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Neuroscientific evidence for defensive avoidance of fear appeals

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Previous studies indicate that people respond defensively to threatening health information, especially when the information challenges self-relevant goals. The authors investigated whether reduced acceptance of self-relevant health risk information is already visible in early attention allocation processes. In two experimental studies, participants were watching high- and low-threat health commercials, and at the same time had to pay attention to specific odd auditory stimuli in a sequence of frequent auditory stimuli (odd ball paradigm). The amount of attention allocation was measured by recording event-related brain potentials (i.e., P300 ERPs) and reaction times. Smokers showed larger P300 amplitudes in response to the auditory targets while watching high-threat instead of low-threat anti-smoking commercials. In contrast, non-smokers showed smaller P300 amplitudes during watching high as opposed to low threat anti-smoking commercials. In conclusion, the findings provide further neuroscientific support for the hypothesis that threatening health information causes more avoidance responses among those for whom the health threat is self-relevant.

Keywords: fear appeals; defensiveness; health information; smoking; ERPs.

An important goal of health education messages is to encourage and motivate people to engage in health-promoting and disease-preventive behaviours. One way of achieving this goal is to confront target groups with fear-arousing information to promote self-protective action (e.g., smoking kills, quit now). However, randomized controlled studies suggest that these so-called *fear appeals* are less effective than often assumed by health education researchers and practitioners (Ruiter & Kok, 2005, 2006). A large body of experimental research suggests that threatening health messages are met with defensive responses especially by those for whom the health threat is most personally relevant (for an overview, see Van't Riet & Ruiter, 2013).

Previous studies into the cognitive nature of defensive reactions towards fear appeals were restricted to self-report measures such as risk denial, biased information processing, re-appraisal strategies and message derogation (Van't Riet & Ruiter, 2013). In addition, self-report measures of cognitive effort (Liberman & Chaiken, 1992) and more implicit measures of reading time (Brown & Locker, 2009) and response time (Klein & Harris, 2009) have been used to provide an index of the amount of attention that is allocated to threatening health information. These latter studies suggest that most people at risk react defensively by attending away from the threatening message. However, these measures do not allow a direct observation of the amount of attention that is allocated to the threatening information during message processing (Kessels, Ruiter, & Jansma, 2010).

Here we aim to explain people's defensive reactions to threatening health messages by studying early cognitive processes during message exposure. In two previous studies, we addressed this question by studying attention-allocation processes in response to pictures and written messages that depict the negative health consequences of smoking and unhealthy nutrition, respectively (Kessels, Ruiter, Brug, & Jansma, 2011; Kessels et al., 2010). In this study, we extend our line of research with two experimental studies that study attention-allocation processes in response to threatening health commercials (instead of pictures or written messages) by recording event-related potentials (ERPs).

The relationship between mental resources of attention and ERPs has been discussed especially with regard to one target ERP component, namely the P300. The P300

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shows larger amplitudes whenever the target stimulus is attended to compared with when there is less or no attention to the target with a maximum peak around 300 ms (Kok, 1997). The P300 may reflect controlled attention processes and as such provides an index for a cognitive attention allocation and update of stimulus processing with working memory information (Polich, 2007).

This study used almost the same experimental setup as was used in our previous study (Kessels et al., 2011). While watching health commercials, participants need to pay attention to specific odd auditory stimuli in a sequence of frequent auditory stimuli (oddball paradigm). In studying defensive reactions to threatening health information, we thus focus on a shift of attention away from threatening contents and towards a distracting source. Based on the underlying rational of resource allocation, we assume that the observed auditory attention effects in P300 ERP can be used as an inverted index of the amount of attention allocated to watching the commercials (cf. Kessels et al., 2010; Ruiter, Kessels, Jansma, & Brug, 2006). Therefore, based on the recent fear appeal literature findings that people show defensive reactions to personal relevance, high-threat information (i.e., they shift their attention away from relevant but negative information), we predicted that in the high personal relevance conditions attention to the high tones is increased during watching high-threat health commercials compared with watching low-threat health commercials, resulting in faster reaction times and higher mean amplitudes of the P300 in response to the auditory targets for the high-threat condition than for the low-threat condition (H1).

In contrast, we expected that for those of whom the threat has low personal relevance, threat information follows the general pattern of the effect of emotional information on attention-allocation processes with more attention for high-threat information than for low-threat information (Kessels et al., 2010). Therefore, in the low personal relevance conditions, we expected that in response to the auditory target tones reaction times are slower and the mean amplitudes of P300 are lower for the high-threat health commercials than for the low-threat commercials (H2).

The experimental studies received approval from the Ethical Committee Psychology and Neuroscience at Maastricht University, the Netherlands.

EXPERIMENT 1

Method

Participants

Twenty-two female psychology undergraduate students took part in this experiment. Furthermore, only those who indicated to smoke cigarettes on a daily basis were tested as part of the stimulus material was about quitting smoking. All participants were right handed, had normal or corrected-to-normal vision and had normal hearing. Participants received course credits or a €15 worth gift voucher for their participation. Because the datasets of six participants could not be used due to too many artefacts or technical problems during data collection, 16 participants remained in the sample. These participants were 18 to 22 years of age ($M = 20.06$) and smoked 9.78 cigarettes per day on average (range: 3 to 20 cigarettes).

Materials

To vary the threatening content of video scenes, we selected from a larger pool of health commercials promoting quitting smoking, having safe sex and moderate alcohol use, 10 commercials of which we believed had high threatening contents and 10 that were believed to be not or low threatening (i.e., threat: low Vs. high). Twenty-two first-year undergraduates who did not participate in the main experiment evaluated the 20 health commercials. They were asked in a forced-choice paradigm to evaluate every time they heard an auditory tone in the commercials as either “unpleasant” or “pleasant” to watch. The auditory tone was presented every 1000 ms to have a continuous evaluation of the health commercials. For each threat condition, we selected five smoking-related commercials and five non-smoking-related commercials.

On the basis of valence and consistency of button presses, 16 commercials were selected: eight high-threat and eight low-threat commercials. Again we made sure that smoking relevance of the commercials was equally distributed across threat conditions, four in each threat condition. In general, the high threat commercials were those that explicitly showed the negative consequences of unhealthy behaviour. The low-threat commercials were less explicit in showing the negative consequences of unhealthy behaviour, but instead were more humoristic. All commercials were presented in the original language (i.e., 15 in English and 1 in Dutch).

The commercials were distributed across four blocks according to threat and smoking relevance. One block showed high-threat commercials about smoking, a second block showed high-threat commercials about unsafe sex and alcohol use, a third block showed low-threat commercials about smoking and a fourth block showed low-threat commercials about unsafe sex and alcohol use. The four blocks were presented in random order. Within a block the four commercials were presented in fixed order, and were repeated four times in that same order to obtain enough stimulation time for presenting the auditory tones.

In addition to watching the commercials, participants performed an auditory oddball task. To this end high (1000 Hz) and low (500 Hz) auditory tones were presented. The high tones (target stimuli) had an occurrence probability of 17%, the low tones (non-target stimuli) had an occurrence probability of 83%. The tone length was 100 ms with a rise time of 10 ms. The low and high tones were presented in random order, with intervals of 1000 ms. We presented approximately 100 high tones and 480 low tones per experimental condition. Tones and auditory information from the commercials were presented through the same speakers.

Design and procedure

The experiment had a three factorial design with threat (low Vs. high), smoking relevance of the commercials (no Vs. yes) and auditory tone (non-target Vs. target) as within-subjects factors.

After the electrode cap was mounted, participants were tested in a dimly lit sound-attenuating room. They were seated in a comfortable chair, approximately 80 cm from the computer screen with the screen's centre situated at eye level. The videos were presented on the screen in a small format of 11 by 8 cm to minimize eye movements ($7.8^\circ \times 5.7^\circ$ visual angle). Participants were explained that the experiment had four sessions (blocks) of each 10 min in which they would listen to high and low tones, while watching health commercials. Between the blocks a break was planned of 2 min. On hearing a high tone (target) participants were expected to respond by pressing the button as fast as possible. On hearing a low tone (non-target), no overt response was required. Participants were further instructed to stay fixated to the health commercials while performing the oddball task. It was made clear to them that the oddball task and video task did not differ in importance, but that both tasks were equally important and had to be performed. The oddball and watching tasks were preceded by a practice round of 90 oddball trials without commercial presentation. One entire session (including placing and removing the electrode cap) took about 2 h.

Measures

Reaction times. Button-press responses were measured from high tone onset.

EEG. EEG was recorded from 30 scalp sites (extended version of the 10/20 system) using tin electrodes mounted in an electrode cap, referenced to the left mastoid signal. Horizontal eye movements were recorded by a bipolar montage of two electrodes placed on the right and left external canthus. Vertical eye movements and eye blinks were measured by a bipolar montage using two electrodes placed upon the upper and lower orbital ridge of the left eye. The electro-oculogram was recorded for later offline rejection of trials contaminated with eye movements. EEG and electro-oculogram signals were digitized at 250 Hz and amplified using a 32-channel NeuroScan SynAmps amplifier with a bandpass of 0.05–30 Hz. All electrode impedances were kept below 5 k. Neuroscan version 4.3 was used for data acquisition and offline analysis.

P300 ERP. From the continuous EEG signal, epochs of 700 ms were obtained from the corrected continuous EEG signal, including a 100 ms prestimulus (tone) baseline. The data were then filtered with a bandpass of 1–30 Hz, after which trials including artefacts were rejected from further analyses (threshold $\pm 75\ \mu V$). By averaging the remaining artefact-free epochs per participant per threat level and smoking relevance condition, the ERPs were derived separately for non-target and target tones. Difference waveforms were computed for each participant and experimental condition by subtracting the ERP to the non-target tones from the ERP to the target tones. The difference waveforms were quantified by mean amplitude measures (μV) to assess the effects of threat and smoking relevance on the P300 component. The latency window for the P300 (i.e., 250 ms–380 ms) was derived from visual inspection of the grand average difference waves. The analyses were restricted to nine electrode sites, F3, Fz, F4, C3, Cz, C4, P3, Pz and P4, because the effects of threat and smoking relevance on the P300 were largest for these electrodes (see Figure 1).

Data analysis

Proportions of errors and reaction times (millisecond) were subjected to repeated measures analyses of variance (ANOVA) that crossed the within-subjects factors threat and smoking relevance. The mean amplitude measures (microvolt) of the P300 effect were subjected to repeated measures ANOVA that crossed threat, smoking relevance, hemisphere (left, midline, right) and anterior–posterior (frontal, central, parietal). We report only effects involving the factors threat and/or smoking relevance. To control for sphericity violations in the ANOVAs, we reported probability values with Greenhouse-Geisser correction for F tests with more than one degree of freedom in the numerator.

Results

Error analyses

Trials in which no response was registered within 850 ms after presentation of the auditory target tone or in which a response was given in reaction to the non-target tone were considered as errors and left out of the analyses of both the reaction time data and the ERP data. The average proportion of reaction time errors was 1%

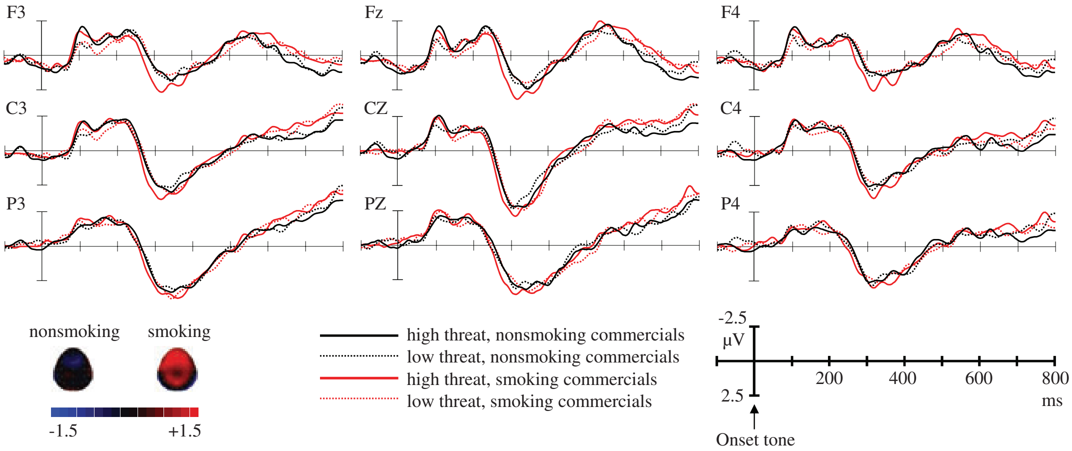

Figure 1. Grand average event-related difference waveforms for non-smoking (black lines) and smoking commercials (grey lines) by threat level. The topographical maps present the signal distribution of the P300 threat effect (high threat minus low threat) at 300 ms after tone onset for non-smoking and smoking commercials.

(range: 0% to 3%). We found no significant differences in the proportion of those errors among experimental conditions (*p*s > .10). The proportion of valid responses to the auditory target that could not be analysed because of eye and other movements ranged from 3% to 17% across participants with an average of 10%. No significant differences were found in the proportion of rejected trials among experimental conditions (*p*s > .36). On average 443 (*SD* = 11) non-target and 87 (*SD* = 3) target epochs per participant were used for the main analyses and grand average waveforms in Figure 1.

Reaction times

For reaction times a significant main effect of threat was found, $F(1, 15) = 14.71$, $p = .002$, which was qualified by an interaction effect with smoking relevance that approached significance, $F(1, 15) = 4.35$, $p = .05$. Planned comparisons showed that the effect of threat was significant for the smoking commercials, $t(15) = 3.85$, $p = .002$, $d = .64$, but not for the non-smoking commercials, $t(15) = .16$, $p = .87$, $d = .03$. Respondents reacted faster to the high tones while watching high-threat smoking commercials ($M = 404$; $SD = 34$) than while watching low-threat smoking commercials ($M = 424$; $SD = 31$), whereas their reactions did not differ between the low- and high-threat non-smoking commercials ($M = 414$; $SD = 33$ and $M = 413$; $SD = 32$, respectively).

ERP

P300. A repeated measures ANOVA yielded significant interaction effects of threat and smoking relevance, $F(1, 15) = 5.26$, $p = .04$, and of threat, smoking relevance and anterior–posterior, $F(1.29, 19.34) = 4.35$, $p = .04$. We decided to test the threat effects for each level of smoking relevance separately.

For the smoking commercials, a Threat × Anterior–Posterior repeated measures ANOVA found a significant main effect of threat, $F(1, 15) = 5.10$, $p = .04$, indicating that participants attended stronger to the target tones while watching high- as opposed to low-threat smoking commercials.

For non-smoking commercials, a Threat × Anterior–Posterior repeated measures ANOVA found no significant effects involving the factor threat, Fs < .89, ps > 39.

Discussion

In Experiment 1, we found faster reaction times and stronger auditory ERP attention effects to rarely presented high tones among a series of low tones while smokers watched high- rather than low-threat health commercials. On both the RT and P300 measures, this effect seemed to be strongest for the health commercials that most directly challenged participants' daily behavioural routine, the anti-smoking commercials. These findings thus confirm H1 that self-relevant threatening health information is met with defensive responses by allocating attention away from the uncomfortable source.

We found no support for an attention advantage of high-threat information over low-threat information when the health information was supposed to be less self-relevant (H2). Unfortunately, we did not have data to assess the extent to which the personal relevance manipulation was successful, but the study participants were undergraduate students and therefore they might have evaluated the topics of alcohol use and unsafe sex as self-relevant to some extent resulting in a weak experimental manipulation of self-relevance. In a second study we therefore aimed to manipulate self-relevance in a more direct way by presenting anti-smoking commercials to both smokers and non-smokers. In addition, we increased the number of commercials to reduce the amount of repetition.

EXPERIMENT 2

Overview and hypotheses

In contrast to Experiment 1, we used only commercials related to smoking, manipulated relevance of the topic by testing non-smoking and smoking participants and presented health commercials in random order across participants instead of the block design used in Experiment 1. We used the same dual-task from Experiment 1. We predicted for smokers that attention to the high tones is more increased—reflected in higher amplitudes of the P300—during watching high-threat health commercials than during watching low-threat health commercials (H1). We expected the reverse pattern for non-smokers with more attention for the high-threat commercials than for the low-threat commercials as reflected in higher mean amplitudes of the P300 in response to the auditory targets while watching low as opposed to high-threat commercials (H2). Due to a programming failure we were not able to link behavioural responses to the auditory targets (reaction times) with experimental condition.

Method

Participants

Twenty-five new participants who were right handed, had normal or corrected-to-normal vision and normal hearing participated in this study. Because the datasets of three participants could no be used due to too many artefacts or technical problems, 22 (7 males and 15 females) participants remained in the sample. These participants were 18 to 33 years of age ($M = 22.62$; $SD = 3.56$). Smoking status was measured with one item that asked whether the participants smoked cigarettes or not (1 = yes, 2 = no). Twelve participants answered no and were classified as non-smokers, 10 participants answered yes and were classified as smokers. Of these latter groups five participants smoked 1–5 cigarettes per day, three smoked 5–10 cigarettes per day and two smoked 11–20 cigarettes per day. Participants received course credits or a €15 worth gift voucher for their participation.

Materials

Thirty-seven health commercials were mainly taken from a pool of commercials available through AdForum.com. We further collected commercials from organisations that are responsible for the mass media smoking campaigns in Australia, Canada, The Netherlands, United Kingdom and United States of America. All commercials were related to smoking and aimed to motivate people to consider quitting smoking or not starting smoking. The distinction between both behavioural objectives was not explicit in most of the selected commercials.

High-threat commercials ($n = 19$) showed explicitly the negative consequences of smoking. Total duration of all 19 high-threat commercials was 636 s. Low-threat commercials ($n = 18$) were less explicit in showing the negative consequences of smoking, but instead were more humoristic. Total duration of all 18 low-threat commercials was 631 s. All commercials were novel compared to Experiment 1 and were presented in their original language (i.e., English).

In addition to watching the smoking commercials, the same auditory oddball task was presented as in Experiment 1.

Designs and procedure

Experiment 2 had a mixed design with threat (low Vs. high) and tone (non-target Vs. target) as within-subjects factors and smoking status (smokers Vs. non-smokers) as between-subjects factor. Participants started with filling out a questionnaire that assessed their smoking behaviour.

The procedure for the EEG measurement was nearly similar to Experiment 1. Experiment 2 consisted of two sessions in which all high- and low-threat commercials were presented in random order. Both sessions were equal in length (21 min and 15 s) and content, thus all commercials were presented twice. A break of 2 min was planned in between both sessions.

Next, participants viewed the first 15 s of each commercial and rated each commercial on the dimensions of pleasantness (1 = *very unpleasant*, 7 = *very pleasant*) and arousal (1 = *very passive*, 7 = *very active*). One entire session (including placing and removing the electrode cap) took about 3 h.

Measures

The same EEG recordings and ERP measuresas in Experiment 1 were used. The latency window for the P300 (i.e., 290 ms–550 ms) was derived from visual inspection of the grand average difference waves of 18 electrodes (see Figure 2).

Data analysis

Proportions of errors were subjected to repeated measures ANOVA that crossed the within-subjects factor threat (low Vs. high) and the between-subjects factor smoking status (smoker Vs. non-smoker). To examine whether the P300 attention effects were modulated by the

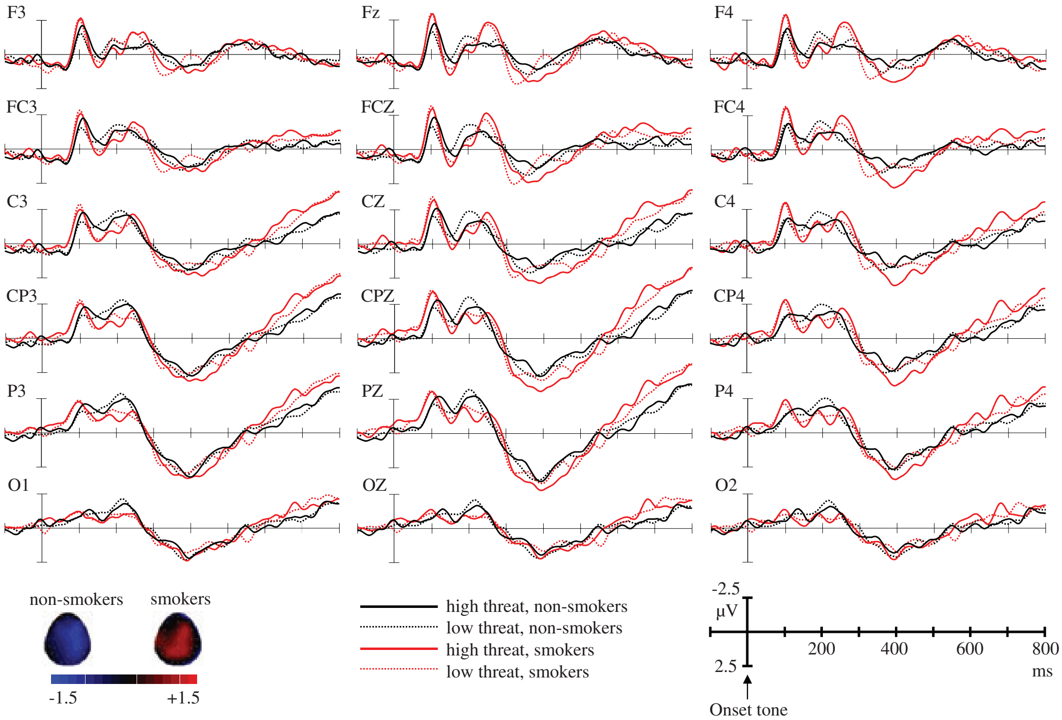

Figure 2. Grand average event-related difference waveforms for non-smokers (black lines) and smokers (grey lines) by threat level. The topographical maps present the signal distribution of the P300 threat effect (high threat minus low threat) at 350 ms after tone onset for non-smokers and smokers.

experimental conditions, we subjected mean amplitude measures (microvolt) from the entire session (session 1 and 2 collapsed) to repeated measures ANOVA that crossed threat, smoking status, hemisphere (left, midline, right), anterior–posterior (frontal, central, parietal) and electrodes (2). The factors hemisphere, anterior–posterior and electrodes divided the scalp into nine electrode clusters: left frontal (F3 and FC3), midline frontal (Fz, FCz), right frontal (F4 and FC4), left central (C3 and CP3), midline central (Cz and CPz), right central (C4 and CP4), left parietal (P3 and O1), midline parietal (Pz and Oz) and right parietal (P4 and O2). Because habituation and fatigue might have occurred in session 2, the same ANOVA was repeated for session 1 only.[1]

Greenhouse-Geisser correction was again used for F tests with more than one degree of freedom in the numerator.

Results

Manipulation check

A Threat × Smoking repeated measures ANOVA found a main effect of threat on pleasantness, $F(1, 18) = 98.60$, $p < .001$. As expected, the high-threat commercials were evaluated as more unpleasant to watch ($M = 3.00$; $SD = 0.63$) than the low-threat commercials ($M = 4.64$; $SD = 0.43$). No effects were found on the measure of arousal ($ps > .11$).

Error analyses

Across experimental conditions the average percentage of errors was 1% (range: 0% to 3%). No significant differences were found in the percentage of errors between the experimental conditions ($ps > .16$). On average 396 ($SD = 37$) non-target and 96 ($SD = 13$) target epochs per participant were used for the main analyses and grand average waveforms in Figure 2.

ERP

P300—entire session. A repeated measures ANOVA on the mean ERP amplitudes for the P300 component for the entire session showed significant interaction effects between threat and smoking status, $F(1, 18) = 4.68$, $p = .04$, between threat and location, $F(1.17, 21.12) = 5.22$, $p = .03$, between threat, smoking status and hemisphere, $F(1.64, 29.54) = 3.55$, $p = .05$, and between threat, smoking status, anterior–posterior and

[1]Although visual inspection of the difference waves for both sessions showed almost the same pattern of findings in the P300 time-window, the threat effects for smokers and non-smokers were strongest in session 1. For session 2 no significant support was found for an effect of threat for smokers and non-smokers ($ps > .14$).

electrodes, $F(1.53,\ 25.57) = 4.36$, $p = .03$. Effects of threat were tested for smokers and non-smokers separately.

For smokers a main effect of threat, $F(1, 8) = 6.59$, $p = .03$, and a significant interaction between threat, anterior−posterior and electrodes, $F(1.33, 10.65) = 10.79$, $p = .005$, was found. The threat effect for smokers supported H1, showing more attention allocation to the auditory targets during watching high-threat commercials as opposed to low-threat commercials. This simple effect of threat was significant at the central sites, $F(1,\ 8) = 8.21$, $p = .02$, and parietal sites, $F(1,\ 8) = 14.35$, $p = .005$, but not at the frontal site, $F(1,\ 8) = .90$, $p = .37$. For non-smokers no significant effects involving the factor threat were found, $F\text{s} < 1.82$, $p\text{s} > .18$.

P300 session 1. A repeated measures ANOVA on the mean ERP amplitudes for the P300 component for session 1 only showed significant interaction effects between threat and smoking status, $F(1,\ 18) = 11.83$, $p = .003$, between threat, smoking status and hemisphere, $F(1.71, 30.84) = 4.95$, $p = .02$, between threat, smoking status, anterior−posterior and electrodes, $F(1.40, 25.11) = 4.18$, $p = .04$, and between threat, smoking status, hemisphere, anterior−-posterior and electrodes, $F(3.43, 61.73) = 2.83$, $p = .04$. The effects of threat for smokers and non-smokers were tested separately.

A repeated measures ANOVA for smokers showed a main effect of threat, $F(1,\ 8) = 6.28$, $p = .04$, and a significant interaction between threat, anterior−posterior and electrodes, $F(1.28,\ 10.22) = 7.13$, $p = .018$. The threat effect for smokers supporting H1, showing more attention allocation to the auditory targets during watching high-threat commercials as opposed to low-threat commercials, was significant at the central sites, $F(1, 8) = 6.63$, $p = .03$, and parietal sites, $F(1,\ 8) = 7.66$, $p = .02$, but not at the frontal site, $F(1, 8) = 3.91$, $p = .08$.

For non-smokers a repeated measures ANOVA revealed a main effect of threat, $F(1,\ 10) = 5.08$, $p = .048$, and a significant interaction between threat, hemisphere and electrodes, $F(1.60,\ 16.02) = 4.40$, $p = .04$. The threat effect for non-smokers supporting H2, with more attention allocation to the auditory targets during watching low-threat commercials as opposed to high-threat commercials, was more pronounced at the right hemisphere, $F(1,\ 10) = 11.10$, $p = .01$, than at midline hemisphere, $F(1,\ 10) = 4.03$, $p = .07$, and the left hemisphere, $F(1,\ 10) = 1.99$, $p = .19$.

Discussion

Experiment 2 both replicated and extended the findings of Experiment 1. On the P300 component support was found for H1. That is, smokers had more attention for the auditory oddball task when they watched high-threat commercials than when they watched low-threat commercials. In addition, for session 1 significant support was found for H2 on the P300 component as non-smokers allocated more attention resources to the auditory targets when watching low as opposed to high-threat commercials in the P300 time-windows.

These effects on the P300 component suggest that smokers shift attention away from negative and self-relevant health information to a task performed in parallel. This finding provides further support for the theory of defensive avoidance of threatening information as put forward in social and health psychological literature (e.g., Freeman, Hennessy, & Marzullo, 2001; Keller, 1999; Keller & Block, 1999; Sherman, Nelson, & Steele, 2000). In addition, we found support for a general attention preference for threatening health information in this experiment, but only if this information was not targeting self-relevant risk behaviours (cf. Kessels et al., 2010).

GENERAL DISCUSSION

Our findings support recent findings in the fear appeal literature which suggest that people react defensively to threatening health information. In addition to the findings of earlier studies that used pictures (Kessels et al., 2010, 2011), this study found neuroscientific evidence that threatening health commercials cause more attentional avoidance among those for whom the health threat is self-relevant. In two experiments, smokers showed an increased P300 amplitude in response to an auditory target while watching high-threat as opposed to low-threat commercials about the negative health consequences of smoking. This threat-induced moderation of the P300 was not found in smokers who watched non-smoking related commercials (Experiment 1) and was not found in non-smokers (Experiment 2). Further support for our defensive avoidance hypothesis for whom the threat information was self-relevant was found in the reaction time data in Experiment 1. Smokers responded faster to the auditory target while watching high-threat as opposed low-threat anti-smoking commercials.

The P300 findings for the smoking participants are in line with the view that people are motivated to reduce feelings of cognitive dissonance (Festinger, 1957; Kunda, 1990). According to the cognitive dissonance theory (Festinger, 1957) and Kunda's (1990) argument for motivated reasoning, people experiencing dissonance because of their self-image are threatened (e.g., smokers exposed to threatening health commercials about smoking) are motivated to reduce it by changing one of the implicated cognitive or behavioural elements, for example through avoidant and biased processing of presented information (e.g., Kessels et al., 2010; Liberman & Chaiken, 1992). While previous studies used self-report measures or implicit measures of reading time and response time (Brown & Locker, 2009; Klein & Harris, 2009), this study provided support for motivated reasoning through the use of attention measures during message processing. The P300 findings thus indicate that avoidance responses can arise during the early process of attention allocation at the interface between sensory and memory processing.

In the first session of Experiment 2 we also found support for an attention advantage of high-threat information over low-threat information when the health information was supposed to be less self-relevant. From an evolutionary perspective, an attention preference mechanism for imminent threat was expected, but only for those for whom the information was not self-relevant (Kessels et al., 2010).

A limitation of this study is that the indirect nature of the experimental paradigms do not exclude the possibility that the enhanced P300 during high-threat Vs. low-threat anti-smoking commercials was the result of better task performance due to increased levels of attentional capacity because of higher levels of arousal in the high-threat conditions (Proctor & Van Zandt, 1994). Also, our selections of health commercials in the two studies do not allow for a comparison between high-threat commercials and neutral commercials on processes of attention allocation. Some of the commercials in the low-threat conditions in both experiments included humouristic scenes. Humour has been associated with increased attention and recall. Therefore, to the extent that the low-threat commercials were indeed evaluated as humouristic, the effects on the P300 could have been further enhanced by using humouristic rather than neutral commercials in the low-threat conditions (Schmidt & Williams, 2001).

Another possible limitation is that use of the auditory oddball might have interacted and be affected by the auditory component of the commercials. In future research we might use the technique of event-related desynchronization (ERD) to measure approach and withdrawal every second while watching commercials (Pfurtscheller & Aranibar, 1977).

Our results complement those reported by Kessels et al. (2010) and provide further neuroscientific support to findings in the fear appeal literature that suggest that people react defensively to threatening health information, especially if this information is able to question self-relevant health behaviours such as smoking among daily smokers. In addition, the findings strongly suggest that threatening commercials are not an effective tool in motivating people to attend to health messages, but instead decrease chances of successful persuasion.

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