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Curiosity, surprise, and the recall of tobacco-related health information in adolescents

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Abstract

A key goal of health communications designed to prevent smoking initiation during adolescence is for the tobacco-related information to be retained in memory beyond immediate message exposure. Here, we test the role for epistemic emotions, specifically curiosity and surprise, in facilitating memory for tobacco-related health information. Participants (n=294 never-smoking adolescents, ages 14–16 years) performed a trivia guessing task wherein they guessed the answers to general trivia and smoking-related trivia questions. A subset of participants (n=154) completed a surprise trivia memory task one week later and answered the previously viewed questions. Results indicate that curiosity about the answers to smoking-related trivia is associated with more accurate recall of smoking-related trivia answers one week later. Surprise also facilitated memory for smoking-related trivia, but the association was limited to cases where confidence in prior knowledge was low. Indeed, when participants had high confidence in their prior knowledge, surprise about the answer to trivia questions was associated with worse recall. Findings suggest that engendering states of curiosity for smoking-related information may facilitate retention of that information in never-smoking adolescents and highlight the need to examine both surprise and confidence in health communications to avoid low message recall.

Keywords

adolescence; tobacco; curiosity; smoking; memory

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Tobacco smoking is a health-compromising behavior that often has its onset during adolescence (Chen & Kandel, 1995; Lantz, 2003). Most established adult smokers report

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tobacco use initiation during adolescence (Mowery et al., 2004), so much so that 90% of daily smokers report that they started to smoke before the age of 18 years (U.S. Department of Health and Human Services, 2012). Smoking initiation is a multi-determined process (Freedman et al., 2012; Lydon et al., 2014) requiring multicomponent prevention approaches (Botvin & Eng, 1982; Das et al., 2016). One important component in prevention efforts is anti-smoking health communication (Pierce et al., 2012; Wakefield et al., 2010). Anti-smoking health communications aim to prevent smoking initiation through messaging that warns of the risks and consequences of tobacco use (Portnoy et al., 2014). Specifically, these messages target tobacco-related beliefs and attitudes to decrease the value associated with smoking and increase the value of health-promoting behaviors (e.g., avoiding smoking initiation; Capella et al., 2015; Fishbein & Cappella, 2006). A key goal of these health communication efforts is for the tobacco-related information to be retained in memory beyond immediate message exposure to have a sustained impact on health behaviors. Here, we test the role for epistemic emotions, specifically curiosity and surprise, in facilitating memory for tobacco-related health information.

Health communication and memory

The critical role for memory in health communication-associated behavior change is highlighted in the hierarchy-effects model of advertising. This model postulates that advertising works by first being perceived and retained (Lavidge & Steiner, 1961). This model extends to health communication, where exposure to, and recall of, a campaign are necessary initial steps for campaign effects to emerge (Dunlop et al., 2011; Richardson et al., 2011; Southwell et al., 2002). Indeed, behavior change theories (Bandura, 1986; Fishbein & Cappella, 2006; Janz & Becker, 1984) posit that fostering knowledge about a health behavior plays a role in increasing the likelihood of positive health behavior change (Bandura, 2004; Ryan, 2009). Specifically, knowledge about a health behavior influences self-efficacy, an individual's perception of their ability to perform a behavior, and outcome expectancies, the anticipated consequences of behavior (Boehm et al., 1995; Chegini et al., 2022; Faghri & Buden, 2015; Kaschalk-Woods; Stewart et al. 2013). When a person remembers prior information to which they have been exposed, the information can assist and guide in-the-moment and future decision-making that aligns with the desired behavior change (Petty & Cacioppo, 1986; Shadlen & Shohamy, 2016; Shohamy & Adcock, 2010; Weilbächer & Gluth, 2016), such as instances during which individuals are confronted with smoking opportunities.

This role for memory in health communication efforts has been tested by examining the effectiveness of smoking initiation prevention programs in adolescents. Since adolescence is a developmental period of increased sensation-seeking that heightens adolescents' risk for engaging in health compromising behaviors (Crone & Dahl, 2012), the Real Cost campaign, a national campaign sponsored by the Food and Drug Administration, targeted youth, ages 12–17 years, who were susceptible nonsmokers or smoking experimenters. The campaign sought to reduce tobacco use intentions and behaviors by educating viewers through health communications containing information about the health risks and consequences of smoking (Duke et al., 2015). Youth recalling more frequent exposure to Real Cost campaign advertisements had greater recall of campaign-targeted anti-smoking beliefs (Kranzler et al.,

2017), greater perceptions of the serious consequences of smoking (Huang et al., 2017) and decreased odds of subsequent smoking initiation (Farrelly et al., 2017) relative to those with lower campaign recall. Similar findings emerge for the truth® campaign, a national anti-smoking campaign launched in February 2000 that exposed youth, ages 12–17 years, to television commercials about the effects of tobacco and tobacco industry marketing tactics. Individuals reporting greater campaign recall were more likely to endorse campaign-targeted beliefs and attitudes towards smoking, as well as reduced intentions to smoke, up to three years following campaign launch (Davis et al., 2009; Farrelly et al., 2009; Farrelly et al., 2002).

Thus, in the ideal health communication scenario, information from health communication efforts is remembered beyond immediate exposure and informs future smoking decisions. As a result, there are substantial ongoing efforts to identify factors that may facilitate recall of anti-smoking health communications, including the frequency and recency of message broadcasting (Dunlop et al., 2014), the use of emotive testimonials and graphic imagery in messages (Niederdeppe et al., 2011), and the use of messages that elicit negative emotions (Richardson et al., 2014). The role for messages eliciting epistemic emotions, emotions that relate to knowledge and the generation of knowledge (Pekrun & Stephens, 2012), in facilitating recall of campaign-target health beliefs and attitudes is understudied. Yet, recent work suggests that engendering certain epistemic emotions, in particular curiosity and surprise, may be a promising way to promote recall for health communications (Clark et al., 2022).

Curiosity and memory

Curiosity is an epistemic emotion associated with the desire to acquire new information and knowledge, motivating individuals to fill the knowledge gap between what they know and what they want to know (Berlyne, 1954; Loewenstein, 1994). Curiosity may improve health communication efforts by increasing memory for anti-smoking information. Recent empirical studies show that states of curiosity enhance learning and memory (Gruber et al., 2014; Kang et al. 2009; Wade & Kidd, 2019). In these studies, study participants complete a trivia paradigm and are sequentially presented with general trivia questions. The question answers are withheld until participants rate how curious they are to know the answer. Then participants complete a surprise memory task and are prompted to recall the answers to the trivia questions to which they were previously exposed. By using pre-answer curiosity ratings to predict trivia recall on the memory task, these studies find better recall for questions eliciting high curiosity.

Mechanisms underlying the memory-facilitating effect of curiosity have been interpreted from the perspective that the information one is curious about is valued. Individuals value information about which they are curious, choosing to wait and pay for information about which they are curious even when that information has no immediate instrumental value (Bennett et al., 2016; Cabrero et al., 2019). Through interactions between the incentive salience system (including the substantia nigra/ventral tegmental area) and the hippocampus, this value conferred to information enhances future memory for information people are curious about, similar to the way external incentives (i.e., money, food, praise, etc.) enhance

memory (Adcock et al., 2006; Gruber et al., 2019; Kang et al., 2009). Curiosity's memory-enhancing effect persists for as much as two weeks after trivia administration (Kang et al., 2009), has been observed in adolescents (Fandakova & Gruber, 2021), and has recently been shown to extend beyond general trivia to anti-smoking information in adult daily cigarette smokers (Clark et al., 2022). This indicates that curiosity could plausibly increase the retention of smoking-related health information in adolescents, a possibility that awaits testing.

Curiosity and confidence

The intensity of curiosity is related to confidence, a cognitive experience that depicts a person's subjective certainty about a prediction (e.g., how likely they are to know the correct answer to a question). Confidence and curiosity are theorized to be closely related. Curiosity is theorized to be high when people are close to knowing the correct answer (intermediate to high levels of confidence) but theorized to be low when one has complete confidence that they know the answer or has no idea about the answer (Berlyne, 1954; Loewenstein, 1994). Empirical work indicates that very high or very low confidence generates less curiosity than intermediate levels of confidence (Crandall, 1971; Theobald et al., 2022), including work using the trivia task, where an inverted u-shaped association between curiosity and confidence has been observed (Kang et al., 2009). Namely, individuals exhibit the highest curiosity when they are moderately confident in their answer's correctness.

Surprise and memory

Surprise is a second relevant epistemic emotion, evoked by feedback that violates a person's prior expectations (Reisenzein et al., 2017). Being confronted with unexpected information shifts attention to this information and encourages greater engagement with it (Vogl et al., 2020; Vogl et al., 2019). Greater attentional focus on the information has implications for memory (Petty & Cacioppo, 1986). Indeed, surprise, operationalized as the experience of prediction errors, modulates hippocampal processing to favor memory updating, prompting the hippocampus to abandon ongoing predictions and to make memories malleable (Sinclair et al., 2021).

In line with this role for surprise in memory, there is evidence that surprise about the answer to trivia questions in the aforediscussed trivia paradigm can promote more accurate recall of the answer to those questions during the surprise memory test phase of the task. The role for surprise in memory is complicated by different operationalizations of surprise. A surprise score, calculated as the difference between initial curiosity and reported interest in the answer once revealed, predicted more accurate memory in the trivia paradigm (Marvin & Shohamy, 2016), including in adolescents (Fandakova & Gruber, 2021). Other ways of operationalizing surprise include inferring that surprise is higher on trials during which answers are guessed incorrectly but high confidence in the guess is reported (Kang et al., 2014). Other studies used a more direct measure of surprise, asking participants how surprised they were at seeing the answer, but associations between memory and this more direct measure of surprise were not reported (Wade & Kidd, 2019). Thus, there is some

evidence that surprise could plausibly increase the retention of smoking-related health information in adolescents, a possibility that awaits testing.

The present study

The present study tests the extent to which the memory-enhancing effects of curiosity for general trivia extends to smoking-related health information in adolescents. We presented adolescents with both general and smoking-related trivia questions and asked them to guess the answer, asked them how confident they were in their guess, and asked them how curious they were to know the answer. Participants were then shown the correct answer and asked to rate how surprised they were by the answer. One week later, we presented participants with the same trivia and asked them to provide the answers in a surprise memory task. We hypothesized that, during the trivia memory task, adolescents would show greater memory for trivia questions that they indicated they were curious about in the preceding week's Trivia Guessing Task and that this would be true for both general and smoking-related trivia (Hypothesis 1). We also hypothesized that adolescents would show greater memory for trivia answers they reported being more surprised by in the preceding week's Trivia Guessing Task and that this would be true for both general and smoking-related trivia (Hypothesis 2). In line with the role for confidence in promoting curiosity, we hypothesized an inverted U-shaped curve between confidence and curiosity, such that curiosity is highest at intermediate levels of confidence (Hypothesis 3).

Method

We used data from the Adolescent, Curiosity, and Tobacco (ACT) Study. All research was conducted in accordance with the institutional review board at the host university (study protocol number 849402). All data reported on in the present study are available at the Open Science Foundation (anonymized link for peer review: https://osf.io/6gfm5/?view_only=439afb70a5334d8bb5deb0181225236c).

Participants

Participants were recruited through Qualtrics. Adults were eligible if they were between the ages of 25 and 27 years old and adolescents were eligible if they were between the ages of 14 and 16 years. We focus only on the adolescents in the present manuscript. The adolescent age range was chosen to reflect ages at which the risk for smoking initiation begins to increase and at which smoking prevention efforts are often targeted (Lydon-Staley & Geier, 2018). Adolescent participants (n=294) provided assent to participate in the study. We excluded participants that reported current or past cigarette smoking, screening out participants who responded yes to any of the following three questions: "Have you ever smoked a cigarette (tobacco)?", "In your life, have you smoked 100 or more cigarettes?", and "During the last 6 months, have you smoked a cigarette?". Demographic information may be found in Table 1.

Procedure

After assenting, participants went on to complete a Curiosity Trivia Task which consisted of 2 parts: a Trivia Guessing Task and a Trivia Memory Task. Participants then completed measures to collect demographic information and information about their personality. One week following completion of the Trivia Guessing Task, participants were sent the Trivia Memory Task. We aimed to have approximately 150 adolescents at follow-up to reach a sample size comparable to other work in this area (Clark et al., 2022). Qualtrics' anticipated recontact rate guided the sample size considerations for the Trivia Guessing Task.

Measures

We used participants' data from the Trivia Guessing Task and the Trivia Memory Task.

Trivia guessing task.—Participants completed an adaptation of an existing trivia task (Fastrich et al., 2018). Participants first completed a practice trial of the task. After this practice trial, 30 trivia questions were presented to participants; 15 were general trivia questions and 15 were tobacco-related questions. All trivia questions and answers are available in the supplement. Trivia questions were presented in a random order for each participant. On each trial (Fig. 1), a trivia question was presented, and participants typed a guess of the answer to the question in a text box. Participants were encouraged to report their best guess but were told that they could leave the field blank if they were unable to think of any answer. Once participants pressed the next page button (or after 15 seconds had passed), they were asked to rate their confidence in their answer ("How confident are you that you know the correct answer to this question?") and their pre-answer curiosity about the question's answer ("Rate your curiosity about the answer") on scales from 1 to 10 ("not at all", "extremely"). After these ratings, participants were shown the correct answer for 5 seconds after which participants indicated their level of surprise in the answer ("How surprised are you by the answer to the question?") on a scale from 1 to 10 ("not at all surprised", "extremely surprised"). The trivia question was displayed throughout the trial to ensure that participants correctly remembered the trivia question when they provided an answer or ratings.

Trivia memory task.—Participants completed a Trivia Memory Task (Fastrich et al., 2018) one week after the first session. During this second session, participants were presented with the same questions they had rated in the first session and were asked to recall the answer to the question within 15 seconds (Fig. 1). The questions were presented in randomized order. The consent and assent forms indicated that participants would be recontacted to complete a second session one week following their first session, but they were not told that the second session would be a memory test.

Data cleaning and analysis

The accuracy of participants' guesses in both the Trivia Guessing Task and the Trivia Memory Task was manually coded independently by the second through fourth authors. For trials when coders did not come to a consensus (< 1% of trials), the first and last author discussed the answers and came to a consensus. Responses were scored as either correct or incorrect, with trials for which no response was given coded as incorrect.

Curiosity, surprise, and memory.—Hypotheses 1 and 2 concerned adolescent memory for tobacco-related health information. The outcome variable was trial-level accuracy in the Trivia Memory Task. Using a multilevel logistic regression model, we tested the extent to which pre-answer curiosity on the Trivia Guessing Task was associated with trivia question accuracy (Hypothesis 1) and the extent to which post-answer surprise on the Trivia Guessing Task was associated with trivia question accuracy (Hypothesis 2). We also tested the extent to which the associations between curiosity, surprise, and memory were moderated by trivia type (general vs smoking). To allow a focus on within-person associations (i.e., a participant remembers the answer to a question if they rated being more curious than usual about that question), trial level pre-answer curiosity and post-answer surprise were within-person standardized. On these standardized variables (using curiosity as an example), values of 0 indicated a usual level of curiosity for that participant, values below 0 indicated lower curiosity than usual for that participant, and values above 0 indicated higher than usual curiosity for that participant. We included pre-answer confidence (within-person standardized), trial-level accuracy (indicating whether or not the participant guessed the accurate answer to the question during the Trivia Guessing Task), and the proportion of correct responses during the trivia guessing task as a whole as covariates. These covariates were included given that previous evidence has shown prior knowledge predicts memory test accuracy (Wade & Kidd, 2019). Cohen's *D* is presented as the effect size estimate, calculated using EMAtools (Kleiman, 2017). Models were fit using lme4 (Bates et al., 2015). Significant interactions were followed-up using the Johnson-Neyman technique (Bauer & Curran, 2005).

Confidence and curiosity.—Previous work has posited an inverted U-shaped curve between confidence and curiosity (Kang et al., 2009). We tested for a quadratic association between confidence (within-person z-scored) and curiosity on the Trivia Guessing Task in a multilevel model (Hypothesis 3). We tested the robustness of the findings between confidence and curiosity by adding trial-level accuracy (indicating whether or not the participant guessed the accurate answer to the question during the Trivia Guessing Task), the proportion of correct responses during the trivia guessing task as a whole, trivia type, and post-answer surprise as covariates.

Results

The follow-up Trivia Memory task was completed by 154 adolescents (52.38% of the sample completing the Trivia Guessing Task). Logistic regression indicated that dropout between the baseline and one-week follow-up session was not predicted by average accuracy (b=3.30, p=0.10), average curiosity (b=0.06, p=0.54), average confidence (b=−0.02, p=0.83), or average surprise (b=0.04, p=0.70) on the Trivia Guessing Task.

Adolescents' curiosity facilitates recall of tobacco-related health information

We present results for hypothesis 1, that adolescents would show greater memory during the Trivia Memory Task for both general trivia and smoking trivia questions about which they reported they were curious to know the answer in the Trivia Guessing Task they undertook in the previous week (Table 2). There was no significant interaction between pre-answer

curiosity for a question and trivia type, b=−0.06, p=0.42, such that participants were more likely to accurately answer trivia questions in the Trivia Memory task regardless of trivia type, when they reported higher than usual pre-answer curiosity for that question in the Trivia Guessing Task (Fig 2A). The association between curiosity and accuracy remained significant, b=0.16, p<0.001, d=0.13, when covariates (pre-answer confidence, accuracy from the Trivia Guessing Task, post-answer surprise) were added to the model and when the non-significant interaction between curiosity and trivia type was removed (Table S1).

Surprise and Memory

We tested hypothesis 2, that greater surprise would be associated with greater recall. In contrast to the hypothesis, when participants reported being more surprised about the answer to a question than usual, they had worse memory for that piece of trivia during the Trivia Memory Task, b=−0.12, p=0.003. To follow-up this effect, we tested an interaction between surprise and confidence (Table S2) and observed a significant interaction, b=−0.13, p<0.001, such that one's level of confidence in the answer they guessed before seeing the answer during the Trivia Guessing Task moderated the association between post-answer surprise on the Trivia Guessing Task and memory on the Trivia Memory Task. The association between surprise and memory was significant for values of confidence below −2.13 and above −0.16 (the minimum value was −2.63 and the maximum value was 5.29). As indicated in Figure 2B, surprise was negatively associated with memory when confidence was average to high and positively associated with memory when confidence was very low. There was no evidence that the association between surprise, confidence, and memory was moderated by trivia type (b=0.09, p=0.25).

Curiosity is highest at intermediate levels of confidence

A significant quadratic association emerged between confidence and curiosity, b=−0.16, p<0.001 (Table S3; Fig. S1). Curiosity peaked at intermediate levels of confidence and was low at high and low levels of confidence. There was no evidence that the association between confidence and curiosity was moderated by trivia type, with a non-significant interaction emerging between trivia type and the linear curiosity, b=0.05, p=0.38, and quadratic curiosity, b=0.01, p=0.84, terms.

Discussion

In the ideal scenario, information from health communications is remembered beyond immediate exposure. We examined the extent to which curiosity and surprise facilitate recall of tobacco-related information in non-smoking adolescents. We find that when participants reported being more curious about the answer to a trivia question, they were more likely to recall smoking-related information of the sort often contained in health communication efforts designed to create, change, or reinforce beliefs about the risks associated with smoking at a developmental period (i.e., adolescence) with heightened risk for smoking initiation (Clark et al., 2022; Wakefield et al., 2010).

The finding that non-smoking adolescents benefited from states of curiosity in their recall of smoking-related information has implications for health communication. Adolescence

is a time of increased risk for cigarette smoking initiation. A common goal of health communication preventive interventions is to disseminate information designed to discourage smoking initiation (Fishbein & Cappella, 2006). Health information that is better remembered shows more lasting effects on smoking initiation (Farrelley et al., 2017). In finding that adolescents better recall smoking-related information about which they are curious, the present study suggests that health communications designed to increase curiosity may be successful in facilitating message recall.

Although curiosity is an understudied factor in health communication, the broader literature on curiosity (Berlyn, 1960; Loewenstein, 1994) and advertising work (Daume & Verena Hüttl-Maack, 2020) suggest strategies that may be used in communications to increase the likelihood that viewers will be curious about message content. Manipulations of information gaps and ambiguity, for example, increase curiosity in viewers. Stimuli with information gaps contain information that is perceived as insufficient to evaluate the stimuli, leading viewers to recognize a gap between what they know and what they want to know. The presence of information gaps can be manipulated by presenting reduced amounts of information about the stimuli or via stepwise information disclosure (e.g., Hill et al., 2016; Ruan et al., 2018). Ambiguous stimuli contain information that lacks a clear meaning (Howard & Sheth, 1969) and can be generated by presenting ambiguous textual information, for example (Sääksjärvi et al., 2017). The presence of information gaps and ambiguous stimuli result in participants having some information but not complete information (i.e., inducing intermediate confidence in the information being presented). The potential for information gaps and ambiguity to increase curiosity gains support from the replicated finding we observed (e.g., Kang et al., 2009) indicating that confidence shows an inverted u-shaped association with curiosity, such that curiosity for trivia is highest at intermediate levels of confidence. A clear extension will be to test the effects of information gaps and ambiguity on curiosity towards smoking health information targeted towards adolescents.

A second goal was to examine the role for surprise in memory. Based on previous work (Fandakova & Gruber, 2019) and evidence that surprise encourages deeper processing of information in ways that facilitate memory (Vogl et al., 2022; Petty & Cacioppo, 1986), we hypothesized that surprising answers would be better remembered. There was some evidence for this hypothesis, such that when participants had greater memory for trivia when they reported being surprised by the answer to the trivia question and had low confidence that they knew the answer when first presented with the trivia. However, the association was more nuanced than anticipated, such that surprise was associated with worse memory for pieces of trivia, especially in cases when participants exhibiting medium to high levels of confidence about their knowledge.

The finding that surprise had negative associations with memory deviates from previous work that has shown positive associations between surprise and recall (Fandakova & Gruber, 2019). In previous work, surprise was operationalized as the difference between initial curiosity to know the answer and reported interest in the answer once it was revealed. In these studies, when participants found the answer more interesting at an intensity greater than the intensity with which they were curious to know the answer, they had better recall. In the current case, we used a more direct measure of surprise (e.g., Wade & Kidd, 2019),

asking participants how surprised they were by the answer. The present operationalization may more directly capture surprise as it relates to violations from prior knowledge and expectations, rather than predictions about epistemic emotions (e.g., interest) that learning the answer will trigger.

The negative association between surprise and recall, especially when participants have high confidence in knowing the correct answer prior to reveal, can be interpreted through long-standing literature indicating that people with more issue-relevant knowledge are more likely to counterargue communications that oppose their prior knowledge (Craik, 1979; Lord et al., 1979; Taylor & Fisk, 1984). Similarly, when people evaluate the truth of information, they draw on their own knowledge and rely on feelings of familiarity and fluency (Lewandowsky et al., 2012; Schwarz et al., 2007). When an answer deviates from prior expectations, people may engage in message derogation and interpret that the answer may not be truthful, in turn negatively affecting memory. Thus, the present study reveals a nuanced role for surprise in recall that necessitates more research before considering efforts to manipulate surprise in health communications.

Strength, Limitations, & Future Outlook

The findings should be considered in the context of study strengths and limitations. We recruited participants using convenience sampling. Further, non-smokers were recruited given that smoking initiation preventive interventions are usually targeted towards never smokers. This recruitment strategy makes implications for health communication efforts clearer given that preventive health communications aim to delay smoking initiation in adolescent non-smokers but makes generalizability to the general population difficult. We did not assess tobacco use beyond cigarettes in the current sample and the smoking trivia questions were geared towards tobacco cigarette smoking. An important next step will be to examine whether the memory-facilitating effects of curiosity translate to other tobacco products, including e-cigarettes, the most commonly used tobacco products by youth (Gentzke et al., 2019), and how youth using multiple tobacco products may exhibit curiosity for nicotine-related health information.

Approximately one half of the sample completed the one-week follow-up Trivia Memory Task. Despite the difficulty of participant retention for the one-week follow-up assessment, the relatively large temporal gap between the Trivia Guessing Task and the Trivia Memory Task allowed the consideration of recall over a timescale more relevant to health communication efforts than same-session recall tasks (e.g., Wade & Kidd, 2019). The decision to examine adolescents between the ages of 14 and 16 years was driven by the importance of these ages for smoking initiation behaviors (Lydon-Staley & Geier, 2018). As such, we cannot provide insight into how older adolescents (e.g., ages 17 to 19 years) would have responded. However, this study adds to an emerging literature showing that the memory-facilitating effects of curiosity are surprisingly robust, being observed, for example, in adult daily cigarette smokers who report being curiosity about anti-smoking trivia (Clark et al., 2022), despite the fact that learning about the negative outcomes associated with smoking can induce an unpleasant tension in smokers (i.e., cognitive dissonance; Festinger,

1957). We note also that age is just one of many markers of adolescence (Hollenstein & Lougheed, 2013) and that others (e.g., pubertal status) may impact curiosity.

The associations between curiosity, surprise, and recall were small, according to traditional benchmarks (Cohen, 1988). However, the associations observed involved naturalistic within-person fluctuations in curiosity and surprise that will be less extreme, and thus exhibit smaller effect sizes, than both experimentally-induced and between-person comparisons. The advantage of the current approach is that it is more ecologically valid than laboratory manipulations and the within-person design provides a better match to the desire to make within-person inferences (i.e., when curiosity is higher than usual, is recall more accurate than usual?) than a between-person design (Molenaar, 2004).

Curiosity's multifaceted nature has elicited various operationalizations, including conceptualizing curiosity as a trait (the propensity to seek out novel and varied information) vs. state (psychological response arising from a situation) (Kashdan et al., 2020; Lydon-Staley et al., 2020) and curiosity as an information-seeking behavior (Lydon-Staley et al., 2021). An additional operationalization of curiosity of interest to health communication scholars is curiosity about smoking. Indeed, curiosity about smoking is one of the most frequently endorsed reasons smokers give for starting to smoke (Cronan et al., 1991; Pierce et al., 2005; Sarason et al., 1992). In the present study, we conceptualize curiosity as an epistemic emotion and did not focus on other conceptualizations.

It is important to note that smoking prevention campaigns target factors beyond specific knowledge and, thus, a clear next step would be to evaluate curiosity's potential role in aiding memory for campaign-targeted beliefs, for example (Sangalang et al., 2019). Furthermore, curiosity and surprise may spur interpersonal communication of smoking and health information, key processes involved in the generation and diffusion of antitobacco campaign effects (Hwang, 2012; Hornik, 2002; Hornik & Yanovitzky, 2003). As the present study did not assess behaviors in the week prior to the surprise memory test, future studies should evaluate what pre-memory test behaviors, including discussions with peers, may contribute to the retention of information presented in the trivia task. Future studies may also consider investigating the effect of the different operationalizations of curiosity, such as curiosity about tobacco, on tobacco use attitudes, intentions, and behaviors.

Conclusion

The present study finds that states of curiosity facilitate memory for tobacco-related information in never smoking adolescents. We additionally find that surprise can facilitate memory for tobacco-related health information but that this is limited to cases where confidence in prior knowledge is low. When participants had high confidence in their prior knowledge, surprise about the answer to trivia questions was associated with worse recall. Findings suggest that health communication efforts that engender states of curiosity for the information they disseminate to encourage behavior change may benefit from curiosity-facilitated message recall and highlights the need to examine both surprise and confidence in health communications to avoid inaccurate message recall.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

All data reported on in the present study are available at the Open Science Foundation (anonymized link for peer review: https://osf.io/6gfm5/?view_only=439afb70a5334d8bb5deb0181225236c).

Citation Diversity Statement

Recent work in several fields has identified a bias in citation practices such that papers from women and other minority scholars are under-cited relative to the number of such papers in the field (Caplar et al., 2017; Chakravartty et al., 2018; Dion et al., 2018; Dworkin et al., 2020; Maliniak et al., 2013; Wang et al., 2021). Here we sought to proactively consider choosing references that reflect the diversity of the field in thought, form of contribution, gender, and other factors. First, we obtained the predicted gender of the first and last author of each reference by using databases that store the probability of a first name being carried by a woman (Zhou et al., 2020). By this measure (and excluding self-citations to the first and last authors of our current paper), our references contain 17.65% woman(first)/woman(last), 18.78% man/woman, 21.84% woman/man, and 41.74% man/man. This method is limited in that a) names, pronouns, and social media profiles used to construct the databases may not, in every case, be indicative of gender identity and b) it cannot account for intersex, non-binary, or transgender people. We look forward to future work that could help us to better understand how to support equitable practices in science.

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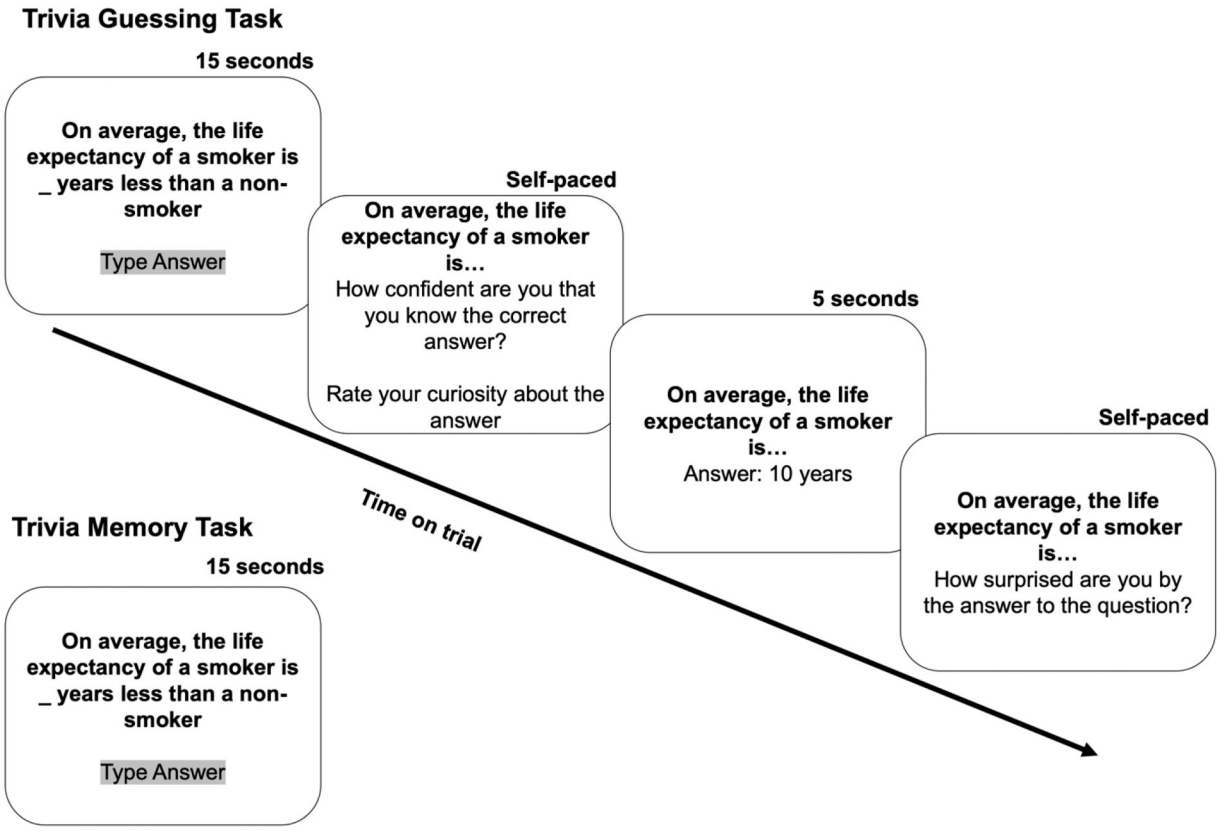

Figure 1.

Experimental Procedure. In their first session, participants completed an initial, Trivia Guessing Task (**top**). Each trial consisted of a 15-second guessing phase during which participants viewed a trivia question and were prompted to type their guess of the answer. Next, participants rated their confidence in their guess and their curiosity about the answer. Participants were then shown the answer for 5 seconds before rating how surprised they were by the answer. The question associated with the trial was visible during each part of the trial to ensure participants knew which trivia questions they were responding to. Fifteen questions were general trivia and 15 were smoking-related trivia. One week later, participants completed a Trivia Memory Task (**bottom**). During this task, the same 30 questions participants encountered during the initial task were presented again. This time participants were given 15 seconds to type the answer to the questions. In both the initial and one-week follow-up tasks, the order of the trivia questions was randomized.

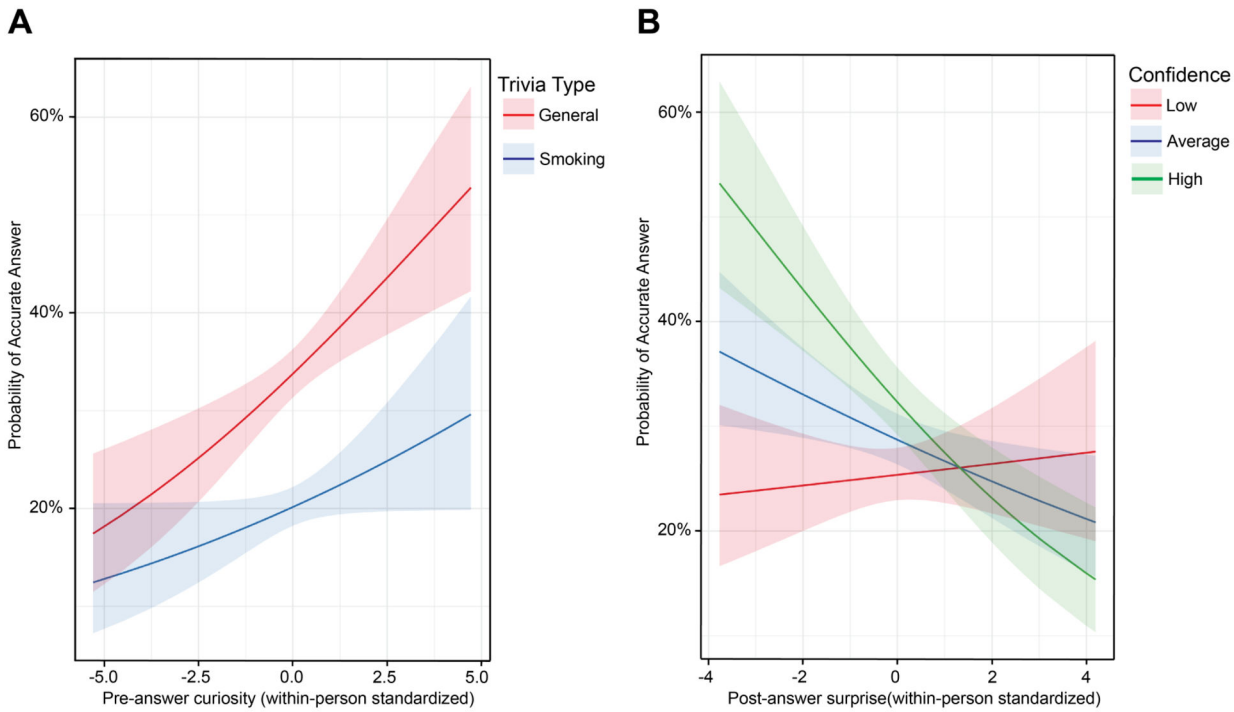

Figure 2.

Plot of the association between pre-answer curiosity (x-axis) and the probability of providing the correct answer to a piece of trivia on the Trivia Memory Task (y-axis) by trivia type (**A**). The interactions between curiosity and trivia type were not significant, with higher than usual pre-answer curiosity to know the answer to a trivia question in the Trivia Guess Task associated with a higher probability of providing the correct answer to that trivia question during the Trivia Memory Task. Plot of the association between post-answer surprise (x-axis) and the probability of providing the correct answer to a piece of trivia on the Trivia Memory Task (y-axis) as moderated by levels of pre-answer confidence (**B**). Values for low, average, and high confidence represent the mean and +1/−1 standard deviations from the mean of the pre-answer confidence variable.

Table 1.

Demographic characteristics of participants

Age	***Mean* = 15.35**	***Standard Deviation* = 0.79**
Gender	Agender	2
	Genderfluid	3
	Genderqueer	1
	Man	90
	Multiple	14
	Non-binary	4
	Other gender category/identity	1
	Prefer not to disclose	5
	Questioning or unsure	1
	Transgender	4
	Woman	168
Race/Ethnicity	Asian American	12
	Black/African American	49
	Hispanic/Latine	48
	Native American/American Indian	1
	Other	7
	Pacific Islander	1
	Multiple	45
	white/European American	118
Sexual Orientation	An identity not listed	5
	Asexual	6
	Bisexual	36
	Gay	1
	Heterosexual	194
	Lesbian	7
	Multiple	17
	Pansexual	9
	Prefer not to disclose	9
	Queer	1
	Questioning or unsure	8

Notes: n=294.

Table 2.

Results of the multilevel model examining the association between pre-answer curiosity and accuracy on the Trivia Memory Task

	Memory Task Accuracy			
	Est.	***SE***	***p***	***d***
Intercept	−0.67	0.06	<0.001	-
Trivia Type	−0.70	0.07	<0.001	−0.31
Pre-answer Curiosity	0.17	0.05	<0.001	0.12
Trivia Type X Pre-answer Curiosity	−0.06	0.07	0.42	−0.04

Notes: *Notes*: *Est.*= estimate; *SE*= standard error; *p*= p-value; *d*= Cohen's *D*; *N*=4560 trials nested in 152 participants (note that participants with no variance in pre-answer curiosity are removed following within-person standardization). General Trivia was the reference category for Trivia Type. Estimates are unstandardized.