Long-term Associations Between Substance Use-Related Media Exposure, Descriptive Norms, and Alcohol Use from Adolescence to Young Adulthood

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Abstract

Adolescents and young adults in the United States are constantly exposed to substance-related media and advertising content. The current study seeks to explore, developmentally, how exposure to substance-related media content influences both normative beliefs about peer alcohol use and individual alcohol use. Youth ($N = 4{,}840$; 50.6% female) were followed for ten years from age 12 to 22. Auto-regressive latent trajectory with structured residual (ALT-SR) models were used to explore within-person reciprocal associations between substance-related media content, descriptive norms, and alcohol use. Results indicated that, across adolescence and young adulthood, exposure to substance-related media content was associated with increased alcohol use via perceived alcohol norms. The pathway from media exposure to alcohol use was mediated by increased perceived norms for adolescents only. With screen time increasing over the last decade, it is important to invest resources into real-time interventions that address substance-related social media content as it relates to misperceived norms and to begin these interventions in early adolescence.

Keywords

Substance use; Social Media; Adolescent; Norms; Addiction

Introduction

Adolescence and young adulthood are both at-risk developmental periods for initiation and escalation of alcohol use, including heavy drinking. For example, the prevalence of lifetime drinking increases from 23.1% in 8th grade to 61.5% in 12th grade (Johnston et al. 2019), and further increases to 85% among 19-to 28-year-olds (Schulenberg et al. 2018). Similarly, being drunk in the past year shows a steep increase from 6% of 8th graders to 36% of 12th graders (Johnston et al. 2019) and 61% of 19-to 28-year-olds (Schulenberg et al. 2018). Heavy drinking peaks during young adulthood as youth transition to new and independent adult roles (Center for Behavioral Health Statistics and Quality 2017; Harris Abadi et al. 2011; Wisk and Weitzman 2016), and is often associated with a host of negative consequences (Blanco et al. 2008; Perkins 2002; White and Hingson 2013). Two distinct yet related types of social influences are key risk factors for problematic drinking and related consequences during adolescence and young adulthood: exposure to alcohol and drug content in media, and alcohol use norms (e.g., beliefs about peer alcohol consumption). Prior research shows that exposure to alcohol or drug content via media (e.g., social networking sites, advertising, news, movies, video games) influences both use and normative beliefs (Jackson et al. 2018). However, little is known about how exposure to substance-related media content might influence young people's substance use vis-à-vis their normative beliefs about substance use. With youth spending more time online (Casiano et al. 2012) and being exposed to increasing numbers of advertisements (e.g., billboards, ads on Facebook or other social media sites; King et al. 2017), it is crucial to understand the mechanisms through which this exposure may influence their own use in order to inform programming and policies to reduce alcohol use and its consequences.

Theoretical and Empirical Evidence: Exposure to Substance-Related Media Content, Normative Beliefs, and Alcohol Use

Several cross-disciplinary theoretical/conceptual models, such as the *theory of reasoned action* (Ajzen and Fishbein 1972) and *developmental transitions and trajectories* (Havighurst 1948) aid our understanding of why youth initiate substance use and the variation in patterns of use that exists across the life span (Schulenberg and Maggs 2002). For example, the theory of reasoned action posits that adolescent substance use is determined by two cognitive components. The first is adolescents' attitudes regarding their own use (e.g., value-expectancy), which are a function of both personal consequences and the value placed on those consequences. Thus, if an adolescent holds positive attitudes towards substance use, the expected benefits may outweigh any costs. The second refers to adolescents' beliefs regarding social norms surrounding substance use. Here, it is posited that adolescents' beliefs are based on perceptions that others approve and use substances, which will, in turn, influence their decisions surrounding use. The temporal ordering in which aspects of learned behavior (e.g., social media exposure to substance use content) and normative beliefs about substance use may vary by developmental age. For instance, in the *transitions and*

trajectories framework, transitions refer to the actual process of change (e.g., pubertal development, transitioning from adolescence to young adulthood), whereas trajectories are defined as patterns of systematic and successive change over time (e.g., development of alcohol use, changes in delinquency over time). Examining how certain transitions (e.g., adolescence to young adulthood) are embedded into individual trajectories (e.g., alcohol use) can point to important periods of life that may reflect increases or decreases in functioning or risk. In the current study, these overarching theories help guide questions about the effects of exposure to substance-related content via social media on normative beliefs and level alcohol use from a developmental perspective as youth transition from adolescence into young adulthood.

Adolescents and young adults in the United States are constantly exposed to media and advertising content. Research has shown that youth spend an average of 8 h per day engaged with some form of online media (King et al. 2017) and are exposed to numerous alcohol ads and peer-related alcohol content (Barry et al. 2016; Collins et al. 2016). This is alarming, as recent studies show that media exposure is a major factor driving risk of escalating (or continued) alcohol use (Ross et al. 2015) and normative beliefs about alcohol use (Collins et al. 2017). Theoretical models including *social learning theory* can aid our understanding of how social media influences both behavior and normative beliefs. Briefly, social learning theory posits that an individual's behavior is modeled after the behavior of others (Bandura 1977). Over the past four decades, social learning theory has been applied to the substance use literature emphasizing how learning from the environment that is both direct (e.g., personal experience) and indirect (e.g., beliefs about others) is a major determinant of both substance use behaviors and cognitions (Petraitis et al. 1995; Simons et al. 1988). For example, in early work by Akers (1995), social learning theory was applied to adolescent drug and alcohol use with social learning variables such as peer norms, peer acceptance of use, and deterrence of use, explaining nearly 55% of the variance in alcohol or marijuana use. Although much of Aker's work has focused on criminal and deviant behavior, many of the theoretical aspects can be applied to the current study. For example, Akers and Jennings (2015) note seven processes by which learning occurs, and several of these processes include discussion of norms. Specifically, the frequency of delinquent or criminal behaviors is a function of norms in which learning takes place when behaviors (criminal behavior) are more highly reinforced than non-criminal behavior. Thus, for the current study, using this framework one can conclude that being exposed to high volume of substance-related media content may reinforce normative beliefs about peer use and eventually influence individual behaviors such as substance use.

Other researchers have posited that the media might be considered a super peer in terms of its influence on young adult social and psychological development (Elmore et al. 2017; Strasburger et al. 2009). A review of the literature found that exposure to alcohol-related advertising and promotion predicted both onset of drinking (among youth who have not started drinking) and increased alcohol consumption among adolescents who had started drinking (Smith and Foxcraft 2009). More recent research found that exposure to peers' alcohol-related social media content (e.g., images or videos of drinking on social media) predicted alcohol consumption both concurrently and prospectively (Boyle et al. 2016), and one study using auto-regressive cross-lagged models found that greater substance-related

media exposure predicted higher probability of alcohol use one year later, and alcohol use was marginally associated with increased exposure to substance-related media exposure (Tucker et al. 2013).

In addition to media exposure influencing actual use, prior research notes exposure to substance-related media content can also affect perceived norms. *Social norms theory* (Perkins and Berkowitz 1986) posits that people are driven to behave in ways that are consistent with their perceptions regarding the behavior of others; however, perceptions of others' behaviors are often misperceived such that healthy or prosocial behaviors are underestimated and risky behaviors are overestimated (Chung and Rimal 2016; Perkins and Berkowitz 1986; Rimal and Real 2005). A number of studies demonstrate that adolescents and young adults consistently overestimate the drinking behavior of their peers, and these overestimations are associated with increased consumption and negative consequences of drinking (Borsari and Carey 2003; Neighbors et al. 2007). Prior work has also demonstrated associations between perceived norms, substance-related media exposure, and drinking behavior. For example, one study of high school students found that when adolescents believed that alcohol advertisements in the media realistically portrayed alcohol use, they reported stronger perceived peer drinking norms (e.g., greater overestimation; Elmore et al. 2017). There is some evidence that exposure to substance-related media content influences norms and expectancies surrounding alcohol use (Fleming et al. 2004) and marijuana use (D'Amico et al. 2018). Recently, in a longitudinal study using ecological momentary assessment, Martino and colleagues (2016) found that youth viewed alcohol as more normative when they reported greater exposure to alcohol advertising compared to times when they were not exposed to alcohol advertising. However, prior research also suggests that peer norms are a potential mediating mechanism through which exposure to substance-related media content may influence substance use. That is, some have noted that media exposure may, in fact, alter normative beliefs about substance use, and these altered normative beliefs are what influence risky behaviors (e.g., increased alcohol consumption). For example, longitudinal work has found that exposure to alcohol-related media content and subsequent alcohol use are fully mediated by perceptions of normative peer alcohol use (e.g., perceived approval of drinking, over estimation of drinking; Boyle et al. 2016; Nesi et al. 2017; Osberg et al. 2012).

Within the developmental periods of adolescence and young adulthood, youth are particularly susceptible to influence by perceived norms (Blakemore and Mills 2014; Gardner and Steinberg 2005; Simons-Morton and Farhat 2010; Steinberg and Monahan 2007), thus it is important to understand how perceived norms may affect associations between viewing substance-related media content and drinking behavior. To date, little is known about how these variables may be reciprocally related over these important developmental periods.

Addressing Methodological Limitations: Disaggregating Levels of Variance

Prior studies have attempted to disentangle the temporal effects of media exposure, perceived norms, and alcohol use (either together or separately). For example, Wardell and Read (2013) used an auto-regressive cross-lagged (ARCL) model and found a reciprocal

association between perceived norms for quantity of alcohol use and quantity of alcohol consumption across three waves of data during the first three years of college. Others have found, using similar ARCL approaches, that injunctive norms were reciprocally related to drinking quantity and attitudes about drinking over time (Lewis et al. 2015). Further, Tucker and colleagues (2013) noted reciprocal associations between exposure to substance-related media and alcohol use among adolescents. Unfortunately, ARCL models yield estimates that are a combination of both between-and within-person variance (Berry and Willoughby 2016), thus making estimates difficult to interpret. For example, one would not assume that changes in alcohol use from an adolescent's or young adult's typical level (i.e., individual mean) would be identical to changes in alcohol use compared to their peers (i.e., grand mean). However, most studies that examine reciprocal associations or mechanisms of behavior change use methods that address between-person effects to answer questions about within-person change. In addition to previous work being limited due to using ARCL models, studies that have analyzed mediation of norms have situated the mediator within the same time point as either the independent variable (e.g., exposure to substance-related media content) or the outcome (e.g., drinking behavior) (Boyle et al. 2016; Nesi et al. 2017), making it difficult to discern temporal order.

The current study addresses both of these issues by using advances in longitudinal modeling to extend our understanding of how exposure to substance-related media content, quantity of alcohol use, and perceived descriptive norms about alcohol use are reciprocally related over time. Specifically, auto-regressive latent trajectory with structured residuals models (ALT-SR; Curran et al. 2014) were used to simultaneously consider between-person relations among more systematic—or trait-like—aspects of alcohol use and exposure to media content (e.g., mean levels, growth rates), while simultaneously modeling reciprocal relations between these variables as they manifest *within* individuals over time (more state-like). The ALT-SR also provides several advantages in that this model anchors the reciprocal processes at an arguably more meaningful and relevant level of analysis—*within*-person—and the internal validity of the reciprocal effects are strengthened as each individual serves as his or her own control and therefore all time-invariant confounds are controlled for. In addition, our within-person estimates are lagged such that mediation can be appropriately tested.

The Present Study

Given potential developmental differences that may exist when exploring the long-term effects of exposure to substance-related media content on changes in perceived norms and alcohol use, the current study sought to understand if these patterns were different for adolescents and young adults. Specifically, three distinct hypotheses were tested, each related to a specific theoretical framework. First, in line with prior literature and social learning theory, it was hypothesized that higher levels of exposure to substance-related media content would be associated with subsequent increases in overall initial levels of and change in perceived norms and alcohol use. Second, in line with social learning theory and social norms theory, it was hypothesized that heightened *individual* (i.e., within-person) levels of exposure to substance-related media content would be associated with wave-to-wave increases in perceived norms and alcohol use. Finally, in line with transition and trajectory theories, the current study examined whether early exposure to substance-related

media content during adolescence was associated with incremental changes in perceived norms over time, and if these alterations in norms transitioned into young adulthood, resulting in a cascade of problematic behaviors (e.g., long-term effects of altered norms on individual-level alcohol consumption). Thus, it was hypothesized that exposure to substance-related media content during adolescence would initiate altered normative beliefs and, eventually, result in greater alcohol use at the within-person level of analysis.

Methods

Participants and Procedures

Participants were from two cohorts of students in sixth and seventh grade in 2008, followed through 2018. Adolescents (N = 5,523) were initially recruited from 16 middle schools from three districts in southern California as part of an alcohol and drug use prevention program, CHOICE (D'Amico et al. 2012). Table 1 presents participant characteristics from the first time point in the current study, wave 4 in 2010. Briefly, youth were, on average, 13.2 (SD = 0.73) years old and 50.6% female at wave 4. The majority of youth identified as Hispanic (52.9%), followed by Asian (16.9%), White (16.1%), African American (3.0%), Multi-ethnic (9.5%), American Indian (0.8%), and Native Hawaiian (0.8%). Procedures are reported in detail in the prevention trial and subsequent work describing the longitudinal sample waves (D'Amico et al. 2016; D'Amico et al. 2012). Briefly, participants completed waves 1 through 5 (wave 1: fall 2008; wave 2: spring 2009; wave 3: fall 2009; wave 4: spring 2010; wave 5: spring 2011) during physical education classes at 16 middle schools. Follow-up rates in middle school ranged from 74% to 90%, excluding new youth who could have come in at a subsequent wave. Participants transitioned from middle schools to more than 200 high schools following wave 5 and were subsequently re-contacted and re-consented to complete annual web-based surveys. At wave 6, when the transition to high school occurred, 61% of the sample participated in the follow-up web-based survey. Sample retention was 80% from wave 6 to wave 7, 91% from wave 7 to wave 8, 89% from wave 8 to wave 9, and 90% from wave 9 to wave 10. It is important to note that failure to complete a certain wave was not significantly associated with demographics or risk behaviors, such as drinking and marijuana use at the previous wave (D'Amico et al. 2016; Dunbar et al. 2017). All study procedures were approved by the research organization's Institutional Review Board.

All prospective analyses used data from wave 4, when participants were between the ages of 12 and 15, through wave 10, when participants were between 19 and 22. Data analysis began from wave 4 onward because this is when youth were first asked about exposure to substance-related media content across a variety of social media and advertising platforms. Because data were set up in naturally occurring cohorts (e.g., age), an accelerated longitudinal cohort design was used, which creates a planned missing data pattern such that participants only contribute data at the time points in which they were in the study. However, because our metric of time is age (versus follow-up wave), we are able to model development from 12 to 22 years old. Due to missingness on some variables, our final analytic sample size was 4,840.

Measures

Covariates—All analyses controlled for gender (female as reference group), race/ethnicity (coded: Asian, White, African American, Hispanic, American Indian/Native Hawaiian, and multi-ethnic), parental education (coded: 1 = less than high school education), and intervention status (coded: 1 = received intervention in middle school in 2008). Further, wave 1 covariates included alcohol use and baseline marijuana use, as well as risk factors such as peer (e.g., best friend) alcohol use, peer marijuana use, parental alcohol use, and parental marijuana use. Wave 4 best friend and parent alcohol and marijuana use were also entered into our models as control variables.

Alcohol use—Using items similar to those in large-scale national surveys (Johnston et al. 2019; SAMHSA 2018) participants were asked the number of days they had at least one drink of alcohol during the past month (Ellickson McCaffrey et al.2003). Participants responded on a 7-point scale ranging from 1 = 0 days, 2 = 1 day, 3 = 2 days, 4 = 3–5 days, 5 = 6–9 days, 6 = 10–19 days, and 7 = 20–30 days. The average was taken for options that refer to a range of days (e.g., 3–5 days), so each response corresponds to the number of days participants used alcohol in the past month.

Perceived norms—Using items similar to those in large-scale national surveys (Johnston et al. 2019; SAMHSA 2018) participants were asked to think about a group of 100 students or peers and indicate how many had drunk alcohol at least once in a month. Response options ranged from 0 to 100 with multiples of 10 as anchors (Ellickson et al. 2003). Responses were recoded to percentages to match prevalence of actual behavior in the sample.

Substance-related media exposure—Participants responded to seven separate items asking how often in the past three months they had seen or heard the following (Tucker et al. 2013): (a) videos on the internet showing someone who is drunk or high; (b) pictures or comments on a social networking site (e.g., Facebook) showing or talking about someone who is drunk; (c) movies showing someone who is drunk or high; (d) television programs showing someone who is drunk or high; (e) alcohol advertisements on billboards, magazines, or some-where else; (f) songs that talk about getting drunk or high; and (g) video games that show someone getting drunk or high. Participants responded on a 7-point Likert scale ranging from 0 = not at all to 6 = every day. Cronbach alpha values ranged from α = 0.91–0.93 (M_α = 0.92).

Analytic Approach

The present study used advanced modeling techniques (ALT-SR; see Fig. 1 for conceptual model) to understand how substance-related media exposure, perceived descriptive norms, and alcohol use are reciprocally related over time in a large and diverse cohort of youth who have been followed for 10 years from age 12 to 22. Using this model allows us to test associations across three different levels of variance. That is, the ALT-SR separates the variance into three separate 'bins.' The first level or bin is the portion of variance that does not change (e.g., the level or intercept), which aids in our understanding of basic differences across age. The second is the portion of variance that changes over the entire span of the

study (e.g., the slope), which aids in our understanding of basic individual differences in alcohol use, perceived norms, and substance-related media exposure. The third bin is the portion of variance that changes wave-to-wave (e.g., the within-person cross lags), which aids in our understanding of within-person fluctuations across the developmental periods of adolescence and young adulthood.

One of the major assumptions under accelerated longitudinal designs is that each cohort (e.g., age at the first wave of data analysis) can be considered part of the same developmental trajectory. First, cohort differences were assessed by testing nested hierarchical linear models for all three variables of interest. We began by testing models with (1) linear and quadratic time, (2) demographic control variables, and our cohort indicator, and (3) an interaction between our cohort and time variables. No significant cohort by time interaction differences were found in our final models across all three variables, indicating we could treat our data as one continuous developmental cohort (age 12–22 years).

Next, a taxonomy of auto-regressive latent trajectory with structured residuals models (ALT-SR; Curran et al. 2014) was estimated to examine the simultaneous between-and within-person effects of exposure to alcohol content, drinking norms, and individual frequency of alcohol use (see Fig. 1 for conceptual model). Using the ALT-SR specification, the between-person effects are captured by correlating (or regressing) our latent intercepts and growth parameters (represented by $\varphi_{standardized}$ below and labeled letter "a" in Fig. 1). Thus, the remaining within-person variance is "pushed" into the residual (errors) cross-lagged portion of the model. Here, the residuals of our observed variables are identified as latent variables (labeled letter 'b' in Fig. 1) by constraining all means and variances (e.g., alcohol use at age 14, descriptive norms at age 15) to zero (similar to creating a latent growth model). However, diverging from basic latent growth modeling, newly created structured residuals are used (e.g., $\in_{W1}$ or $\in_{Z1}$). These newly created structured residuals are used to estimate remaining variance left over after accounting for our correlated change processes (e.g., intercept and slopes) by estimating auto-regressive components (labeled letter 'c'), within-time correlations (labeled letter 'd'), and the within-person crosslagged effects (labeled letter 'e').

A model building process was used to test for quadratic effects and any potential piecewise growth processes. Specifically, a series of models tested if (1) random slopes were needed for our three variables of interest, (2) if the addition of a quadratic effect significantly improved model fit, and (3) if a quadratic effect was needed, estimating the utility of having a random quadratic slope variance. For all nested model tests, general fit statistics were used including Comparative Fit Index (CFI) of 0.95 or greater, Root Mean Square Error of Approximation (RMSEA) of 0.05 or less, and Standardized Root Mean Square Residual (SRMR) of less than 0.08 to indicate good model fit. Briefly, a model with random linear slopes for all three variables of interest and a fixed quadratic slope for frequency of alcohol use fit the model best.

Once the best functional form of the data was established, a taxonomy of ALT-SR models was estimated. Specifically, three ALT-SR models examined if constraining estimates to be equal over time fit the data better than a freely estimated model. Constrained versus

unconstrained models were compared for 1) auto-regressive components for each variable, 2) within-time correlations for each variable, and 3) within-person cross-lagged estimates across all possible bi-directional effects. Once the best fitting ALT-SR model was established, specific developmental processes were tested by, first, establishing basic auto-regressive associations between variables of interest (Model 1). Second, Model 2 established an *overall* association between substance-related media exposure, descriptive norms, and alcohol use, where cross-lagged effects were constrained to be the same across both developmental periods (e.g., adolescence and young adulthood). Finally, Model 3 assessed *developmental variation* in the magnitude of time-specific associations among substance-related media exposure, descriptive norms, and alcohol use by allowing within-person cross-lagged effects to vary across adolescence (ages 12–17) and young adulthood (ages 18–22). That is, effects from 12–17 years old were constrained to be the same, and effects from 18–22 years old were constrained to be the same.

Data for some analytic variables were missing for 12% of the sample. To address missing data, full information maximum likelihood estimator (FIML) in *Mplus* was used. FIML treats all observed indicators as latent factors and allows each person to contribute whatever data are available instead of removing individuals with missing data. To adjust for non-normality, all standard errors were boot-strapped (iterations = 10,000). All models controlled for participant self-reported biological sex, race/ethnicity, mother's education, and intervention assignment. All analyses were conducted in *Mplus* version 8 (Muthén and Muthén, 1998–2018). Demographics (e.g., gender, race/ethnicity, employment) and substance use at the prior wave (e.g., alcohol, cigarettes, marijuana) did not predict attrition at Wave 10, similar to prior studies utilizing these data (D'Amico et al. 2018).

Results

Table 2 provides all model results with parameter estimates and standard errors. Standardized estimates (β) and unstandardized estimates (b) are reported below. Between-person correlations (i.e., intercept and random slopes) are represented by $\varphi_{standardized}$ below.

Between-Person Associations (Hypothesis 1)

Overall, mean trajectories showed increases in exposure to substance-related media content ($b_{linear} = 0.30$, $SE = 0.001$, $p < 0.01$), alcohol norms ($b_{linear} = 0.80$, $SE = 0.01$, $p < 0.01$), and frequency of alcohol use ($b_{linear} = -0.14$, $SE = 0.03$, $p < 0.01$; ($b_{quadratic} = 0.08$, $SE = 0.01$, $p < 0.01$) over time. The intercept and slope factors represented by the latent growth model indicated moderate to strong associations for between-person frequency of alcohol use, perceived descriptive alcohol norms, and substance-related media exposure. Table 2 presents initial level and slope-to-slope correlations under the "(Co) Variances (between-person)" column. In line with the first hypothesis, higher levels of exposure to substance-related media content are associated with subsequent increases in overall initial levels of and change in perceived norms and alcohol use at the between-person level; individuals who reported high initial levels (intercept) of alcohol use also reported higher initial levels of perceived descriptive norms ($\varphi_{standardized} = .18$). Further, there was a significant correlation between initial levels of substance-related media exposure and descriptive norms ($\varphi_{standardized} = .26$).

Examination of change-to-change (slope-to-slope) correlations showed an association between alcohol use slopes and increases in descriptive norms ($\varphi_{standardized} = .31$). Finally, changes (increases) in exposure to substance-related media content were associated with changes (increases) in alcohol use ($\varphi_{standardized} = .07$, ns) and perceived descriptive alcohol norms ($\varphi_{standardized} = .08$, *ns*).

Within-Person Associations

Overall model (Hypothesis 2)—To address the second hypothesis, whether heightened *individual* levels of exposure to substance-related media content were associated with wave-to-wave increases in perceived norms and alcohol use, lagged trajectories were constrained to be equal across time (see Fig. 2; Table 2, Model 1). Results indicated partial support for hypothesis 2, such that when individuals reported higher exposure to substance-related media content compared with their typical levels, they subsequently reported higher descriptive alcohol norms the next year ($b = 0.19$; 95% CI [0.12, 0.26]; $\beta = 0.11$). In addition, reporting higher descriptive alcohol norms than one's typical average was subsequently associated with higher exposure to substance-related media content ($b = 0.04$ 95% CI [0.03, 0.06]; $\beta = 0.08$) and greater alcohol use ($b = 0.06$; 95% CI [0.02, 0.09]; $\beta = 0.05$) than one's typical average the next year. Interestingly, there was no direct association between exposure to substance-related media content and alcohol use. However, following the pathway from exposure to substance-related media content at age 12 in Fig. 1, reporting greater exposure to substance-related media content was associated with greater descriptive norms the next year, at age 13 (similar pathways for young adults). Continuing, these heightened descriptive norms at age 13 were then associated with reporting higher alcohol use the next year at age 14. Thus, this pathway suggests that perceived norms may be a potential mechanism linking substance-related media exposure and individual-level alcohol use.

Developmental model (Hypothesis 3)—To address hypothesis 3, whether early exposure to substance-related media content during adolescence was associated with incremental changes in perceived norms over time, within-person cross-lagged effects were allowed to vary across adolescence and young adulthood (See Fig. 3; Table 2, Model 2). The developmental model had significantly better model fit compared to the overall model ($-2LL = 1004.4$, $df = 15$, $p < .001$). Again, results indicated partial support for hypothesis 3 such that during adolescence, the same pattern of effects was found as in the overall model. That is, during adolescence (see Fig. 3), reporting higher exposure to substance-related media content than one's typical average was associated with higher descriptive alcohol norms than one' s typical average (Adolescence: $b = 0.15$ 95% CI [0.10, 0.21]; $\beta = 0.08$). In addition, adolescents who reported higher descriptive norms than their typical average reported higher exposure to substance-related media content (Adolescence: $b = 0.05$ 95% CI [0.03, 0.06]; $\beta = 0.05$) and higher frequency of alcohol use (Adolescence: $b = 0.06$ 95% CI [0.03, 0.09]; $\beta = 0.05$) than their average the next year.

During young adulthood, a similar pattern occurred. The only difference in the model for young adults was that alcohol use did not predict exposure to substance-related media content. Thus, taking a closer look at the developmental model, substance-related media

exposure use at age 18 was associated with higher alcohol descriptive norms the next year. Given constraints in the developmental model, these normative beliefs in young adulthood were associated with subsequently reporting more frequent alcohol use than one's typical average.

Post-Hoc Mediation

After assessing the final developmental models, perceived norms appeared to act as a potential mechanism linking exposure to substance-related media content and youths' alcohol use. Thus, given prior theoretical (e.g., social norms theory) and empirical evidence suggesting that perceived norms are an important mechanism linking media exposure and alcohol use (Jackson et al. 2018), a mediation hypothesis was tested. To do this, an indirect effect was estimated by multiplying together the 'a path' (e.g., exposure to substance-related media content at age 14 predicting descriptive alcohol norms at age 15) and the 'b path' (e.g., descriptive alcohol norms at age 15 predicting alcohol use at age 16). To ensure a true indirect effect pathway was being estimated, an additional regression coefficient was estimated (e.g., 'c path' (or direct effect)) from substance-related media exposure at age 14 to alcohol use at age 16. A significant indirect effect was determined by examining bias-corrected confidence intervals of the newly created indirect effect variable.

In the overall and developmental models, descriptive alcohol norms were a prominent mechanism linking exposure to substance-related media content and alcohol use. Thus, three post-hoc mediation analyses were tested: 1) for the overall model, 2) adolescent phase (developmental model), and 3) young adult phase (developmental model). For the overall model, a statistically significant indirect effect (indirect effect = 0.04, 95% CI [0.02, 0.07]) was found showing that when youth reported higher exposure to substance-related media content compared to their own average, they also reported higher descriptive norms at the next time point, and this shift in descriptive norms was subsequently associated with more frequent alcohol use. In the developmental model, a significant indirect effect was found during adolescence (indirect effect = 0.01, 95% CI [0.003, 0.03]) but not during young adulthood (indirect effect = 0.01, 95% CI [−0.002, 0.03]).

Alternative Models

In an attempt to explore possible variation across type of substance-related media exposure, analyses examined three additional models of exposure to different types of substance-related media content: (1) social media, (2) advertisements (e.g., billboards, magazines), and (3) TV/video (e.g., television ads, movies, music) were estimated. To do this, items corresponding to three general categories (noted above) of substance-related media exposure were averaged. Social media contained two items, TV/video contained four items, and advertisements contained one item. All procedures outlined in the analytic plan were followed in these alternative models, thus estimating overall developmental models for each media exposure type (e.g., effects constrained to be the same across adolescence and young adulthood) and developmental models (e.g., effects constrained to vary between adolescence and young adulthood). Tables for results can be found in supplementary material. In the overall model (e.g., one developmental period), across all three types of substance-related media exposure, the same pattern of effects was found as the main findings (i.e., mean

exposure across all types; see Supplementary Tables 1–3, Model 1). That is, when individuals reported higher exposure to substance-related media content (either social media, advertisements, or TV/video) compared to their typical levels, they subsequently reported higher descriptive alcohol norms the next year. These higher descriptive alcohol norms were then related to reporting greater alcohol use than one's typical average. Thus, it seems when considering development as one continuous phase, results are robust to the main findings, which consider exposure to any (e.g., multiple) type of substance-related media content.

However, when investigating developmental models by exposure type (e.g., estimates constrained to be equal during adolescence and young adulthood), differential effects were found for TV/video exposure and advertisements. For exposure to substance-related media content via social media, the same pattern of effects was found as developmental models exploring any exposure (see Supplemental Table 1, Model 2). During both adolescence and young adulthood, reporting higher exposure to substance-related media content than one's typical average was associated with reporting higher descriptive norms than one's typical average the next year. These heightened norms were then associated with reporting greater alcohol use the following year. When assessing potential mediation, again, descriptive norms were a significant mediator between exposure to substance-related media content via social media and alcohol use for adolescents (indirect effect = 0.01, 95% CI [0.003, 0.03]) but not young adults (indirect effect = 0.01, 95% CI [−0.001, 0.03]). Interestingly, when exploring developmental models for advertisements (see Supplemental Table 2) and TV/video exposure (see Supplemental Table 3) this pattern of effects (e.g., exposure to substance-related media content predicting higher descriptive norms and these increased normative beliefs predicting alcohol use) was found only during adolescence and not young adulthood. When assessing indirect effects, norms were a significant mechanism for TV/video substance-related media exposure during adolescence only (adolescence indirect effect = 0.01, 95% CI [0.003, 0.02]; young adult indirect effect = 0.01, 95% CI [−0.001, 0.03]). No mediation was evident for advertisement substance-related media exposure during adolescence (adolescence indirect effect = 0.002, 95% CI [0.001, 0.005]; young adult indirect effect = 0.01, 95% CI [−0.001, 0.02])

Discussion

A great deal of research has emphasized the importance of social influences such as exposure to alcohol and drug content in the media, as well as normative beliefs about peer alcohol and drug use, in predicting substance use and consequences during adolescence and young adulthood (Jackson et al. 2018; Wardell and Read 2013). Given that adolescents and young adults spend up to 8 h a day online and are exposed to a myriad of advertisements content (Barry et al. 2016; Collins et al. 2016), it is important to understand how these associations may vary across developmental periods so that prevention programming can better address the changing online landscape as youth transition from adolescence to young adulthood.

This study builds upon past research and theory regarding the link between exposure to substance-related media content and individual-level alcohol use by using a multiwave longitudinal study across important developmental periods to examine a key potential

mechanism: perceived peer alcohol norms. Two important findings extend knowledge on how exposure to substance-related media content may play a role in shaping perceived norms and alcohol use from a developmental perspective. First, the current study found evidence of between-person associations linking exposure to substance-related media content and frequency of alcohol use across both adolescence and young adulthood. Second, the current study did not find a direct link between substance-related media content and alcohol use at the within-person level. Instead, across adolescence and young adulthood, exposure to substance-related media content was associated with increased alcohol use via perceived alcohol norms. That is, the association observed in prior studies between media exposure and alcohol use may be explained, in part, by perceptions of peer alcohol use. When assessing these periods separately, perceived norms were only a significant mediator during adolescence, highlighting the importance of this cognitive construct during this developmental period. Finally, the alternative models indicated strong congruence with initial models (e.g., assessing average levels of exposure to substance-related media content). That is, adolescence remained an important period of life when considering effects of various types of substance-related media content. Specially, across all three types of media content, reporting greater exposure to substance-related media can increase normative beliefs for peer alcohol use, which then predicts greater alcohol use during adolescence. Further, norms remained a prominent mechanism of change for models assessing social media and TV/video exposure.

In support of the first hypothesis, adolescents who reported higher initial levels of substance-use media exposure *and* reported increasing (from adolescence to young adulthood) media exposure over time also reported steeper increases in alcohol use. This supports prior research findings at the between-person (or more trait-like) level. For example, Jernigan and colleagues (2016) found in their systematic review of 12 longitudinal studies that exposure to alcohol-related marketing was associated with higher odds of initiation of alcohol use and higher odds of engaging in binge drinking. Further, at the between-person level of analysis, exposure to a higher volume of substance-related media content was associated with higher initial levels of perceived drinking norms as well as changes (increases) in perceived norms. Results support the principles of social learning theory and can provide some basic guidance for prevention programming. For example, prior research has noted rapid increases in descriptive alcohol use norms during adolescence (Pedersen et al., 2013). These normative beliefs are compounded by several factors including the adolescent's peer group as well as media content. One potential solution to reducing alcohol use is through counter campaigns that contest normative beliefs on social media platforms. Numerous studies have investigated counter campaigns that address smoking, drinking, and drug use with mixed findings (Allara et al. 2015; Wakefield et al. 2010). One potential solution would be to combine large-scale counter campaigns with social norming campaigns, which could address both use and beliefs around use.

Interestingly, in the developmental model no evidence of a direct association between exposure to substance-related media content and frequency of alcohol use at the within-person level was found. Instead, when investigating wave-to-wave lagged effects (within-person), findings indicated that exposure to substance-related media content in adolescence *and* young adulthood increased overestimation of alcohol use, which, in turn, predicted

higher frequency of alcohol use. However, examination of potential mediation indicated a small effect of mediation only during adolescence. This may be because perceived norms have been found to have less of an influence as youth get older (Salvy et al. 2014), or it may be that peers are more influential during adolescence versus young adulthood (Chien et al. 2010; Elmore et al. 2017; Steinberg and Monahan 2007). It could also be a ceiling effect whereby young adults have been exposed to a large quantity of substance-related media content, thus the effect dissipates by young adulthood. Another explanation for this finding may relate to the importance of peers during adolescence. That is, prior theoretical and empirical work has noted that media is a "super peer" (Elmore et al. 2017). Given adolescence is a time when peers become a salient influence on both behavior and cognitions (Chien et al. 2010; Gardner and Steinberg 2005), it follows that many adolescents and young adults today connect with peers or are influenced by content they see on social networking sites, media ads, movies, and television. Thus, when adolescents see substance-related media content from their peers or media content that provides a positive image of substance use, youth believe that engaging in substance use will result in positive outcomes (e.g., positive expectancies of use). Though this particular theory was not tested in this study, it is possible that this process occurs through a message interpretation processing model (Collins et al. 2017), such that when youth encounter media messages about substance use, those who find the messages more similar to their own experiences (*similarity*), more appealing (*desirability*)*,* and more accurate in their depiction of the real world (*realism*) are more likely to incorporate those messages into their own thinking. These favorable perceptions of media messages contribute to youth identifying with and wishing to see themselves in situations portrayed within those messages (*identi®cation).* Recent studies have found that young adults use social media to portray positive and highly valued outcomes of high risk drinking practices (Hebden et al. 2015; Lyons et al. 2015.; Niland et al. 2014). Thus, some media content that youth are exposed to not only conveys messages about what happens when youth drink alcohol (or use drugs), but also *who* is using substances. Given that teens are online for up to 8 h per day (King et al. 2017), and are exposed to an average of three alcohol ads per day (Collins et al. 2017), and peers are one of the most influential factors predicting substance use and related problems during adolescence (Van Ryzin et al. 2012), prevention programs must address social media during this developmental period.

From a prevention perspective, results highlight that adolescence is a period when normative correction interventions may mitigate long-term increases in alcohol use and related consequences. Indeed, many prevention programs address alcohol use norms during both middle school and high school (e.g., D'Amico et al. 2012). Normative feedback interventions attempt to alter an individual' s perceptions of the frequency and quantity of their peers' substance use (Foxcroft et al. 2015), and interventions designed to reduce misperceptions and provide youth with accurate normative data about the drinking behavior of their peers have been successful in reducing and preventing heavy drinking behavior across multiple age groups (Lewis and Neighbors 2006; Miller and Prentice 2016; Prestwich et al. 2016). When normative feedback is delivered within multicomponent interventions with youth, it is a key factor leading toward observed changes in drinking. For example, Davis and colleagues (2016) found that youth who received motivational interviewing plus

normative feedback had fewer heavy drinking days at 6-months post-treatment. Indeed, reducing perceived peer drinking is a consistent mediator of treatment effects in multicomponent interventions to decrease drinking among young people (Reid and Carey 2015). Thus, focusing efforts to correct adolescents' perceived norms of peer alcohol use may help attenuate the influence of media exposure on alcohol use, especially during adolescence. Given most youth are exposed to substance-related media content via social media platforms (e.g., Facebook, Instagram, Snapchat), it may be useful to integrate normative feedback interventions into mobile applications. This would allow for real-time (or respondent driven) interventions for youth, which would provide normative correction when it is needed (e.g., when being exposed to substance-related media content) versus a blanket normative correction campaign. One potential avenue would be through media literacy interventions which seek to enhance self-efficacy and ability to evaluate and accurately interpret marketing in the media (Vahedi et al. 2018). In recent randomized controlled trials, utilizing media literacy techniques have mixed findings as some have found reductions in intentions to use alcohol or other tobacco products (Kupersmidt et al. 2010), whereas others have not found reductions in self-reported alcohol use (Primack et al. 2014). It may be useful to include aspects of normative feedback (e.g., norm correction) into these interventions, as the combination of improved cognitions surrounding marketing and reduced perceived norms may mitigate long-term alcohol use and related consequences. However, countering the strong effects of social media content will likely require some combination of individual skills training implemented at a large scale and effective public policies (e.g., buy-in from local, state, and federal government as well as from the platforms that provide access to content) (Biglan 2018).

In sum, this study addressed several gaps in the literature, and findings highlight important policy and intervention implications for youth. Exposure to substance-related media content in the media is a clear risk factor for alcohol use among young people; however, efforts to control youth exposure to such media may be difficult. Policies about what content can be shown on billboards, television, and the Internet may be controversial and are not easily regulated. Even if content was banned in some media (e.g., regulating what content could be advertised on billboards), youth would likely still be exposed to substance-related media content via other media. This exposure would most likely be on the Internet and through social media, which is unregulated. Thus, it is important to intervene on these beliefs more globally, particularly during early-to mid-adolescence.

Although this study provides the first empirical look at the developmental cascade of events linking exposure to substance-related media content, descriptive norms, and alcohol use, several limitations should be noted. First, all variables were self-reported, which may provide biased estimates of alcohol use and media exposure; however, it is important to note that alcohol use rates in the current sample are similar to national norms (Johnson et al. 2019). Second, information about actual peer use was not available, which would provide additional information on the difference between perceived peer use and actual alcohol use. Prior work has found that using data from close friends or natural drinking groups provides better estimates of perceived norms (Dumas et al. 2017). Third, while alternative models provide additional information regarding potential heterogeneity across substance-related media exposure types, caution should be taken when interpreting these effects. This is

because separating out exposure types assumes that youth are only exposed to one type of media outlet, which is highly unlikely (Martino et al. 2016). This analysis may therefore overestimate effects of one type of media exposure given youth are, generally, exposed to multiple media outlets. Further, prior research has found no difference across various types of media exposure when predicting substance use (Tucker et al. 2013), thus utilizing a total score or average exposure across multiple media outlets is a more appropriate and realistic depiction of youth's exposure to substance-related media content. Finally, while results from the modeling approach advance our understanding of the temporal order of associations, they should not be interpreted as implying causality.

Conclusion

With substance-related media content rapidly expanding to social media and other platforms, understanding how exposure to this content may affect youth across both adolescence and young adulthood is crucial given developmental differences (e.g., neurocognitive, physiological, and psychological) that exist during these important time periods. The current study examined how exposure to substance-related media content influenced descriptive norms and alcohol use across adolescence and young adulthood. Results pointed to several important implications. First, findings support the long-lasting effects of exposure to substance-related media content on descriptive norms as effects were strong across the developmental periods of both adolescence and young adulthood. Second, this study provides evidence of a temporally lagged effect of substance-related media exposure on descriptive norms and frequency of alcohol use from a developmental perspective. With screen time increasing over the last decade, it is important to invest resources into real-time interventions that address substance-related social media content as it relates to misperceived norms, and to begin these interventions in early adolescence when youth begin to spend more time on social media.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Biography

Jordan P. Davis is an assistant professor at the University of Southern California, and an Associate Director of the USC Center for Artificial Intelligence in Society, and an Associate Director of Research for the USC Center for Mindfulness Science. His major research interests focus on development from adolescence to young adulthood and how early life

trauma experiences and concurrent exposure to violence influence developmental outcomes such as substance use and continued violence exposure.

Eric R. Pedersen is a senior behavioral scientist at the RAND Corporation. His research interests are primarily in areas of young adult/adolescent alcohol use and comorbid mental health disorders. Pedersen has received funding to develop brief, online interventions to reduce alcohol misuse among young adult populations such as college students and recent veterans. He is interested in finding ways to prevent alcohol misuse and promote treatment engagement among non-treatment-seeking young adults.

Joan S. Tucker is a senior behavioral scientist at the RAND Corporation. She conducts research primarily in the areas of substance use and sexual risk behavior. Her work on substance use includes identifying developmental trajectories of substance use, risk factors for initiation and escalation, and short-and long-term consequences of use during adolescence and young adulthood. Much of Tucker's recent research has focused on developing and evaluating brief interventions for substance use and sexual risk behaviors in vulnerable populations.

Michael S. Dunbar is a behavioral scientist at the RAND Corporation. Dunbar's research examines the ways in which situational factors and policy environments influence patterns of health behaviors, particularly nicotine and tobacco use. His work employs a range of methodologies, including experimental research, surveys, program evaluation, and ecological momentary assessment. His current studies span a range of populations (e.g., adolescents; adults; military personnel; sexual and gender minorities), and focus on topics including tobacco dependence, substance use trajectories, barriers to accessing healthcare, and efforts to improve utilization of behavioral health services in underserved populations.

Rachana Seelam is a research programmer at RAND. Her research interests include substance use, adolescent development, trauma history, and data science.

Regina Shih Regina Shih is director, Social and Behavioral Policy Program, and a senior behavioral and social scientist at the RAND Corporation. She currently has three primary research areas: aging and disability policy, environmental health, and behavioral health. Her aging policy work includes (1) examining the effects of a long-term care rebalancing initiative; (2) examining age-friendly initiatives on the resilience of older adults to disasters; (3) developing a national blueprint for dementia long-term care; and (4) developing instruments to assess medication reconciliation for post-acute care settings. Her behavioral health work includes (1) studying the impacts of poor sleep and developing recommendations for the DoD to improve sleep programs and policies in the military; and (2) identifying multi-level risk and protective factors for adolescent substance use and risk behaviors.

Elizabeth J. D'Amico Elizabeth D'Amico is a senior behavioral scientist at the RAND Corporation and a licensed clinical psychologist. D'Amico is nationally recognized for her work developing, implementing, and evaluating interventions for adolescents. She is a member of the Motivational Interviewing Network of Trainers (MINT) and the interventions she has developed all utilize motivational interviewing (MI). D'Amico has evaluated several

MI interventions with adolescents and young adults in a variety of settings, including middle schools, primary care, homeless shelters, and teen court. She recently developed and tested a group intervention for urban Native American adolescents that integrated MI and traditional healing practices. She has also conducted epidemiological work to examine predictors and consequences of adolescent substance use. She is the principal investigator of a large longitudinal study that examines substance use patterns over 14 years among youth from sixth grade through age 24. Her most recent work has focused on the effects of medical marijuana advertising on adolescents' marijuana use.

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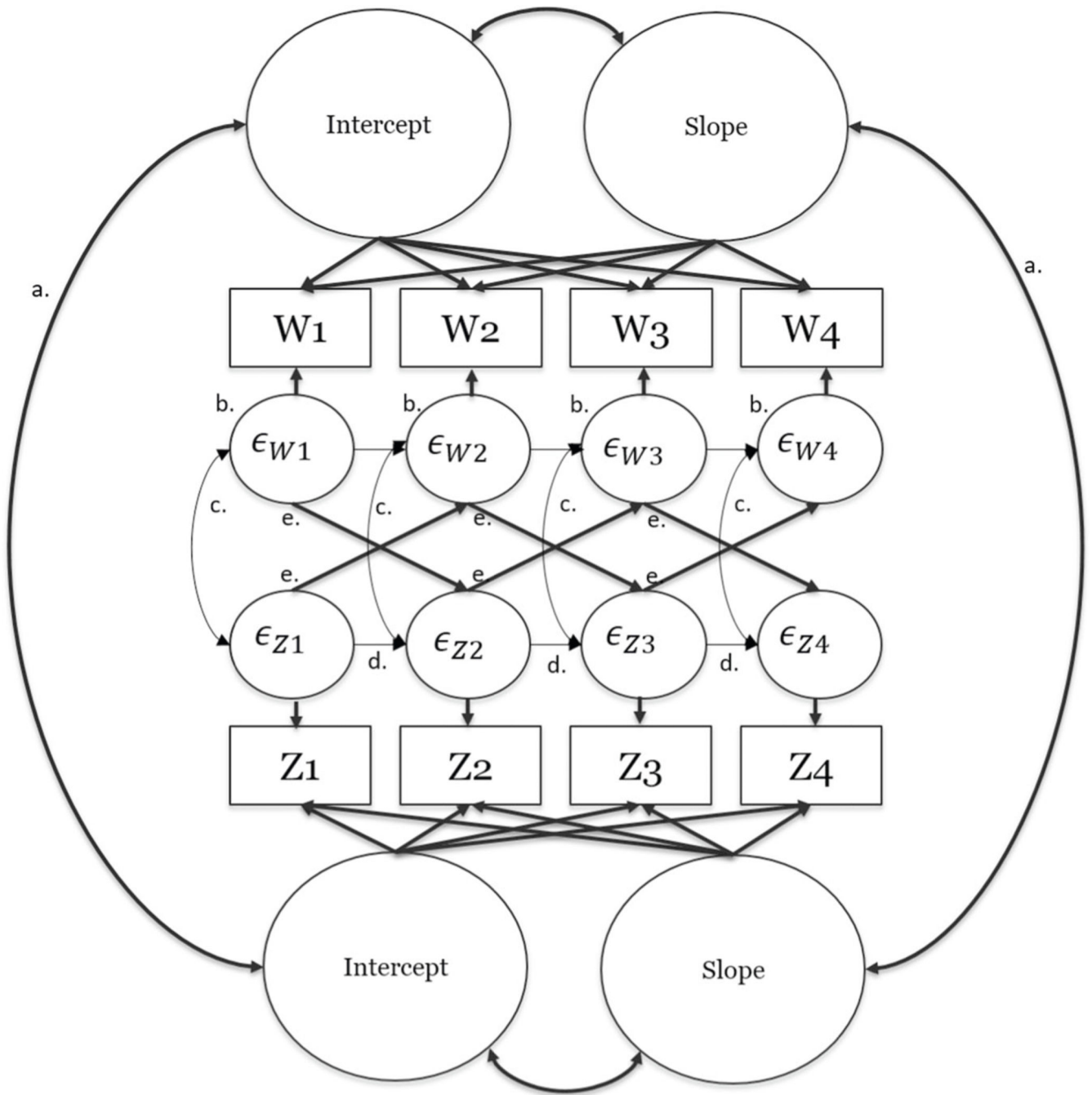
Fig. 1.
Conceptual ALT-SR model. The model above is only conceptual representing two variables
(*W* and *Z*). This model does not represent the complexity of every aspect of ALT-SR
models. The correlations between intercepts and slopes (letter 'a') represent the between-
person effects of each variable in the model. Here we have only shown intercept-to-intercept
and slope-to-slope correlations. However, all random intercepts and random slopes are to be
correlated in final models (e.g., intercepts correlated with slopes). The residuals (e.g., error)
of our measured variables are identified as latent residuals (letter 'b') with observed means

and variances constrained to zero. Here we estimate the residual variance as a newly created latent variable (e.g., $\in_{W1}$ or $\in_{Z1}$) (e.g., $\in_{W1}$ or $\in_{Z1}$) and estimate the "residuals of the residuals" to identify newly created within-person latent constructs. These newly created structured residuals (e.g., $\in_{W1}$ or $\in_{Z1}$) are then used to estimate the remaining variance that is left over after our intercept and slope variance are accounted for. We estimate the autoregressive components of our structured residuals (letter 'c'), the within-time correlations of our structured residuals (letter 'd'), and the within-person cross-lagged effects (letter 'e')
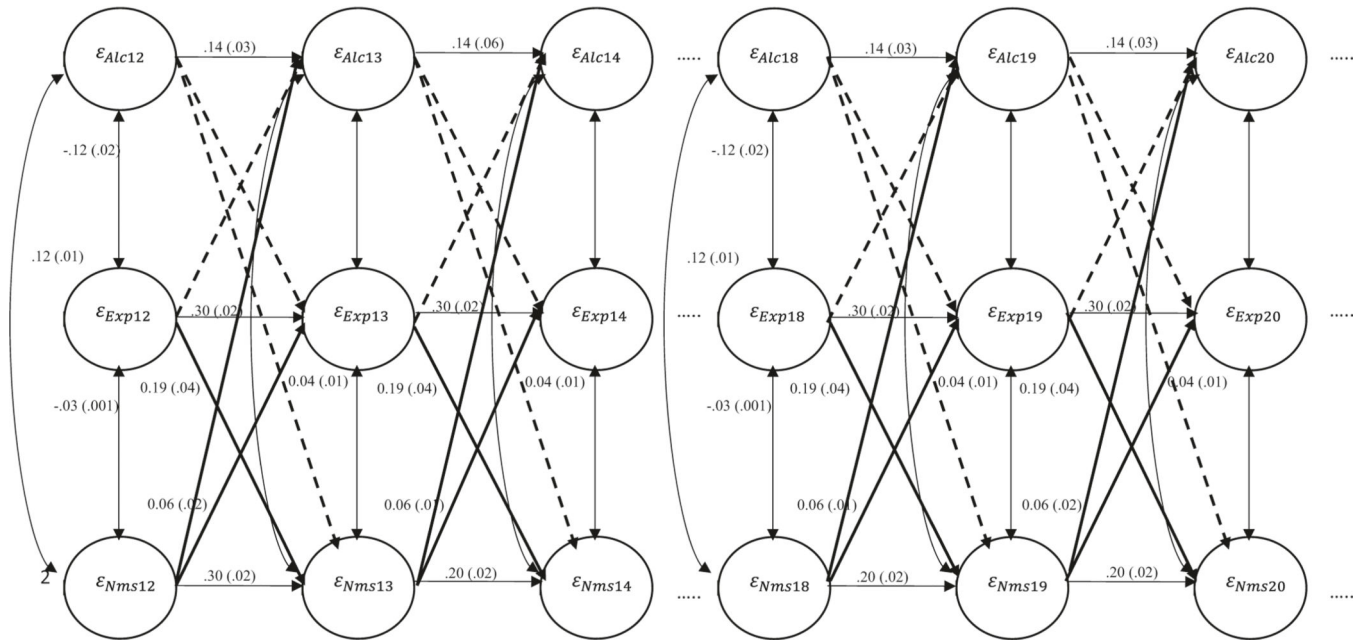
OVERALL MODEL

Fig. 2.
ALT-SR model displaying within-person cross lagged effects for our overall model (no developmental split). Significant parameter estimates (Standard Error) are only shown. Full parameter estimates can be found in Table 2. Note: Bold line indicates significant path, dashed line represents non-significant path. Alc = Frequency of alcohol use, Exp = Exposure to AOD content, Nms = Descriptive norms. Each time point represents a year lag (e.g. Alc12 to Exp13 represents alcohol use at age 12 to substance related media exposure at age 13). In this model, we constrained cross-lagged effects to be equal across both developmental periods

Fig. 3.
ALT-SR model displaying within-person cross lagged effects for our developmental model.
Significant parameter estimates (Standard Error) are only shown. Full parameter estimates
can be found in Table 2. Note: Bold line indicates significant path, dashed line represents
non-significant path. Alc = Frequency of alcohol use, Exp = Exposure to AOD content, Nms
= Descriptive norms. Each time point represents a year lag (e.g. Alc12 to Exp13 represents
alcohol use at age 12 to substance related media exposure at age 13). In this model, we
constrained cross-lagged effects to be equal across both developmental periods
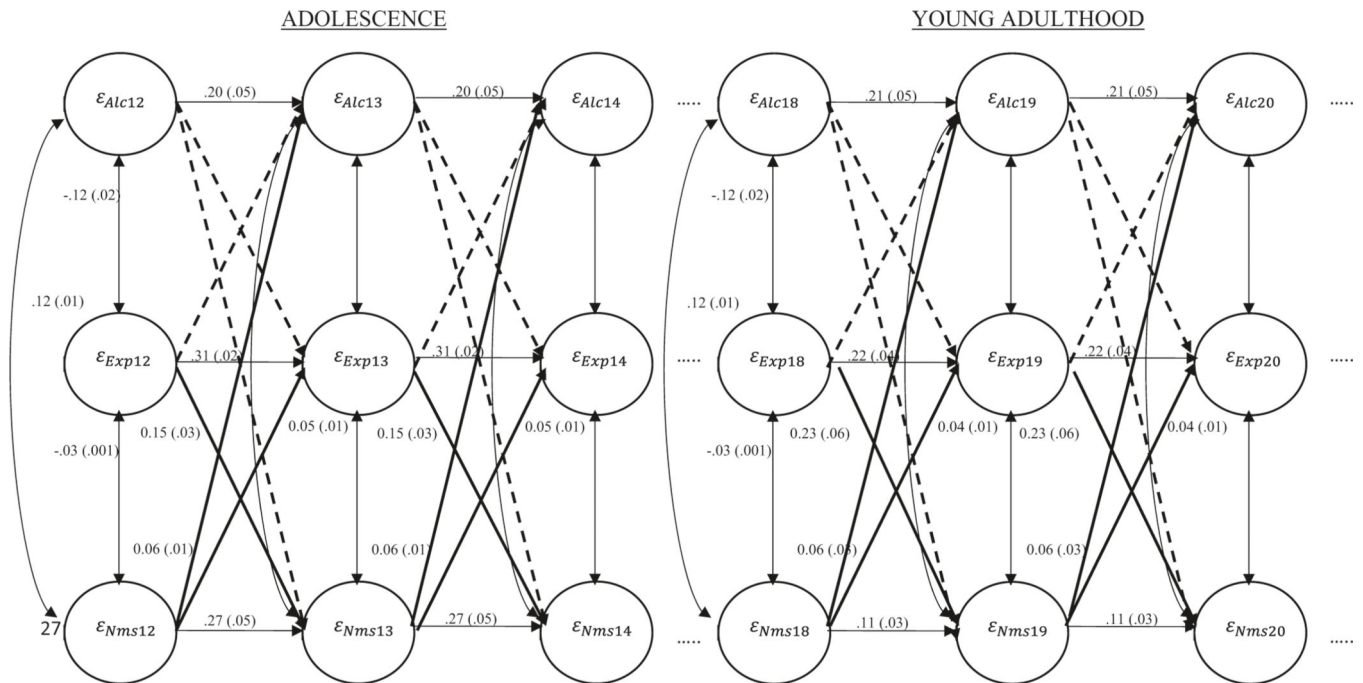
Table 1

Participant characteristics

	Total sample (N = 4840) M (SD) or n (%)
Demographics	
Age, in years	13.16 (0.73)
Female *n* (%)	2792 (50.6%)
Mother's high school education	2434 (33.0%)
Race/ethnicity n (%)	
White	887 (16.1%)
African-American	166 (3.0%)
Hispanic	2919 (52.9%)
Asian	934 (16.9%)
American Indian	45 (0.8%)
Native Hawaiian	46 (0.8%)
Multi-ethnic	524 (9.5%)
Study variables	
Alcohol use	0.31 (2.09)
Substance-related media exposure	1.91 (1.28)
Alcohol descriptive norms	2.55 (2.20)

Table 2

Final ALT-SR model estimates for associations between alcohol use, descriptive alcohol norms, and substance-related media exposure: Overall and developmental models

	Overall model	Developmental model	
		Adolescence	Young adulthood
Within-person cross-lags			
Alc Use$_{t+1}$ on Alc Nrm$_t$	0.06 (0.02) *	0.06 (0.01) *	0.06 (0.03) *
Alc Nrm$_{t+1}$ on Alc Use$_t$	−0.01 (0.02)	−0.01 (0.02)	−0.01 (0.02)
Alc Use$_{t+1}$ on Media Exp$_t$	−0.01 (0.03)	−0.03 (0.04)	−0.03 (0.04)
Media Exp$_{t+1}$ on Alc Use$_t$	−0.004 (0.01)	−0.01 (0.01)	0.001 (0.01)
Media Exp$_{t+1}$ on Alc Nrm$_t$	0.04 (0.01) *	0.05 (0.01) *	0.04 (0.01) *
Alc Nrm$_{t+1}$ on Media Exp$_t$	0.19 (0.04) *	0.15 (0.03) *	0.23 (0.06) *
Auto-regressive			
Alc Nrm$_{t+1}$ on Alc Nrm$_t$	0.20 (0.02) *	0.27 (0.02) *	0.11 (0.03) *
Media Exp$_{t+1}$ on Media Exp$_t$	0.30 (0.02) *	0.31 (0.02) *	0.22 (0.04) *
Alc Use$_{t+1}$ on Alc Use$_t$ *(Co) variances (between-person)*	0.14 (0.04) *	0.20 (0.05) *	0.21 (0.05) *
Alc Use$_{int}$ with Media Exp$_{int}$	0.16 (0.10)	0.18 (0.09) *	
Alc Use$_{int}$ with Alc Nrm$_{int}$	0.18 (0.09) *	0.22 (0.08) *	
Media Exp$_{int}$ with Alc Nrm$_{int}$	0.26 (0.08) *	0.28 (0.08) *	
Alc Use$_{slp}$ with Media Exp$_{slp}$	0.07 (0.06)	0.18 (0.15)	
Alc Use$_{slp}$ with Alc Nrm$_{slp}$	0.31 (0.09) *	0.32 (0.12) *	
Media Exp$_{slp}$ with Alc Nrm$_{slp}$	0.08 (0.16)	0.18 (0.21)	
Alc Use$_{int}$	−0.58 (0.27) *	0.13 (0.18)	
Media Exp$_{int}$	0.63 (0.13) *	2.14 (0.20) *	
Alc Nrm$_{int}$	−0.21 (0.22)	2.14 (0.20) *	
Alc Use$_{slp}$	−0.27 (0.08) *	0.08 (0.08)	
Media Exp$_{slp}$	0.38 (0.03) *	0.29 (0.03) *	
Alc Nrm$_{slp}$	0.95 (0.06) *	0.76 (0.05) *	

	Overall model	Developmental model	
		Adolescence	Young adulthood
Residual (Co) variances			
Alc Use$_{\epsilon it12-\epsilon it22}$	7.04 (0.45) *	5.58 (0.10) *	13.9 (0.38) *
Media Use$_{\epsilon it12-\epsilon it22}$	1.64 (0.04) *	1.59 (0.03) *	1.48 (0.05) *
Alc Nrm$_{it12-et22}$	5.60 (0.11) *	5.46 (0.09) *	6.17 (0.20) *
Fit statistics			
−2LL [a]	238266.5	237262.1	
AIC [b]	238552.5	237478.1	
BIC [c]	239155.6	238178.4	
RMSEA [d]	0.03	0.03	
SRMR [e]	0.14	0.13	
CFI [f]	0.90	0.95	

Estimates for all control variables on all latent intercept, and linear growth parameters are not shown for readability. Our model building process is not shown for ease of reading. However, Model 1 included estimates for autoregressive paths only; Model 2 includes cross-lagged effects of alcohol use, substance-related media exposure, and alcohol norms to be equal across adolescence and young adulthood (overall model, above); and Model 3 includes estimated cross-lagged paths to vary across adolescence and young adulthood (developmental model, above). In the table above, subscripts identify time of measurement. For example, a single *t* indicates paths were constrained to be equal over time. Subscript *int* indicates latent intercept (mean level) to obtain between-person parameter estimates. Subscripts with an epsilon (Eit) indicate residual variance measured from Time 1 to Time 7

SE Parameter Estimate, *Alc Use* Frequency of alcohol use, *Media Exp* Substance-related media exposure, *Alc Nrm* Descriptive alcohol norms, *df* degrees of freedom

*
p < .05

[a]
Negative two log-likelihood

[b]
Akaike Information Criteria

[c]
Bayesian Information Criteria

[d]
RMSEA (Root Mean Square Error) indices below .05 are considered to be representative of good model fit

[e]
SRMR (Standardized Root Mean Square Residual) indices below .08 are considered to be representative of good model fit

[f]
CFI (Comparative Fit Index) scores above .90 are indicative of good model fit