *SD* above the individual mean were assigned to the pleasant category, whereas passages that were rated at least 0.5 *SD* below the individual mean were assigned to the unpleasant category. Passages within +/−0.5 *SD* of the individual mean were classified as neutral. Based on this categorization we calculated a one-factor (unpleasant, neutral, pleasant) repeated measures ANOVA on the ideograph ratings. This analysis revealed a significant

main effect of the valence of the music passage ($F(2,52) = 5.8$, $p < .006$). The effect was Huynh-Feldt corrected.

7. This analysis captures as much variance as possible inherent to the data. We also ran an alternative, more common analysis of the data. This analysis confirmed the primary analysis. First, we classified each of the music passages into one of three valence categories (see note 6 above). Then, we calculated mean SCR in a time window of 2 to 5 seconds following the onset of the ideograph, calculated the median of this value for each valence category and participant, and split the trials according to this value. Based on the valence categorization and the median split, we calculated a repeated measures ANOVA with the factor music passage valence (unpleasant, neutral, pleasant), and the factor affective responding (low SCR, high SCR) on the z-transformed ideograph ratings. This analysis revealed a significant main effect of the valence of the music passage ($F(2,50) = 4.0$, $p < .03$), and a significant interaction of valence and affective responding ($F(2,50)=4.4$, $p < .02$). All effects were Huynh-Feldt corrected. Note that we had to exclude one participant from this kind of analysis because the responses were within such a narrow range that it was not possible to identify a sufficient number of trials for each of the factor steps.
8. We also ran an alternative, more common analysis of the data that confirmed the primary analysis. First, we classified each of the kanji evaluations into one of three valence categories (see note 6 above). Then, we calculated mean activity in the muscles corrugator supercilii and zygomaticus major in a time window of 2 to 5 seconds following the onset of the ideograph, respectively. Then we z-transformed these values individually. Based on the valence categorization we calculated repeated measures ANOVAs with the factor kanjievaluation (unpleasant, neutral, pleasant) on the z-transformed activity in each muscle. This analysis revealed a significant main effect of valence for the muscle corrugator supercilii ($F(2,52) = 5.3$, $p < .01$), and for the zygomaticus major responding ($F(2,52)=4.0$, $p < .03$). All effects were Huynh-Feldt corrected.

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