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Distraction Effects of Smoking Cues in Antismoking Messages: Examining Resource Allocation to Message Processing as a Function of Smoking Cues and Argument Strength

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Abstract

Findings from previous studies on smoking cues and argument strength in antismoking messages have shown that the presence of smoking cues undermines the persuasiveness of antismoking public service announcements (PSAs) with weak arguments. This study conceptualized smoking cues (i.e., scenes showing smoking-related objects and behaviors) as stimuli motivationally relevant to the former smoker population and examined how smoking cues influence former smokers' processing of antismoking PSAs. Specifically, by defining smoking cues and the strength of antismoking arguments in terms of resource allocation, this study examined former smokers' recognition accuracy, memory strength, and memory judgment of visual (i.e., scenes excluding smoking cues) and audio information from antismoking PSAs. In line with previous findings, the results of the study showed that the presence of smoking cues undermined former smokers' encoding of antismoking arguments, which includes the visual and audio information that compose the main content of antismoking messages.

Keywords

memory; smoking cues; argument strength; audio processing; visual processing

Mass media campaigns employing antismoking public service announcements (PSAs) are considered a centerpiece of tobacco control programs trying to reduce cigarette smoking or avoid initiation. Such PSAs have shown to be effective in influencing the target audience's awareness, knowledge, and beliefs related to smoking behavior, which in turn increase antismoking intention and behavior change (Davis, Gilpin, Loken, Viswanath, & Wakefield, 2008). However, the effectiveness of antismoking PSAs is not guaranteed (Davis et al., 2008; Wakefield et al., 2008). A line of recent research has shown that the effectiveness of antismoking PSAs can be undermined when smoking cues, defined as visual scenes illustrating smoking-related objects or behaviors, are employed. This is especially true when the smoking cues are employed by PSAs whose antismoking arguments are weak (Kang, Cappella, Strick, & Lerman, 2009; Lee, Cappella, Lerman, & Strasser, 2011; Lee, Cappella, Lerman, & Strasser, 2012). The findings suggest that smoking cues, if not used

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appropriately, can distract viewers from processing the important elements of the antismoking PSAs, that is, antismoking arguments. As a result, such PSAs are less effective. Although there are theoretical reasons and consistent empirical evidence suggesting that substance cues often lead to cognitive biases in individuals, little is known about how smoking cues influence encoding and retrieval of the main content of antismoking messages. This study is designed to fill this gap in the literature. In an attempt to explicate how target message viewers process antismoking PSAs, this study defines smoking cues and argument strength in terms of resource allocation and examines the encoding and retrieval of audio and noncue visual information by former smokers who view the PSAs.

Smoking Cues: Motivationally Relevant Stimuli to Smokers and Former Smokers

The addiction literature supports the claim that substance-related cues, such as smoking cues, are causal factors in substance use and relapse following treatment. Studies have shown that exposure to a variety of smoking cues consistently elicits conditioned appetitive responses, including increases in craving as well as changes in physiological responses, such as heart rate, skin conductance, and blood pressure (Niaura et al., 2002). Findings in brain research have also indicated that smoking cues are associated with greater neural activation in areas implicated in visuo-spatial attention, and not only in those associated with reward processing (Due, Huettel, Hall, & Rubin, 2002). A series of studies has argued that the conditioned appetitive responses to such cues in smokers and former smokers leads to their cognitive processes being biased (Bradley, Field, Mogg, & Houwer, 2004; Niaura et al., 2002; Tiffany, 1990). Various measures yield similar results (Bradley et al., 2004; Ehrman et al., 2002; Mogg, Bradley, Field, & Houwer, 2003; Sayette & Hufford, 1994). The findings support the notion of automatic allocation of resources (i.e. attention) to smoking cues such that these cues acquire high motivational salience for the individuals and become highly attention-grabbing, attractive, and desired. Sayette et al. (1994) measured smokers' reaction times to audio probes when presented with smoking and neutral cues. Presentation of smoking cues as opposed to neutral cues increased self-reported smoking urges and slowed the reaction times, indicating the reduction of cognitive resources in smokers. Mogg et al. (2003) examined visual orienting to smoking cues and found that smokers had a longer fixation of gaze on smoking cues than on control ones, a difference that was not found in nonsmokers. In general, smokers reported greater preferences for smoking cues than for control cues and had faster response times in detecting visual probes that replaced visual smoking cues compared to control cues (Bradley et al., 2004; Ehrman et al., 2002; Mogg et al., 2003). More importantly, the faster response to visual probes was strongly associated with a bias toward evaluating smoking cues more positively (Bradley et al., 2004; Mogg et al., 2003). Compared to smokers and nonsmokers, former smokers displayed an intermediate level of attentional bias, but did not differ significantly in bias score from either group (Ehrman et al., 2002).

In antismoking PSAs, smoking cues are frequently employed because such cues, highly relevant to the target viewers, are expected to draw the viewers' attention more to the messages and be functional in delivering the main arguments of messages (Roser, 1990). A line of research has examined the effect of smoking cues related to the effectiveness of antismoking PSAs. Kang et al. (2009) assessed smokers' self-reported smoking urges after their antismoking PSA viewing and measured their heart rates during PSAs that differed in smoking cues (presence vs. absence) and argument strength (low vs. high). Findings showed that smokers who viewed smoking cue PSAs with weak arguments reported increased smoking urges and showed increased attention during PSA viewing, which was revealed in their decreased heart rate. Another study showed that smokers' thoughts of wanting to continue smoking increased after PSAs in which smoking cues were shown in the context of weak arguments, with a range of both message components (i.e., MSV, I^2 audio and video) and individual smoking-related dispositions controlled (Lee et al., 2011). Antismoking PSAs in such conditions were also evaluated as less persuasive (Kang et al., 2009; Lee et al., 2011; Lee et al., 2012). In addition, Sanders-Jackson et al. (2011) used an eye tracker to examine whether or not smokers' visual attention during viewing antismoking PSAs was directed more at the smoking cues present or at other visuals more pertinent to the PSAs' antismoking purposes. The result indicated that the presence of smoking cues reduced variation in visual fixation during PSA viewing. Further, the effect of smoking cues undermining messages' persuasiveness was replicated in former smokers. When smoking cues were shown in antismoking PSAs with weak arguments, behavioral self-efficacy, attitude, and intention to abstain were reduced in former smokers who had already refrained from smoking for at least one year (Lee et al., 2012). Extending these previous findings, the present study examines how smoking cues shown in antismoking PSAs influence the processing of audio and noncue visuals pertinent to antismoking arguments.

Smoking Cues, Resource Allocation, and Limited Capacity

Media viewers can and do allocate cognitive resources to process media messages with single or multiple streams of continuous audio and video information (Lang, 2000, 2006a, 2006b). Importantly, the amount of cognitive resources the media viewers can allocate is limited. The resource allocation to message processing occurs through automatic and controlled mechanisms. Controlled processing involves goal-directed or intentional resource allocation. Automatic processing is involuntary and driven by biological factors (Shiffrin & Schneider, 1977). Several structural features in media messages (e.g., cuts, edits, sound effects) have shown to elicit automatic attention responses—orienting responses (ORs) which in turn elicit automatic resource allocation to process the OR-eliciting stimuli (Lang, 1990; Ohman, 1979). In addition, motivationally relevant content can elicit automatic resource allocation to process the messages by activating underlying dual motivational systems—appetitive and aversive (Lang, 2006a, 2006b). Thus, OR-eliciting message features and motivationally relevant content influence the level of resources actually allocated to process a message. The level of resources required to process a message is influenced by the interaction of the viewer with message content features (e.g., difficulty, familiarity). The difference between resources allocated and resources required is the level of available resources, which influences the thoroughness of message processing (Lang, 2000, 2006a, 2006b). Having many resources available leads to thorough message processing and, consequently, good memory performance while having fewer resources available (i.e., more resources are required than are allocated) leads to less thorough message processing and, consequently, poor memory performance (Lang, 2000). If smoking cues are motivationally relevant stimuli to smokers and former smokers then these cues should prompt the allocation of cognitive resources to the cues. Our question is how the automatic resource allocation to smoking cues influences former smokers' encoding of the remaining information—audio and noncue visuals that compose the antismoking arguments of PSAs.

The extent to which smoking cues elicit automatic resource allocation will limit the resources that can be allocated to remaining information, because of viewers' limited cognitive resources. That is, the presence of smoking cues may interfere with the processing of audio and noncue visuals. Such unintended distraction effects have been observed with other kinds of message features used in advertisements such as celebrities, music, sexual appeal, and humor (Kellaris, Cox, & Cox, 1993; Maclnnis, Moorman, & Jaworski, 1991; Strick, Holland, Baaren, & Knippenberg, 2010). For instance, Strick et al. (2010) had participants view humorous, positive nonhumorous, and neutral nonhumorous texts paired with novel consumer brands. Eye movement data indicated that humorous texts received prolonged attention compared to both positive and neutral nonhumorous ones. Humorous text was remembered well but at the expense of memory for the brand. That is, humor elicited viewers' automatic resource allocation, which decreased resource allocation to processing brands. Similarly, we predicted that the presence of smoking cues in antismoking PSAs will decrease the level of resources available in the viewer to process audio and noncue visuals. Processing audio and noncue visuals will be greater for PSAs without smoking cues compared to those with cues. Audio processing is a controlled process and likely to require more resources than visual processing, which is relatively automatic and occurs with much lower cognitive cost (Lang, Potter, & Bolls, 1999; Shiffrin & Schneider, 1977). Therefore, the negative impact of smoking cues on resource allocation will be greater for processing audio than visual information. Recognition, defined as a proportion of accurate recognition, has been used to indicate the encoding (Lang, 2000). Thus, hypothesis 1 predicts:

> H1: Audio and visual recognition will be greater for no-cue PSAs than smoking cue PSAs; the difference in recognition rates will be larger for audio information.

Argument Strength and Resource Allocation

Argument quality has been defined as the audience's subjective perception of arguments as strong and cogent versus weak and specious (Petty, Cacioppo, & Goldman, 1981). Strong arguments elicit predominantly favorable thoughts about a message, creating stronger persuasion, whereas weak arguments elicit predominantly unfavorable ones, creating weaker persuasion (Petty & Cacioppo, 1986; Zhao, Strasser, Cappella, Lerman, & Fishbein, 2011). Argument strength has been considered a strong predictor for persuasion and one of the most commonly manipulated message features in persuasion literature (Johnson, Maio, & Smith-McLallen, 2005; Park, Levine, & Westerman, 2007). Previous studies of smoking cues in antismoking PSAs have employed argument strength as a key variable and shown that inclusion of smoking cues undermines messages' persuasiveness. Specifically, when smoking cues were shown in PSAs whose antismoking arguments were strong, the perceived effectiveness of messages was relatively intact. When the arguments of PSAs were weak, the perceived effectiveness of messages was significantly weakened (Kang et al., 2009; Lee et al., 2011; Lee et al., 2012).

Individuals are more motivated to devote the processing resources required to evaluate the true merits of a topic when involvement is high rather than low. As a topic increases in personal relevance, it becomes more important to form an accurate opinion (Petty & Cacioppo, 1984, 1986; Petty, Cacioppo, & Goldman, 1981; Petty, Cacioppo, & Schumann, 1983). LC4MP and previous evidence support that signal stimuli—those significant and meaningful for individuals—elicit automatic resource allocation to encoding such that the motivational and personal relevance of signal stimuli automatically activate individuals' motivational systems, which, in turn, increase resource allocation to encoding the stimuli (Lang, 2000, 2006a, 2006b). In processing antismoking PSAs, (former) smokers are likely to be highly motivated to devote the processing resources to evaluate main arguments of the PSAs due to their motivational relevance to the messages.

In antismoking PSAs, argument strength has been conceptualized as smokers' judgments of perceived strength and persuasiveness of the textual arguments extracted based on audio and video components of the messages (Zhao et al., 2011). Strong arguments are ones evaluated as more compelling and convincing than weak arguments and thus more likely to elicit a greater level of cognitive resources allocated. Although little research addresses the direct relationship between argument strength and cognitive resource allocation, some findings support the claim that strong arguments, compared to weak ones, elicit more cognitive resources allocated and are remembered better. For instance, Petty et al. (1981) found that college students who heard radio editorials on topics relevant to them recalled more of the strong arguments than of the weak ones. The result was replicated in later studies (Munch & Swasy, 1988; Swasy & Munch, 1985) showing that messages with strong arguments yielded stronger memory traces compared to those with weak arguments. Meadowcroft and Reeves (1989) found that children with highly developed schema allocated more cognitive resources to central story content when the content was meaningful. When story structure was manipulated so the content was no longer central to a story, significantly fewer cognitive resources were allocated to the same material. More cognitive resources are allocated to message processing when the arguments of messages are well elaborated and have substantial meaning to the viewers. Taken together, antismoking PSAs with strong arguments, defined as coherent and persuasive to the target audience, should elicit more cognitive resources allocated to message processing than those with weak arguments.

Previous research on modality in audio-visual contexts suggests that the audio and video channels differ in the amount of meaning that they carry (Crigler, Just, & Neuman, 1994; Russell, 2002). Solomon and colleagues (1994, 1993) argued that the audio channel of television advertisements delivers semantic information—the script of the message—whereas the video channel serves to create the context in which the story is set. This is because audio can be processed even when viewers are not looking (Rolandelli, Wright, Huston, & Eakins, 1991). Crigler et al. (1994) also posited that the audio channel of television news carries more meaningful information whereas visuals make the stories more "realistic," help to clarify the stories, and have an emotional impact, although particular vivid or concrete visuals have shown to be associated with greater memory of the story as a whole. Further, when there is more than one modality present and they are competing rather than redundant or supportive, perception prefers the "best" sensory modality for the task at hand to the less effective sense (Guttman, Gilroy, & Blake, 2005; Morey, Cowan, Morey, & Rouder, 2011). If argument strength (AS) is as important to the processing of antismoking messages as theory and previous studies suggest, and if the core elements of the argument are mainly—although not exclusively—carried by the audio channel, then automatic resource allocation should be given more to audio than to visuals in antismoking PSAs as a whole. That is our hypothesis. Then, there will be more resources allocated for processing audio from PSAs with strong arguments than those with weak arguments. As a result, encoding audio will be more efficient for high AS PSAs compared to low AS PSAs whereas processing visuals will be limited for high AS PSAs, due to media viewers' finite cognitive resources, and will be more efficient for low AS PSAs. Thus, it is predicted that:

> H2: Audio recognition will be greater for high AS PSAs than for low AS PSAs; on the other hand, visual recognition will be greater for low AS PSAs than for high AS PSAs.

How do smoking cues and argument strength interact on processing audio and noncue visuals? Encoding audio will be most efficient for high AS PSAs with no cues because the strong arguments elicit more resources allocated to processing audio and the distraction of smoking cues is absent. Likewise, it will be least efficient for low AS PSAs *with* smoking cues because weak arguments elicit fewer resources allocated to processing audio and the distraction of smoking cues is present. In contrast, encoding noncue visuals will be the most efficient for low AS PSAs with no cues because weak arguments of the PSAs result in more resources allocated to processing visuals and the distraction of smoking cues is absent. Processing will be most difficult for high AS PSAs with smoking cues because strong arguments of the PSAs result in fewer resources allocated to processing visuals and the distraction of smoking cues is present. Thus, it is predicted that:

> H3: Audio recognition will be best for no-cue PSAs with strong arguments and worst for smoking cue PSAs with weak arguments. On the other hand, visual recognition will be best for no-cue PSAs with weak arguments and worst for smoking cue PSAs with strong arguments.

Smoking Cue, Argument Strength, Memory Strength, and Decision Criteria

This study uses signal detection measures along with simple recognition accuracy to examine former smokers' processing of antismoking PSAs. Signal detection measures employing accurate recognition of target items and inaccurate recognition of foil items determine whether the differences in recognition accuracy come from greater memory sensitivity to discriminate between the familiar and unfamiliar information or a decisional shift in how willing individuals are to say they recognize information (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994). For example, Shapiro and Fox (2002) found that typical items from media stories had greater recognition accuracy than atypical items. Their results for memory strength and decision criterion revealed that participants had reasonable memory strength for atypical items even a week later. However, the participants were less willing to say they recognized atypical items and more willing to say they recognized typical items. As a result, typical items were said to be better remembered than they actually were.

Based on signal detection theory, there are two measures of recognition: memory sensitivity and criterion bias. Memory sensitivity and criterion bias are calculated by having the rates of correct recognitions of target items, called *hits*, and incorrect recognitions of foil items, called *false alarms* (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994). Target items are bits of information presented in the messages and foil items are information that was not. Memory sensitivity indicates memory strength, measuring how well individuals discriminate between target items and foil items when making recognition decisions, and is often used to index encoding in much the same way that recognition accuracy has been used (Fox, 2004; MacMillan & Creelman, 1991). In contrast, criterion bias indicates an individual's willingness to say he or she recognizes target and foil items, measuring the level individuals set for how familiar an item must be to consider it old information and recognize it (Fox, 2004; MacMillan & Creelman, 1991). Criterion bias reflects individuals' failure to recognize target items or false recognition of foil items (as target items) (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994). A more liberal criterion bias creates more hits and more false alarms whereas a more conservative criterion bias creates fewer false alarms but also fewer hits. This is because the more liberal the criterion, the lower the level of familiarity required before individuals say that they recognize information. The more conservative the criterion, the higher the level of familiarity required before individuals say that they recognize information (Fox, 2004). If the presence of smoking cues interferes with viewers' encoding information from antismoking PSAs, memory strength for audio and noncue visuals should be greater than when there is no smoking cue in the PSAs. Thus, it is predicted that:

> H4: Memory sensitivity will be better for no-cue PSAs than for smoking cue PSAs.

If the motivational relevance of antismoking arguments elicits more resources allocated to audio for PSAs with strong arguments compared to PSAs with weak arguments, then memory strength for audio should be greater for high AS PSAs than low AS PSAs, which is consistent with Hypothesis 2. Similary, if fewer resources are allocated to audio for low AS PSAs and, as a result, more resources are allocated to visuals for PSAs with weak arguments, memory strength for visuals should be greater for PSAs with weak arguments. Thus, it is predicted that:

> H5: Memory sensitivity for audio will be greater for high AS PSAs compared to low AS PSAs. On the other hand, memory sensitivity for visuals will be greater for low AS PSAs compared to high AS PSAs.

> H6: Memory sensitivity for audio will be best for no-cue PSAs with strong arguments and worst for smoking cue PSAs with weak arguments. On the other hand, memory sensitivity for visual will be best for no-cue PSAs with weak argument and worst for smoking cue PSAs with strong arguments.

However, it is not clear whether there will be differences in recognition as measured by decision criteria between the smoking cue and no-cue conditions and between the high AS and low AS conditions. If the memory performance differences arise because of differences in memory strength and not decision shifts, then there should be no difference in criterion bias for either smoking cues or argument strength. Previous research suggests that as the amount of resources available decreases as a function of increased difficulty, the criterion bias becomes more conservative; however, right before cognitive overload occurs, when more resources are required than allocated, the criterion bias becomes very liberal (Fox, Park, & Lang, 2007). Based on the prediction about the interaction between smoking cue and AS on recognition performance, criterion bias may be more conservative for audio from cue PSAs with weak arguments and for visuals from cue PSAs with strong arguments unless there is cognitive overload. No research has been done on this decision-making aspect of recognition related to smoking cues and argument strength. The effects of smoking cues and argument strength on criterion bias are best considered here as research questions. Thus, the following research questions are asked:

RQ1: Will there be a difference in criterion bias between smoking cue and no-cue PSAs?

RQ2: Will there be a difference in criterion bias between high and low AS conditions? Will there be a difference in criterion bias between audio and visual information?

RQ3: Will there be an interaction of smoking cues and AS on criterion bias?

Method

Design and Stimuli

The study employed a 2 (smoking cue) × 2 (argument strength: AS) mixed design. Smoking cue was a between-subject factor with half of the participants receiving PSAs with smoking cues and the other half not. AS was a within-subject factor with two levels: high and low. The study used 24 antismoking PSAs targeting adults and focusing on the negative health consequences of smoking and the desirability of treatment-seeking and quitting smoking. The PSAs were selected from a set of 199 antismoking PSAs that had been coded previously for smoking cues and whose arguments had been rated by a separate, comparable group of smokers. Smoking cues were defined as visual scenes related to smoking behavior and coded into four categories: a) objects associated with smoking; b) the holding or handling of a cigarette without actually smoking it; c) the puffing and inhaling of a cigarette; and d) no smoking cues. Reliability for the scenes with smoking cues was .82 (Krippendorff’s α) and reliability for the presence (versus absence) of smoking cues was virtually 100% (Cappella, Bindman, Sanders-Jackson, Forquer, & Brechman, 2009). Argument strength (AS) was defined as smokers’ judgments of perceived strength and persuasiveness of the textual antismoking arguments extracted from the PSAs. Argument evaluation involved three steps. First, two trained coders transcribed the visual and verbal claims of the PSAs. Next, two different coders reviewed and edited the claims previously generated to capture all implicit and explicit content of the PSAs. Then, the arguments extracted from the PSAs were assessed for perceived argument strength by nationally representative sample of smokers (Zhao et al., 2011). AS scores employed in this study came from an independent set of smokers. Participants in both smoking cue and no cue conditions were exposed to both low and high AS conditions but the presentation order of AS differed. Smoking cue and AS were crossed, creating four conditions: a) smoking cue PSAs with low AS first; b) smoking cue PSAs with high AS first; c) no-cue PSAs with low AS first; and d) no-cue PSAs with high AS first. For each condition, there were six PSAs presented randomly.

Participants and Procedure

The study had a total of 105 adult former smokers (54 female) who were recruited via online ads (i.e., Craigslist). Interested individuals called to determine their eligibility for the study prior to participation. A research assistant conducted screening interviews and eligible participants had to meet the following criteria: a) aged 21–65; b) had smoked more than 100 cigarettes in their lifetime; c) had smoked on a daily basis but quit smoking completely for at least one year; and d) not currently undergoing treatment for smoking cessation. The average age of study participants was 35 years (SD = 11). They reported to having smoked an average of 15 cigarettes a day (SD = 8.5) when they were smokers, smoked for an average of 12.6 years (SD = 8.9, min = 1, max = 39), and refrained from smoking for an average of 6.5 years (SD = 7.66, min = 1, max = 37). The average age at which participants reported smoking their first cigarette was 16 (SD = 2.65). The participants were slightly nicotine dependent according to the Fagerström Test for Nicotine Dependence (FTND: M = 3.61, SD = 2.05). The participants completed individual sessions in the laboratory. Upon arrival, each participant was informed of the purpose of the study and the experimental procedure, asked to sign an informed consent form, seated in a comfortable chair, and provided with a desktop computer. Four sensors were placed on the participants for the collection of ongoing physiological responses. These will not be discussed further in this paper. Each participant was randomly assigned to one of four conditions and instructed to pay close attention to the antismoking PSAs, about which they would later be asked survey questions. Each participant watched two sets of six PSAs followed by a series of survey questions related to message effectiveness. The participants were then presented either visual or audio recognition tasks randomly. Upon session completion, the participants were debriefed, provided with $75.00 for participation and transportation, and dismissed.

Measures and Analysis

Visual recognition—For visual recognition, three visual targets were selected from each PSA. Each visual item was a visual image randomly chosen from the first 10 s, second 10 s, and third 10 s, while excluding any visual scenes related to smoking cues. There was a total of 72 visual target items ($2_{cue} \times 2_{AS} \times 6_{message} \times 3_{item}$) and a total of 72 corresponding visual foil items. Foils were taken from antismoking PSAs that were not included in this study. Targets and corresponding foils were similar in terms of camera angle, color, number of objects, and theme of the image. During the visual recognition task using *Direct RT* software, each visual item was randomly presented on the screen for 250 ms. Participants were instructed to indicate if they recognized each visual item by pressing either “yes” or “no” on a keyboard.

Audio recognition—Three audio targets were chosen from each PSA. Each audio item was an audio clip obtained during the first 10 s, the second 10 s, and the third 10 s. Audio targets were 2 – 2.5 s in length and also had three corresponding foil items, which were chosen by considering type and number of sounds, sources of sound (e.g., human voice,

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background music, and special effect sound), and number and gender of speakers. Foils were selected from antismoking PSAs that were not used in this study. There was a total of 144 audio items (72 targets and 72 foils). During the audio recognition task using *MediaLab* software, participants responded if they recognized each audio item by clicking either a “yes” or a “no” button.

Memory sensitivity (*d′*)—Memory sensitivity, denoted by *d′*, was calculated by converting the hit and false alarm rates to standard scores with a mean of zero and standard deviation of 1, then subtracting the standardized score of false alarm from the standardized score of hit (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994). A larger *d′* value indicates that the participant is more sensitive at discriminating between target and foil items. When the participant is unable to discriminate between target and foil items, the value for *d′* is zero, in which case the hit rate equals the false alarm rate (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994).

Criterion bias (*c*)—Criterion bias, denoted by *c*, was calculated by multiplying the sum of the standardized hit rate and false alarm rate by −0.5 (Fox, 2004; MacMillan & Creelman, 1991; Shapiro, 1994). When the value for *c* is negative, in which case the false alarm rate for foil items is greater than the miss rate for target items, decision criterion is liberal and the participant is more likely to answer “yes” (MacMillan & Creelman, 1991). When the value for *c* is positive, in which case the false alarm rate is less than the miss rate, decision criterion is conservative and the participant is more likely to answer “no” (MacMillan & Creelman, 1991). When the value for *c* is zero, in which case the false alarm rate equals the miss rate, decision criterion is unbiased and the participant is just as likely to say “yes” as he or she is to say “no” (MacMillan & Creelman, 1991).

Results

Presentation order of argument strength (AS) was not significant for either audio or visual recognition and is not included in any analyses presented below.

Recognition Accuracy, Smoking Cues and Argument Strength

Hypothesis 1 predicted that recognition would be better for no-cue PSAs than smoking cue PSAs. The difference in the recognition between cue and no-cue PSAs was predicted to be greater for audio information. As predicted, participants viewing no-cue PSAs had better performance in audio recognition tasks ($M = .85$, $SE = .01$) compared to those viewing cue PSAs ($M = .78$, $SE = .01$; $F(1, 102) = 17.61$, $p < .001$, $\eta^2 = .15$). For visual recognition, although the mean had the predicted pattern—namely that recognition is greater for no-cue PSAs ($M = .76$) than for cue PSAs ($M = .72$)—the results were not statistically significant. Thus, Hypothesis 1 was partially supported.

Hypothesis 2 predicted that audio recognition would be greater for the PSAs with high AS compared to those with low AS. Visual recognition was predicted to be greater for the PSAs with low AS than for those with high AS. In line with the prediction, audio from high AS PSAs was remembered better ($M = .87$, $SE = .01$) than that from low AS PSAs ($M = .76$, $SE = .01$; $F(1, 102) = 90.40$, $p < .001$, $\eta^2 = .47$). The result for visual recognition was consistent with the prediction that recognition accuracy is greater for low AS PSAs (*M* = .76, *SE* = .02) than for high AS PSAs (*M* = .72, *SE* = .01; $F(1, 102) = 6.75$, $p = .011$, $\eta^2 = .06$). Thus, Hypothesis 2 was supported.

Hypothesis 3 predicted that audio recognition would be best for high AS PSAs with no cue and worst for low AS PSAs with cues. On the other hand, visual recognition would be best for no-cue PSAs with weak arguments and worst for cue PSAs with strong arguments. There were significant interaction effects of smoking cues by argument strength on both audio and visual recognition. These are shown in Table 1 and Figure 1. As predicted, participants had the best audio recognition score for high AS PSAs with no cue, followed by high AS PSAs with cues, and low AS PSAs with no cue. The recognition for audio was worst for low AS PSAs with smoking cues. For visual recognition, the score was best for no-cue PSAs with weak arguments, which is also consistent with the prediction. However, the score did not differ among the other three conditions. Thus, Hypothesis 3 was partially supported.

Memory Sensitivity, Smoking Cues and Argument Strength

Hypothesis 4 predicted that memory sensitivity (d') would be greater for no-cue PSAs than for cue PSAs. As predicted, d' was greater for no-cue PSAs ($M_{audio} = .72$, *SE* = .03, $M_{visual} = .48$, *SE* = .03) than for cue PSAs ($M_{audio} = .59$, *SE* = .03, $M_{visual} = .39$, *SE* = .03) for both audio and visual recognition ($F_{audio} = 9.33$, p = .003, $\eta^2 = .08$; $F_{visual} = 4.04$, $p = .047$, $\eta^2 = .04$), which is consistent with the prediction. Hypothesis 4 was supported.

Hypothesis 5 predicted that memory sensitivity (d') for audio information would be greater for PSAs with high AS than for those with low AS; on the other hand, memory sensitivity (d') for visual information would be greater for PSAs with low AS than for those with high AS. The result for audio was significant and consistent with the prediction; that is, d' was greater for PSAs with high AS than for PSAs with low AS ($M_{highAS} = .70$, *SE* = .02, $M_{lowAS} = .61$, *SE* = .02; $F(1, 102) = 36.52$, $p < .001$, $\eta^2 = .26$). For visuals, the result was also significant and in the predicted direction; d' was greater for PSAs with low AS (*M* = .48, *SE* = .03) than for PSAs with high AS (*M* = .39, *SE* = .03; $F(1, 102) = 15.19$, $p < .001$, $\eta^2 = .13$). Thus, Hypothesis 5 was supported.

Hypothesis 6 predicted that memory for audio information would be the most sensitive for high AS PSAs with no cue and the least sensitive for low AS PSAs with smoking cues. On the other hand, memory for visual information would be the most sensitive for no-cue PSAs with low AS and the least sensitive for cue PSAs with high AS. It was found that d' for audio was the best for high AS PSAs with no cue and the worst for low AS PSAs with cues and the d' for high AS PSAs with cues and low AS PSAs with no cue were in-between, which was in line with the prediction. The d' for low AS PSAs with cues was significantly lower than the d' for other conditions. However, the difference in d' for high AS PSAs with cues and for low AS PSAs with no cue was not statistically significant. The result for visual processing was not statistically significant even though the patterns of means were in line with the prediction. These results are shown in Table 1 and Figure 2.

Criterion Bias, Smoking Cues, and Argument Strength

Research question 1 asked if participants who viewed the smoking cue PSAs would use a different judgment criterion to make their recognition decisions than would those who viewed the no-cue PSAs. The difference in the means for criterion bias (*c*) for the cue ($M_{\text{audio}} = -.49$, $M_{\text{visual}} = -.53$) and no-cue ($M_{\text{audio}} = -.49$, $M_{\text{visual}} = -.51$) conditions was not significant for either audio or visual recognition.

Research question 2 asked if participants would use different decision criteria to make their recognition judgments of information from high AS PSAs compared to that from low AS PSAs. The results show that in both audio and visual recognition, the participants used more liberal decision criteria for high AS PSAs ($M_{\text{audio}} = -.52$, $SE = .01$, $M_{\text{visual}} = -.52$, $SE = .01$) than for low AS PSAs ($M_{\text{audio}} = -.46$, $SE = .01$, $M_{\text{visual}} = -.52$, $SE = .02$). That is, participants were more willing to say “yes” to information from PSAs with high AS compared to that from PSAs with low AS. The difference between conditions was significant for audio recognition ($F(1, 102) = 66.63$, $p < .001$, $\eta^2 = .40$), but was not for visual recognition.

Research question 3 asked if participants’ decision criteria for making recognition judgments would differ across smoking cues by AS conditions. Interaction effects of cues by AS on *c* were significant for both audio and visual recognition, as shown in Table 1 and Figure 3. The results show that in audio recognition, participants were more willing to say “yes” for the PSAs with high AS than for the PSAs with low AS, regardless of the presence of cues. For the PSAs with low AS, participants became more conservative and less willing to say “yes” for audio information from cue PSAs than for no-cue PSAs. In contrast, decision criteria for visual recognition varied depending on the presence of cues. When arguments were strong, participants were more willing to say “yes” for visual information from cue PSAs than for that from no-cue PSAs. When arguments were weak, they were more willing to say “yes” for visual information from no-cue PSAs than for that from cue PSAs.

Discussion

This study compared former smokers’ memory for audio and noncue visuals from antismoking PSAs in which smoking cues were either present or absent and whose arguments were either strong or weak. Smoking cues were conceptualized as motivationally salient stimuli to the (former) smoker population based on addiction literature and previous findings from studies on the effects of smoking cues and argument strength in processing antismoking PSAs. By defining smoking cues and argument strength in terms of automatic resource allocation, the study proposed and examined the effects of smoking cues and argument strength on encoding and retrieval for audio and noncue visuals from antismoking PSAs. The overarching prediction was that the presence of smoking cues placed in the video channel would influence visual and audio processing negatively and differentially. Both visual and audio recognition were employed to measure memory about antismoking PSAs based on the contention that such PSAs employ both audio and video channels and that viewers must process and allocate cognitive resources to both audio and visual information in order to make sense of the message. The findings provide both theoretical and practical implications.

Overall, the results of this study support the predictions that the presence of smoking cues and the perceived strength of antismoking arguments influence the automatic allocation of resources in processing antismoking PSAs. The presence of smoking cues in antismoking PSAs decreased recognition accuracy for audio information. For noncue visuals, the results on recognition accuracy were not significant but the pattern of means was in the predicted direction. Smoking cues decreased recognition accuracy for visual items from smoking cue PSAs more than from no-cue PSAs. The results of signal detection measures (Shapiro & Fox, 2002) revealed that the differences in memory performance between cue conditions were due to memory strength and not decision shift. Specifically, participants' memory sensitivity to both audio and visual information was greater for no-cue PSAs than for cue PSAs and their decision criteria did not differ by smoking cues in either audio or visual recognition. These results provide support for the theoretical prediction from the addiction literature and from LC4MP (Lang, 2000, 2006a, 2006b) that smoking cues, when present in media messages, are motivationally salient stimuli to (former) smoker populations and elicit automatic resource allocation in message processing.

Secondly, argument strength was predicted to lead to more automatic resource allocation when processing audio information from antismoking PSAs. When arguments were strong, participants' recognition accuracy and memory sensitivity increased for audio but decreased for noncue visual targets. We believe that the basis for these findings is that strong arguments are more motivationally relevant. The ten-item measure of argument strength employed in separate assessments of the arguments (Zhao et al., 2011) had two items that measured importance and relevance of arguments (i.e., applies to me, and is important to me). These items had strong correlations with averaged argument strength scores (> .90). Greater recognition accuracy and memory sensitivity for audio from the high AS condition suggest that greater motivational significance and relevance of strong arguments increased resource allocation to processing audio. Despite the contribution of video information to extracted arguments, argument strength was more likely associated with audio information (Crigler et al., 1994; Russell, 2002; Solomon & Greenberg, 1993; Tsuneki, 1988). And the increased amount of resources allocated to the audio channel in the high AS condition constrained the resources available to processing noncue visual components of the PSAs, because the amount of cognitive resources participants have for processing PSAs was limited (Lang, 2000, 2006a, 2006b). Criterion bias for visual recognition did not differ by argument strength; however, the level of argument strength had a strong impact on criterion bias for audio recognition such that participants had more liberal decision criteria in the high AS condition than in the low AS condition. That is, when participants were uncertain about audio items' presence or absence in the messages shown in the study, they were more willing to say "yes" to the items in the high AS condition compared to the low AS condition. It is well-documented that an evaluation of the source's credibility influences an audience's acceptance or rejection of information (McGuire, 1985). Argument strength taps into arguments' believability. Thus, while participants carried out recognition task, they likely placed greater weight on audio items in the high AS condition as sounding more familiar, leading more liberal criterion than in the low AS condition.

There was a significant interaction of smoking cues and argument strength on recognition accuracy for both audio and visual processing, and the results of memory strength for audio also approached significance. When arguments were strong, recognition accuracy and memory sensitivity increased for audio processing and decreased for visual processing. Furthermore, the presence of smoking cues decreased recognition accuracy and memory strength for both audio and visual processing. The pattern of smoking cues undermining message processing was more pronounced for audio than noncue visuals and for PSAs with weak arguments than for those with strong arguments. Mean comparisons between conditions revealed that in the low AS condition, smoking cues decreased recognition accuracy for both audio and visual information, decreased memory strength for audio, and decreased memory strength for visual information (which approached significance). On the other hand, in the high AS condition, when smoking cues were shown, audio recognition accuracy decreased with approaching significance and memory strength for audio significantly decreased, but neither visual recognition accuracy nor memory sensitivity for visuals differed by smoking cues. Further, the interaction of smoking cues and argument strength on criterion bias was significant for both audio and visual processing, but their patterns of means differed. In audio recognition, participants had more liberal decision criteria for information from the high AS condition than for that from the low AS condition. However, there was no significant difference in criterion bias by smoking cues. In visual recognition, there were virtually no significant mean differences among conditions although the difference between the high AS condition with smoking cues and the high AS condition with no cue approached significance.

These findings are mostly consistent with the predictions from theory and previous research. The negative effect of smoking cues—undermining cognitive processes—was more pronounced for low AS condition than high AS condition, which is consistent with the findings of previous studies suggesting that the presence of smoking cues undermined perceived effectiveness of PSAs with weak arguments evaluated by smokers and former smokers (Kang et al., 2009; Lee et al., 2011; Lee et al., 2012). Also, the presence of smoking cues interfered with audio processing more than with visual processing. This is in line with the theoretical contention that audio information requires more resources to process than does visual. As the difficulty of a message increases and the viewer experiences cognitive overload (that is, the resources required by a message outnumber the resources that can be allocated from the amount of resources the viewer has), audio processing decreases sooner than visual processing (Lang et al., 1999).

These findings also offer important practical implications for designing effective antismoking messages. In theory, the core content of a message can be placed in either the audio or video channel, or both. Our findings suggest that the audio channel is an efficient modality for delivering the core arguments of a message especially when the arguments are strong. While viewing a message with strong arguments, viewers will remember audio and visual elements most when there are no resource intensive components in the video channel (i.e., scenes related to smoking). Scenes portraying smoking objects or behaviors can be helpful by making antismoking PSAs more relevant and engaging to the target audience. However, inclusion of such images can distract viewers from processing audio and noncue visuals which are often the most important content audiences need to take away.

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Despite the findings consistent with theory and previous research, the current study has some limitations. Our measures of memory—recognition accuracy, memory sensitivity, and criterion bias—do not explain viewers' comprehension of messages, but explicate the acquisition of knowledge (i.e., audio and visual components) after message viewing. The set of audio snippets and still images used for audio and video recognition tasks does not embrace the entirety of the message's content. Nevertheless, there were three audio and visual items randomly selected from the first 10 s, second 10 s, and third 10 s of each message, which capture a range of the information present in the PSAs. Future research needs to test these effects while controlling other message characteristics occurring contemporaneously (i.e., MSV, I^2 audio, I^2 video, and emotion) that influence automatic resource allocation, and individual characteristics that influence controlled resource allocation.

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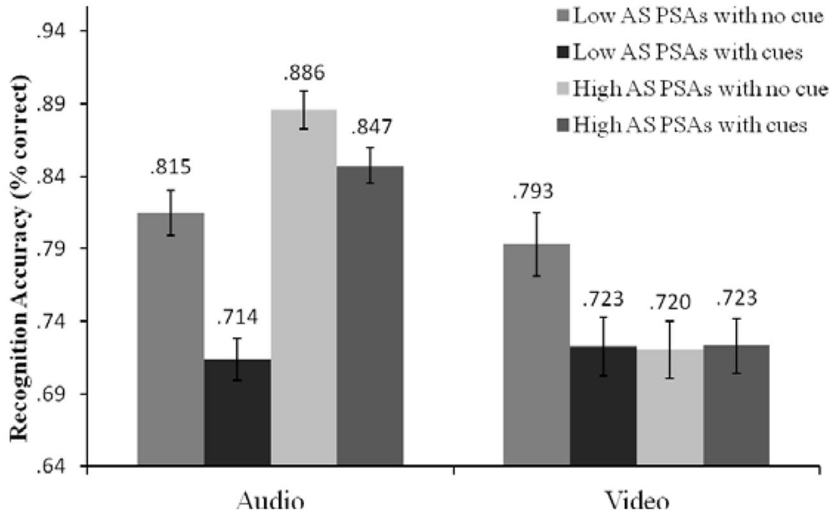

Figure 1.
Mean recognition (% correct) with standard errors for smoking cues by argument strength (AS). Audio and video recognition outcomes.

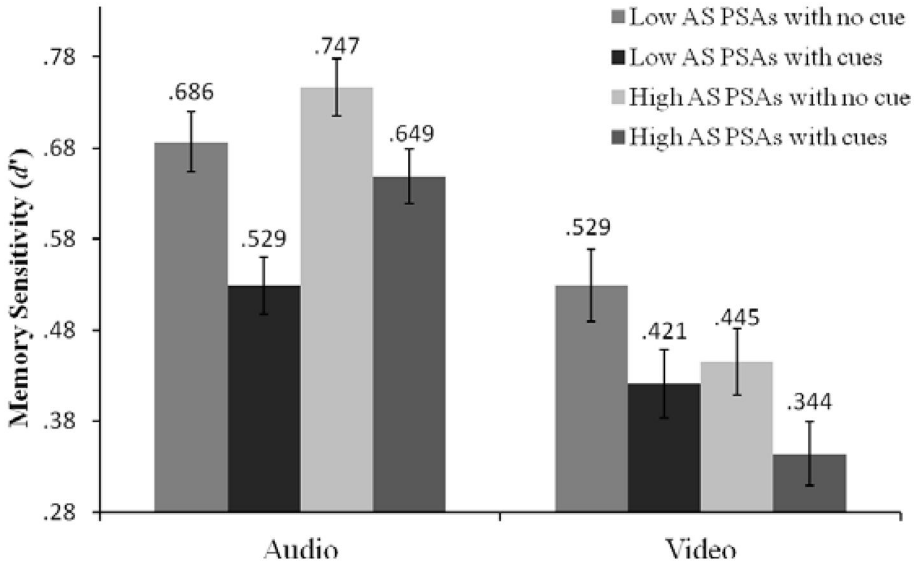

Figure 2.

Mean memory strength (*d*′) with standard errors for smoking cues by argument strength (AS). Audio and video recognition outcomes.

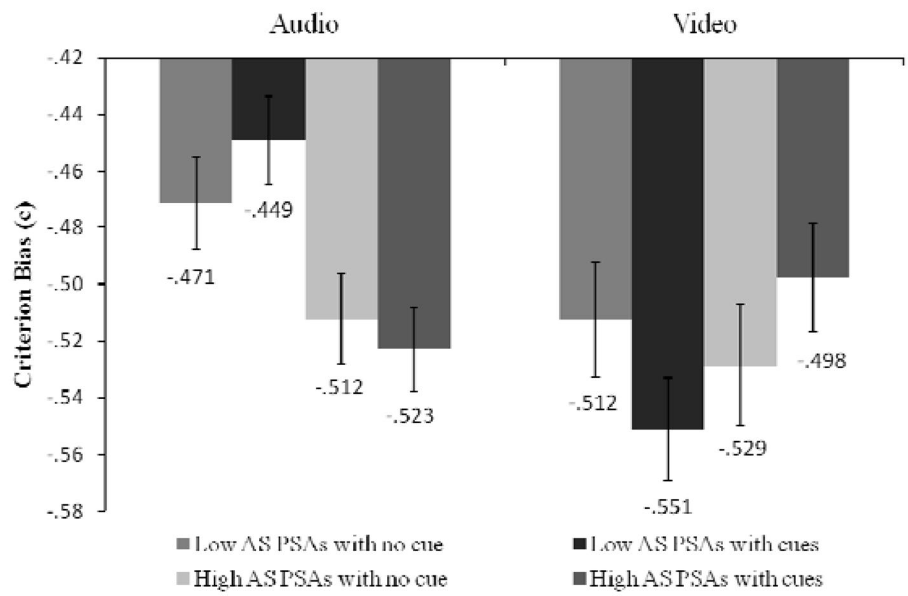

Figure 3.
Mean decision criteria (*c*) with standard errors for smoking cues by argument strength (AS). Audio and video recognition outcomes.

Table 1

Recognition, Memory Strength, and Decision Criteria as a Function of Smoking Cues and Argument Strength (AS)

	Low AS PSAs		High AS PSAs				
	No cue ***M (SD)***	**Cues** ***M (SD)***	**No cue** ***M (SD)***	**Cues** ***M (SD)***	***F***	***p***	η^2
Recognition accuracy (% correct)							
Audio	.81[a] (.11)	.71[b] (.11)	.89[c] (.10)	.85[ac] (.08)	8.26	.005	.08
Video	.79[a] (.15)	.72[b] (.16)	.72[b] (.15)	.72[b] (.14)	7.52	.007	.07
Memory sensitivity (*d*′)							
Audio	.69[a] (.19)	.53[b] (.27)	.75[ac] (.17)	.65[ad] (.25)	3.77	.055	.04
Video	.53[a] (.29)	.42[ab] (.29)	.44[ab] (.25)	.35[b] (.26)	.02	.904	-
Criterion bias (*c*)							
Audio	−.47[ab] (.08)	−.45[a] (.14)	−.51[b] (.08)	−.52[bc] (.13)	5.50	.021	.05
Video	−.53[a] (.12)	−.51[a] (.17)	−.50[a] (.13)	−.55[a] (.14)	16.00	<.000	.14

Note. Cell means in a row with different superscripts differ at p < .05 in paired *t* tests.