Persistence of Shifts in Beliefs Associated With Exposure to Alcohol Advertising Among Adolescents

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ABSTRACT. Objective: The purpose of this study was to quantify the persistence of immediate changes in adolescents' alcohol-related beliefs associated with exposure to alcohol advertising. **Method:** Middle school students ($N = 606$) carried handheld devices for 14 days and logged all of their exposures to alcohol advertisements as they naturally occurred. Perceptions of the typical person one's age who drinks ("prototype perceptions") and perceived norms regarding alcohol use were assessed after each exposure to advertising and at random prompts issued daily throughout the assessment period. Generalized additive modeling was used to determine how long pro-drinking shifts in beliefs persisted after exposure to advertising. **Results:** Following exposure to advertisements, positivity of youth's prototype perceptions immediately increased ($\beta = .07$, 95% CI [.06, .09]) and then decreased ($\beta = -.05$, 95% CI [-.07, -.03]) over the subsequent 1.5 days, whereas perceived normativeness of

alcohol use immediately increased ($\beta = .04$, 95% CI [.01, .06]) and then decreased ($\beta = -.03$, 95% CI [-.05, -.01]) over the subsequent 2 days. Changes in beliefs occurring after 1.5 days for prototype perceptions and after 2 days for perceived norms were not statistically significant, suggesting that these beliefs were no longer affected by the advertising exposure. **Conclusions:** Findings are consistent with theories of alcohol advertising effects that presume that repeated exposure results in cumulative, enduring effects on beliefs. Given the rate of decay of alcohol advertising effects, it may be important to limit youth exposures to one every 2 days to avoid cumulative, lasting pro-drinking shifts in beliefs or to devise ways to interrupt cumulative effects with counter-messaging through media, parents, or other influential others at similar intervals. (*J. Stud. Alcohol Drugs*, 79, 399–407, 2018)

ADOLESCENT ALCOHOL USE is a major public health issue. In the United States, 70%–80% of youth have consumed alcohol and half have been drunk by the end of high school (Eaton et al., 2011; Johnston et al., 2016). Consumption in adolescence is linked to negative outcomes in both youth and adulthood, including school and social difficulties, neurological deficits, and alcohol disorders (Bonomo et al., 2001; Englund et al., 2008; Pitkänen et al., 2008; Squeglia et al., 2009). Multiple systematic reviews have found that greater exposure to alcohol advertising is associated with adolescent drinking initiation and level of consumption (Anderson et al., 2009; Jernigan et al., 2016; Smith & Foxcroft, 2009). Yet, there is limited understanding as to how exposure to alcohol advertising increases youth's risk of drinking—a crucial step in developing interventions to address the risk posed by advertising exposure.

According to social-cognitive and decision-making theories, beliefs and feelings supportive of drinking are engaged at the time of exposure, creating a susceptibility to drink when an opportunity to do so arises (Austin et al., 2006; Bryant & Zillmann, 2002). Implicit in these theories is the notion that effects of advertising on youth's attitudes and beliefs persist over time. Because there is often a lag between

exposure to alcohol advertising and the opportunity to drink, effects of advertising must persist beyond the moment of exposure if they are to affect youth drinking. With repeated exposure, the effects of alcohol advertising are thought to accumulate, creating increasingly positive beliefs about alcohol.

Recently we used ecological momentary assessment (EMA)—an intensive, within-subjects design with repeated measurements (Shiffman, 2009; Shiffman et al., 2008)—to investigate the immediate, momentary effects of exposure to alcohol advertising on adolescents' beliefs about alcohol. In this study, the Tracking and Recording Alcohol Communications (TRAC) Study, adolescents carried handheld devices with them throughout the day for 2 weeks, recording each of their naturally occurring exposures to alcohol advertising at or within minutes of the time of exposure. We found that beliefs about alcohol were more positive at moments of exposure to advertising than at random (control) moments of non-exposure. In particular, adolescents perceived the typical drinker their age more favorably and perceived alcohol use to be more normative among their same-aged peers (Martino et al., 2016), suggesting that alcohol advertising may indeed produce the kinds of acute changes in beliefs that theory predicts. The momentary changes in beliefs that we observed were equivalent to the difference in beliefs associated with a 1-year difference in age in our sample—in other words, large enough to constitute a meaningfully increased risk for drinking.

Presumably, these shifts begin decaying immediately following exposure and do so until another alcohol adver-

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tisement or other pro-alcohol message is encountered. The rate at which these shifts decay, however, is unknown. This represents an important gap in our understanding. Knowing how long the effects of exposure persist would allow us to estimate how often exposure to advertising needs to occur for these effects to begin accumulating. Recent research suggests that African American and Hispanic youth are exposed to three to four alcohol advertisements per day and non-Hispanic White youth to about two per day (Collins et al., 2016). If ad-associated changes in beliefs dissipate within hours, then this level of exposure may not pose a risk for adolescent drinking. If, on the other hand, these changes endure for days or longer, then exposure at this level puts youth, in theory, in a perpetual state of heightened susceptibility to drinking and creates the conditions necessary for an accumulation of pro-drinking beliefs. In the current study, we take advantage of the TRAC Study's intensive measurement design to investigate the plausibility of each of these scenarios.

Method

Participants

We recruited 606 middle school students from two large school districts, after-school clubs, and community organizations in Southern California with flyers and other notices. Enrollment occurred on a rolling basis over 10 months (September 2013 to June 2014). Adolescents were eligible if they were ages 11–14, could speak and write English, and had no psychological condition that would preclude participation. We allowed multiple adolescents from the same household to participate, provided that all met eligibility requirements. Parents provided written informed consent and youth provided verbal assent. Procedures were reviewed and approved by the institutional review board at RAND.

General procedures

Each participant and a parent/guardian came to a neighborhood study center before beginning the EMA protocol. Here, participants completed a paper questionnaire that assessed demographics, intentions to drink alcohol in the next 6 months (1 = *definitely no* to 4 = *definitely yes*), and lifetime alcohol use (even a sip; yes/no), and a 60-minute training on how to use a handheld device for EMA.

Ecological momentary assessment procedures

Participants were issued a Samsung Galaxy Player, Samsung Galaxy Mini, Samsung Galaxy Y Duos, or HTC Explorer with a custom-built data collection application installed. Participants were instructed to keep their device with them at all times except while at school, to initiate data entry each time they encountered an alcohol advertisement,

and to respond to random prompts (see below) for 14 days. Participants earned \$60 for participation. To incentivize compliance, we paid an additional \$25 to participants who responded to 76%–84% of the random prompts, and an additional \$60 to participants who responded to at least 85% of them (Martino et al., 2016).

Exposure event reports. Participants were instructed to initiate an assessment whenever they encountered an alcohol advertisement. Using a drop-down menu, they reported exposure to television, radio, newspaper, and magazine advertisements; billboards; sponsorship of music and sporting events; retail point-of-sale advertisements; brand-logoed items such as hats and T-shirts; various forms of online advertising (banner advertisements, video advertisements, and advertisements on social networking sites such as Facebook and Instagram); and movies and music in which specific brands of alcohol were shown or mentioned. At each exposure assessment, youth responded to questions about the advertisement and their alcohol-related beliefs (see below). These reports took less than a minute to complete. Screen shots of the data collection application used in this study are included in Supplemental Figures A and B (which appear as an online-only addenda to the article on the journal's website).

Random prompt reports. Three times a day, audible alerts from the device prompted participants to complete an assessment of alcohol beliefs. These reports provided an assessment of beliefs at times when participants were not exposed to alcohol advertising and were spread throughout the day using a sampling schedule stratified by the period of day (Shiffman, 2008). On school days, one prompt was issued between 7 A.M. and 8 A.M., one between 3 P.M. and 6 P.M., and one between 6 P.M. and 9 P.M. On non-school days, one prompt was issued between 9 A.M. and 1 P.M., one between 1 P.M. and 5 P.M., and one between 5 P.M. and 9 P.M. Time intervals were selected to provide one morning, one afternoon, and one evening assessment per day. If a signal occurred during an activity they could not interrupt, participants could delay the assessment for up to 15 minutes, after which the assessment was recorded as missing.

Measures

At each exposure event and random prompt, youth reported their perceptions of the typical person their age who drinks ("prototype perceptions") and perceived norms regarding alcohol use. Our measure of prototype perceptions asked participants to "think about boys or girls your age who drink alcohol" and rate how (1) popular, (2) attractive, and (3) cool they are (1 = *not at all* to 4 = *very*; $\alpha = .90$; Gibbons et al., 2010). Our measure of perceived norms asked participants to indicate their agreement (1 = *strongly disagree* to 4 = *strongly agree*) with the statements, "Most teenagers drink alcohol," "Most teenagers I know drink

alcohol,” and “Most students in my grade drink alcohol” ($\alpha = .79$; Thomsen & Rekve, 2006). Participants also reported their alcohol outcome expectancies at exposure events and random prompts. However, we did not find momentary effects of alcohol advertising on these beliefs (Martino et al., 2016); thus, we excluded them from analyses reported in this article. Scores on the measures of prototype perceptions and perceived norms were equal to the average across items. Short (one-item) and long (three-item) versions of each measure were randomly assigned at a given assessment to reduce the response burden over the 2-week monitoring period. A chained regression-based imputation (Enders, 2010) was used to adjust for items not included on the short form and accounted for the correlation among a measure's items.

Quantifying the persistence of alcohol advertising exposure effects

The random prompts provided interim data on prototype perceptions and perceived norms between exposures to alcohol advertising. We quantified persistence as the length of time exposure effects could be detected during this period. More specifically, persistence was operationalized as the time elapsed between the highest (most pro-alcohol) rating of prototype perceptions or perceived norms following an exposure to the point at which no further change in prototype perceptions or perceived norms was observed, in keeping with methods developed by Setodji et al. (2014).

Statistical analysis

A large drop in reported exposures to alcohol advertisements on the 14th day of data collection suggested that most participants were not aware that they were required to report exposures on this day (Kovalchik et al., 2017). We therefore examined reporting only on Days 1–13. A detailed non-response analysis of reported exposures to alcohol advertisements provided evidence of a fatigue effect (Courvoisier et al., 2012): Participants reported steadily decreasing numbers of advertisements as the monitoring period progressed. Weights were used to correct for this and to more accurately represent the mix of advertisements to which participants were exposed (see Kovalchik et al., 2017, for details). Across the 13-day monitoring period, participants reported exposures to a total of 6,695 advertisements. Adjusting for fatigue in reporting, we estimated that youth were exposed to 3.1 advertisements (95% CI [3.0, 3.1]) per student per day (Collins et al., 2016).

A total of 22,932 random prompts were issued over the course of the study (3 prompts per day $\times$ 13 days $\times$ 588 participants). Participants responded to 15,469 of these prompts, for an average compliance rate of 67%, or approximately 2 of 3 scheduled prompts per participant per day, a rate of compliance that is consistent with other EMA studies of

adolescents (e.g., Björling & Singh; Gwaltney et al., 2008; Piasecki et al., 2016). Hispanics and non-Hispanic Blacks exhibited lower compliance than non-Hispanic Whites, and having a sibling in the sample and getting good grades were positively associated with compliance. To correct for potential bias in our regression coefficients due to noncompliance, we applied weights equal to the inverse probability of compliance conditional on race/ethnicity, sibling status, and grades in school (see Kovalchik et al., 2017, for details). Data from random prompts that occurred before a participant recorded any exposure to alcohol advertising (1,851 or 12% of all random prompts) were excluded from analysis because they were irrelevant to estimating persistence as defined by our statistical model.

The vast majority of exposures reported were separated by a day or less, but there were a handful of cases in which a participant reported two consecutive exposures more than 7 days apart. As a result, some random prompts occurred more than 7 days after an exposure to alcohol advertising (6.6% of all random prompts), with no intervening exposures. This resulted in a skewed distribution of time since exposure—that is, the time between an exposure to alcohol advertising and the next exposure. To limit extreme values and to reduce the effect of outliers, the time since exposure was Winsorized (Shete et al., 2004) at 7 days. In other words, prompts occurring more than 7 days after an exposure (with no intervening exposures) were treated as if they occurred on the seventh day following exposure.

We included the following covariates in all models: age (in years), gender, intention to drink alcohol in the next 6 months (any intention vs. none), and lifetime alcohol use (even a sip; yes/no). In our prior analyses of the instantaneous effects of alcohol advertising on beliefs (Martino et al., 2016), we found that exposure was associated with momentary shifts in perceived norms only among non-Hispanic White participants. Thus, we restricted our analysis of the persistence of such effects to this group. Our model of prototype perceptions controlled for race/ethnicity by including it as an additional covariate.

To assess whether prototype perceptions and perceived norms become more favorable after exposure to alcohol advertising, we fit multivariate linear regression models comparing beliefs directly following an exposure to alcohol advertising versus at subsequent random prompts. If our hypothesis of the persistence of exposure effects is accurate, the exposure effect that is estimated by this model represents an underestimate of the true instantaneous impact of alcohol advertising, given that a measure of beliefs taken at random prompts will still reflect, to a degree, the persistence effects of preceding exposures. To evaluate the persistence of effects of exposure to alcohol advertising, we used a semi-parametric Generalized Additive Modeling (GAM) approach (Hastie & Tibshirani, 1990; Lin & Zhang, 1999; Setodji et al., 2012) to estimate the following model:

$$\text{Alcohol-Related Belief}_{it} = \beta_0 + g(\text{Time Since Exposure}_{it}) + \beta_2 X_{it} + \xi_i + \varepsilon_{it}$$

where the outcome variable, *Alcohol-Related Belief_{it}*, is person *i*'s alcohol-related belief (prototype perceptions or perceived norms) recorded at time *t*; *Time Since Exposure_{it}* is the time elapsed between one exposure to alcohol advertising and the subsequent random observations; and *X_{it}* represents a set of covariates. The equation assumes that beliefs at any given moment are a function of the time since the last exposure to an alcohol advertisement (along with other factors), with the time set to zero at times of exposure and set to other values, depending on the timing of the random prompts relative to that exposure. The error term ξ_i represents the participant level random effect, which accounts for the repeated observations that were made of each participant, and ε_{it} is the residual error. *Time Since Exposure_{it}* is measured in days based on the random prompts that occur between exposures. *Time Since Exposure_{it}* takes the value zero at the time of exposure, increases, for example, to 0.25, 0.5, 1, or 2 if a subsequent intervening random prompt occurs 6, 12, 24, or 48 hours later (respectively), and then is reset to zero at the next exposure.

In this model, $g(\)$ represents the unknown nonlinear function that we estimate semi-parametrically using GAM. The empirical function $g(\)$ provides flexibility to estimate the temporal change in alcohol-related beliefs following an exposure without having to rely on the assumption that change is constant (i.e., linear) over time from one exposure to the next. That is, the model makes no assumptions about the nature of the association between alcohol-related beliefs and the time since the last exposure to alcohol advertising, and instead determines the relationship empirically.

A GAM plot (Setodji et al., 2013) of *Time Since Exposure_{it}* on $g(\text{Time Since Exposure}_{it})$ provides a visual assessment of the persistence of an effect of alcohol advertising exposure on alcohol-related beliefs. For ease of interpretation of the GAM plot, we rescaled the persistence effect using predicted probability margins by estimating model-adjusted alcohol-related beliefs. We then identified in the rescaled GAM plot the point (threshold) at which the impact of an alcohol advertisement could no longer be detected in subsequent random assessments (Setodji et al., 2014). Last, we constructed a piecewise linear mixed model (Greene, 2000; Setodji et al., 2013) to examine the slope of persistence before and after the threshold identified in the GAM plot.

Results

Descriptive information on the sample

We excluded data from 5 participants who lost or broke their device, 12 participants who did not respond to any random prompts, and 1 participant who withdrew from the

study. The remaining 588 participants were about evenly distributed across ages 11–14; slightly less than half (46%) were female; and Hispanics (26%), non-Hispanic Whites (25%), and non-Hispanic Blacks (29%) were about equally represented. Sixty-two percent were from households with both parents, and 23% had tried drinking “even a few sips” of alcohol. Descriptive information on all variables included in the multivariate linear models appears in Supplemental Table A.

Estimating the persistence of exposure effects on beliefs

The left side of Table 1 reports the momentary effect of exposure to alcohol advertising on prototype perceptions among all participants. Consistent with Martino et al. (2016), participants' pro-alcohol prototype perceptions increased ($\beta = .07$, 95% CI [.06, .09]) immediately following exposure compared with average perceptions at random moments.¹ Figure 1 shows the GAM plot of the covariate-adjusted non-linear relationship between the time since the last exposure to alcohol advertising and youth's covariate-adjusted prototype perceptions. Consistent with results from the model of instantaneous exposure effects, the covariate-adjusted level of prototype perceptions was highest (i.e., most favorable) immediately after exposure (an average of 1.68 on the 4-point scale); it then declined steadily for 1.5 days until it stabilized at an average of 1.61.

A piecewise linear model was used to examine the persistence of the exposure effect on participants' prototype perceptions up to 1.5 days post-exposure (i.e., the effect threshold that was observed in the GAM plot). Results of this model are shown on the right side of Table 1. The piecewise linear regression confirmed a decrease in the effect of exposure on prototype perceptions during the first 1.5 days ($\beta = -.05$, 95% CI [-.07, -.03]) but no change in the effect thereafter ($\beta = .00$, 95% CI [-.01, .01]).

The left side of Table 2 reports the instantaneous effect of exposure to alcohol advertising on non-Hispanic White participants' perceived norms. As this table shows, non-Hispanic White participants' pro-alcohol perceived norms increased ($\beta = .04$, 95% CI [.01, .06]) immediately following exposure.² Figure 2 shows the GAM plot of the covariate-adjusted non-linear relationship between the time since last exposure to

¹This is an estimate of the peak impact of exposure to alcohol advertising calculated at the moment of exposure. The estimate of 0.029 presented in Martino et al. (2016) is based on a comparison of prototype perceptions measured at exposure versus a weighted average of all random prompts, some of which occur relatively near exposure and some of which occur relatively far from exposure.

²This is an estimate of the peak impact of exposure to alcohol advertising calculated at the moment of exposure. The estimate of .019 presented in Martino et al. (2016) is based on a comparison of perceived norms measured at exposure versus a weighted average of all random prompts, some of which occur relatively near exposure and some of which occur relatively far from exposure.

TABLE 1. Multivariate linear models predicting pro-alcohol drinker-prototype perceptions from exposure to alcohol advertising and the persistence of exposure effects over time

Variable	Instant exposure impact		Exposure persistence	
	β [95% CI]	<i>p</i>	β [95% CI]	<i>p</i>
Time since exposure ^a				
Slope between 0 and 1.5 days			-.05 [-.07, -.03]	<.001
Slope for more than 1.5 days			.00 [-.01, .01]	.98
Alcohol advertising exposure ^b	.07 [.06, .09]	<.001		
Intention to drink ^c	.32 [.17, .46]	<.001		
Lifetime drinking ^d	.12 [-.01, .25]	.06	.12 [-.01, .25]	.06
Gender: female	.08 [-.03, .18]	.17	.08 [-.03, .18]	.17
Age (years)	.07 [.02, .12]	.01	.07 [.02, .12]	.01
Race/ethnicity ^e				
Hispanic	.14 [-.01, .30]	.06	.14 [-.01, .30]	.06
Non-Hispanic Black	.13 [-.02, .28]	.08	.13 [-.02, .28]	.08
Other	.00 [-.16, .16]	.97	.00 [-.16, .16]	.97

^aTime from the last exposure in days (continuous); ^bversus random prompt; ^cany intention compared to none; ^dany alcohol use (even a sip), assessed at baseline; ^ecompared with non-Hispanic White.

FIGURE 1. Plot of the persistence of the impact of alcohol advertising exposure on youth's prototype perceptions from a nonparametric generalized additive model and a piecewise linear regression with a threshold at 1.5 days.

TABLE 2. Multivariate linear models predicting pro-alcohol perceived drinking norms from exposure to alcohol advertising and the persistence of exposure effects over time (non-Hispanic White youth only)

Variable	Instant exposure impact		Exposure persistence	
	β [95% CI]	<i>p</i>	β [95% CI]	<i>p</i>
Time since exposure ^a				
Slope between 0 and 2 days			-.03 [-.05, -.01]	.002
Slope for more than 2 days			.01 [.00, .02]	.16
Alcohol advertising exposure ^b	.04 [.01, .06]	.001		
Intention to drink ^c	.24 [.04, .44]	.02	.24 [.04, .44]	.02
Lifetime drinking ^d	.01 [-.15, .18]	.88	.01 [-.15, .18]	.88
Gender (female)	.16 [.02, .31]	.03	.16 [.02, .31]	.03
Age (years)	.08 [.01, .15]	.04	.08 [.01, .15]	.04

^aTime from the last exposure in days (continuous); ^bversus random prompt; ^cany intention compared to none; ^dany alcohol use (even a sip), assessed at baseline.

FIGURE 2. Plot of the persistence of the impact of alcohol advertising exposure on youth's perceived drinking norms from a nonparametric generalized additive model and a piecewise linear regression with a threshold at 2 days (non-Hispanic White youth only).

alcohol advertising and youth's covariate-adjusted level of perceived norms. Consistent with the results from the model of momentary exposure effects, the covariate-adjusted level of perceived norms was greatest immediately after exposure (an average of 1.62 on the 4-point scale). Perceived norms then declined steadily for 2 days down to an average of 1.58.

Although Figure 2 suggests a subsequent upturn in perceived norms beginning around the third day following exposure, this is a nonsignificant trend (see below) that should not be interpreted. Because youth are typically re-exposed within a day (Collins et al., 2016), only 16% of all random prompts are ones that occurred 3 days or more following an exposure

to an advertisement (with no intervening exposure). Estimates of change during that time are therefore less reliable than estimates of change occurring within the first 2 days following exposure.

Results of a piecewise linear model used to examine the persistence of the exposure effect on non-Hispanic White participants' perceived norms up to 2 days post-exposure are shown on the right side of Table 2. The piecewise linear regression confirmed a decrease in the effect of exposure on perceived norms during the first 2 days ($\beta = -.03$, 95% CI $[-.05, -.01]$) but a nonsignificant change in the effect thereafter ($\beta = .01$, 95% CI $[-.003, .02]$).

Discussion

Young people are exposed to alcohol advertising at a startling rate. Youth see nearly 300 alcohol advertisements each year—an estimate that excludes online advertisements, promotional items, product placements, and advertisements for wine (Snyder et al., 2006). This level of exposure is of concern, given the well-established association between alcohol advertising exposure and initiation and escalation of alcohol use (Anderson et al., 2009; Jernigan et al., 2017; Smith & Foxcroft, 2009). Little is known, however, about the process underlying this association, making it difficult to design interventions to reduce the harmful influence of alcohol advertising on youth drinking.

Our study is the first to examine the longevity of immediate changes in young adolescents' beliefs associated with a single exposure to alcohol advertising. We found that these changes—which are about equal in magnitude to changes associated with 8 months to a year of aging (Martino et al., 2016)—persist for 1.5 to 2 days following exposure. This finding is consistent with conceptual models of alcohol advertising effects that presume an enduring effect of exposure on alcohol-related attitudes and beliefs, and with the empirically documented dose-response relationship between exposure to alcohol advertising and the amount of alcohol consumed by youth (Snyder et al., 2006; Tanski et al., 2015). Specifically, the current study demonstrates that large ad-induced changes do decay, but the time required for them to wear off is longer than the average time to re-exposure (Collins et al., 2016). This pattern of findings is exactly consistent with effects observed in longitudinal studies that find changes in beliefs over time that are large enough to (apparently) cause drinking initiation and increased consumption (Anderson et al., 2009; Jernigan et al., 2017; Smith & Foxcroft, 2009). Presumably, each exposure to alcohol advertising that occurs before “baseline” levels of beliefs are recovered creates a new, slightly higher baseline. Even if such accumulation of effects does not occur (or does not occur in a linear fashion), the reinforcing effect of repeated exposure is important, as it keeps youth at an elevated state of risk for drinking initiation and escalation.

An important limitation of our study is that we did not examine factors that may moderate the length of time that exposure-induced changes in beliefs persist. This probably depends on the particular advertisements to which youth are exposed and other pro- and anti-drinking forces in their lives. It may also depend on cognitive development and receptivity to advertising (Austin et al., 2006; Collins et al., 2017), although it is possible that these factors determine only the magnitude and not the persistence of change. More work is needed to investigate these possibilities. Furthermore, the pattern of persistence that we have established is for the effect of an average exposure to alcohol advertising. Because most exposures are to outdoor and television advertisements (Collins et al., 2016), we can infer that the persistence curves presented in Figures 1 and 2 largely represent these two types of exposure. Persistence curves may look different for other types of exposure.

A second limitation is that our sample of adolescents may not be representative. A commonly cited drawback of EMA is that it requires a technologically sophisticated sample that is motivated to carry data collection devices over an extended period (Piasecki et al., 2007). Third, we cannot be certain that the fluctuations in alcohol-related beliefs illustrated in this article are caused by exposure to alcohol advertising. Yet, our case-control design (Shiffman, 2008), which provides for a within-person comparison of alcohol-related beliefs at times of exposure and no exposure, represents a significant advance over a typical correlational study design. Nevertheless, it is possible that the results reported in this article are, to some unknown extent, spurious. For example, it is possible that the observed associations between exposure and beliefs are in part the result of participants being more attentive to or exposed to alcohol advertising on days when they are more favorably disposed toward drinking.

In addition, some readers may wonder whether demand characteristics have any role in producing the pattern of effects that we demonstrate in this article. Although we cannot unequivocally rule out such a possibility, it seems implausible that participants could have had insight into our intention to chart the persistence of advertising effects and intentionally provided decreasingly favorable responses to questions asked at random prompts occurring between one exposure and the next as a result of that intuition.

Last, our study does not examine the implications of the persistence of alcohol advertising effects for drinking behavior, a topic that should be investigated in future research.

These limitations should be considered in light of our study's many strengths. These strengths include the reliability of measurement and ecological validity inherent to EMA, as well as the detailed portrait of youth's alcohol-related beliefs during the time between one exposure to alcohol advertising and the next it provided.

Our findings have implications for intervention, suggesting a threshold for cumulative effects of alcohol advertising

at approximately 2 days. It may be important to limit youth exposures to one ad or less in this period to avoid cumulative or more lasting pro-drinking shifts in beliefs. Current self-regulatory guidelines specify that television advertising should be placed only where at least 71.6% of the audience is 21 years or older. To cut exposures sufficiently to avoid persistence effects might require a standard closer to 90% or a limit on the total number of ads shown each week during programs with a youth audience. Similarly, outdoor stationary ads are generally restricted within 500 feet of elementary and secondary schools, parks, and places of worship. Tightening these regulations (to cover routes that youth use to travel to and from these locations, for example) might require forbidding all outdoor alcoholic beverage ads. Any restriction in one advertising venue could result in greater concentrations of ads in other venues as advertising budgets are reallocated. New restrictions would thus require careful oversight to prevent actually increasing youth exposure (e.g., Ross et al., 2013). The kind of highly restrictive changes that may be needed are unlikely to be implemented through self-regulation, and, if they are externally imposed, they are likely to meet legal challenges from the beverage industry. As an alternative, it may be possible to interrupt cumulative effects by deliberately shifting beliefs in the other direction on a regular basis. This may require creative interventions that use portable communication media as platforms for the timely delivery of countervailing messages (i.e., at or within 2 days of exposure to ads).

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