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An examination of the prospective associations between objectively assessed exposure to alcohol-related Instagram content, alcohol-specific cognitions, and first-year college drinking

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Abstract

Previous research suggests that exposure to alcohol-related content on social media sites (SMSs) may inflate perceptions of drinking norms, thereby increasing drinking among college students and potentially undermining popular social norms-based alcohol interventions. However, prior research on exposure has used subjective measures of alcohol exposure and has focused mostly on Facebook. The current study focused on Instagram, a popular SMS among college students, and utilized objective time tracking and newsfeed sampling methods to rigorously examine the prospective relationship between exposure to alcohol-related Instagram content (ARIC), alcohol cognitions, and drinking. Participants were 309 matriculating college students (M_{age} = 18.1, SD = 0.26; 62.1% female; 46.9% White/Caucasian; 17.5% Hispanic) who had their Instagram use tracked and newsfeeds sampled via a macro several times during the transition into college (August & September), and completed a baseline survey and two follow-up surveys. A sequential mediation model examined theoretically derived pathways between objective ARIC exposure and alcohol use. Results revealed that objective ARIC exposure during the transition to college was positively associated with drinking at the end of the first year of college, and subjective frequency of ARIC exposure mediated this relationship between objective ARIC exposure and later drinking. Subjective frequency of ARIC exposure also mediated the association between objective ARIC exposure and perceptions of descriptive norms, which, in turn, predicted later drinking. These findings illustrate that greater objective ARIC exposure during the transition into college may increase risky drinking over the first year via increased subjective frequency of ARIC and elevated perceptions of drinking norms. Priority directions for future research are discussed and several

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6.Contributors

Drafts of the introduction, method, results and discussion were written Joseph LaBrie and Bradley Trager. Analyses were conducted by Sarah Boyle and Jordan Davis. Joseph LaBrie, Sarah Boyle, and Andrew Earle developed the theoretical model used in this study, oversaw data collection, and wrote the grant proposal that funded this project (PI, Joe LaBrie). The final draft of this paper was edited by Joseph LaBrie, Bradley Trager and Sarah Boyle. Revisions were completed by Joseph LaBrie, Bradley Trager, and Reed Morgan. All authors contributed to and have approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

novel ways in which social norms-based interventions for first-year students may be enhanced to better combat ARIC-related influences are introduced.

Keywords

Alcohol; Social media; Instagram; Social norms; College students; Objective methods

1. Introduction

Heavy alcohol use remains a problem on college campuses despite increased efforts to reduce high-risk drinking (National Institute on Alcohol Abuse and Alcoholism, 2007; Schulenberg et al., 2019). Consequences associated with heavy drinking during college include alcohol overdoses, blackouts, accidental injuries, poor academic performance, interpersonal violence, and even deaths (e.g., Hingson et al., 2017; White & Hingson, 2013). Perceived peer drinking norms are one of the most reliable predictors of alcohol use amongst college students (Neighbors et al., 2007; Perkins, 2007). Students tend to overestimate how much their peers drink (Borsari & Carey, 2001; Miller & Prentice, 2016; Perkins, 2003; 2007) and higher perceived norms predict heavier alcohol use (Chiauzzi et al., 2013; Haug et al., 2011; Kypri & Langley, 2003; Lewis et al., 2011; Lewis & Neighbors, 2004). Further, social media sites (SMSs), such as Instagram and Facebook, have emerged as a potential influence that may contribute to the development of higher drinking norms (Erevik et al., 2018; Miller et al., 2014; Roberson et al., 2018).

SMSs are ubiquitous in students' daily lives. These platforms allow students to be exposed to peer drinking and partying behavior (e.g., Boyle et al., 2016; Davis et al., 2019; Roberson et al., 2018; Steers et al., 2019; Yang & Zhao, 2018) beyond in-person drinking situations that are expected during college. Exposure to alcohol on SMSs, which can be defined as the frequency of seeing alcohol-related references in posts (i. e., image, text, or video) by others (e.g., Boyle et al., 2016; Geusens & Beullens, 2018; Geusens et al., 2020) has the potential to undermine popular social norms-based interventions by promoting false and risky drinking norms (Boyle, Earle, et al., 2018; Ridout et al., 2012). However, the degree to which exposure to alcohol on SMSs actually contributes to student drinking and related norms that can undermine intervention efforts is uncertain due to a lack of research on college student drinking and Instagram, a platform that students are more likely to associate with alcohol-related content (Boyle et al., 2017; Moreno et al., 2016) and report using more frequently than Facebook or Twitter (Alhabash & Ma, 2017; Villanti et al., 2017). Furthermore, non-experimental studies on exposure have relied solely on self-report (or subjective) measures of exposure (e.g., Boyle et al., 2016; Cabrera-Nguyen et al., 2016; Davis et al., 2019; Erevik et al., 2017, 2018; Nesi et al., 2017; Roberson et al., 2018; Steers et al., 2019; Westgate et al., 2014; Yang & Zhao, 2018). The current study addresses these limitations by using an objective measure of exposure to drinking-related images on Instagram to look prospectively at the impact of this exposure on perceived norms, other alcohol-related cognitions, and later drinking.

1.1. Associations between exposure to alcohol-related content and drinking norms

Over the last decade, exposure to peer drinking may have increased as a result of SMSs' integration into the everyday life of students (Perrin, 2015). SMS platforms, such as Instagram, Snapchat, and Facebook, are used regularly by 98% of college-aged adults (Villanti et al., 2017). College students often use SMSs to learn about peer norms (Kitsantas et al., 2016). Further, a substantial proportion of students report seeing alcohol-related content posted by peers (e.g., 70–97%; Brunelle & Hopley, 2017; Fournier et al., 2013; Morgan et al., 2010), potentially affecting their perceptions and behaviors. For instance, greater self-reported exposure to alcohol posts on SMSs has been linked to heavier drinking and greater norms (Boyle et al., 2016; Brunelle & Hopley, 2017; Erevik et al., 2018; Geusens et al., 2020; Miller et al., 2014; Roberson et al., 2018; Yang & Zhao, 2018). This pattern of effects is similar to those found in experimental studies (Fournier et al., 2013; Litt & Stock, 2011; Mesman et al., 2020). For example, Mesman and colleagues (2020) found that college students who were asked to find an alcohol-related Facebook post from a real-life friend reported more positive affect toward drinking and increased intentions and willingness to drink compared to students who were instructed to find a non-alcohol-related post. Experimental research has also revealed that students exposed to a fake Facebook profile with alcohol-related content reported higher drinking norms compared to a control non-alcohol profile (Fournier et al., 2013).

1.2. Social media-based alcohol influences

The Facebook Influence Model (Moreno & Whitehill, 2014) offers some explanation for SMSs' potential impact on health-related cognitions (e.g., peer drinking norms) and behaviors (e.g., alcohol use) during college. According to this model, SMSs' influence on risky behavior begins with exposure to peers' positive portrayals of risky behaviors. These portrayals are thought to generate more favorable attitudes and beliefs toward risky behaviors and influence perceptions of norms. Young persons, in turn, then engage in behaviors to conform to these perceived norms. Prior studies examining alcohol-specific cognitions as mediators of subjective exposure to alcohol-related content on Facebook or combined across SMS platforms offer some support for this model (Boyle et al., 2016; Boyle, Smith, et al., 2018; Davis et al., 2019; Nesi et al., 2017). These researchers found that greater subjective exposure to alcohol-related content was positively associated with pro-alcohol beliefs (Boyle et al., 2016), injunctive norms (perceptions of how approving peers are of drinking; Nesi et al., 2017), and descriptive norms (perceptions of how much peers drink; Davis et al., 2019). Higher scores on these cognitive variables were associated with heavier drinking.

1.3. Methodological limitations with previous SMS and alcohol research

Taken together, the research described offers initial support for the notion that exposure to alcohol-related content on SMSs may be directly and indirectly associated with risky drinking in college students. However, the extent to which we can attribute alcohol use to exposure to alcohol-related content is limited because much of our understanding on this topic is based on subjective measures of exposure (e.g., Beullens & Vandenbosch, 2016; Boyle et al., 2016; Davis et al., 2019; Erevik et al., 2017). Further, previous research on

alcohol exposure on social media has focused on Facebook (Beullens & Vandenbosch, 2016; Miller et al., 2014), which, among college students, is more popular than Twitter, but less popular than the mainstream image-based platforms Instagram and Snapchat (Alhabash & Ma, 2017; Boyle et al., 2017). To address these limitations and extend the literature on this topic, this study prospectively examined *objectively* assessed alcohol exposure on Instagram during the transition into college to determine if and how it predicts later drinking among first-year students.

1.4. Current study

The current study used a longitudinal design to examine the direct and indirect associations between objective exposure to alcohol-related Instagram content (ARIC) during the transition into college and first-year students' alcohol use. This period was selected due to the confluence of factors during the transition to college that may increase susceptibility to peer influence (e.g., identity formation; using SMSs to gather information about peers; Arnett, 2000; Kitsantas et al., 2016) and exposure to alcohol-related content (e.g., Boyle et al., 2016; Steers et al., 2019). The National Institute on Alcohol Abuse and Alcoholism (2020) also defines the first six weeks of college as a critical high-risk period both for problematic drinking and initiating risky patterns of drinking. As depicted in the conceptual model (see Fig. 1), objective exposure to ARIC was measured during the transition into college via systematic sampling of the participants' newsfeeds and tracking their time spent on the platform (T1). Participants were also asked to complete a baseline survey (T0) prior to the objective exposure sampling period, and two follow-up surveys: one month after entering college (T2) and near the end of the first year of college (T3). Mediators were assessed at T2 and included subjective frequency of exposure to ARIC over the previous two months (reflecting the objective assessment period) and alcohol-related cognitions (descriptive and injunctive norms, positive alcohol expectancies, and pro-alcohol beliefs). Alcohol use was assessed at T0 (covariate) and T3 (outcome). Examination of the pathways in the model and use of an objective measure of exposure to ARIC provides the most comprehensive and rigorous test of these effects to date (see Fig. 1).

1.5. Hypotheses

1. Objectively assessed exposure to ARIC during the transition into college (T1) will be positively associated with later drinking near the end of the first year in college (T3).
2. Greater objectively measured ARIC exposure (T1) will predict greater subjective frequency of ARIC exposure (T2), which, in turn, will predict heavier alcohol use (T3).
3. Greater objective exposure (T1) will predict greater subjective frequency of ARIC exposure (T2), which, in turn, will predict higher scores on alcohol-specific cognitions (descriptive and injunctive norms, positive alcohol expectancies, and pro-alcohol beliefs; all at T2); and higher scores on the alcohol-specific cognitions (T2) will then predict heavier drinking (T3).

2. Material and methods

2.1. Recruitment and procedures

Incoming first-year students at a private mid-sized university on the West Coast were invited in July 2017 (T0) to participate in a larger study on SMS experiences. This parent study, including all aspects reported on in this manuscript, was approved by the university IRB. Email invitations were sent from the university's registrar office and included the following information about the larger study: study description, eligibility criteria (i.e., 18–20 years of age, planned to live on campus during their first year, owned an iPhone or Android smartphone, and had at least one active social media account), compensation structure, and a link to the consent form and screening survey. The consent, which was given prior to completing the screening survey, included all relevant details about this study: number of surveys and study timeline (see Fig. 1); the requirement to provide login information for Instagram (baseline survey; T0); when, why, and how their Instagram login information would be used in the study; and the requirement to download and install the application RescueTime onto their compatible devices (Android smartphones, all tablets and computers) at baseline (T0) to record time spent on SMSs during the newsfeed sampling period in August & September 2017 (T1).

There were 658 students who consented and completed the screening survey, of which 457 met eligibility criteria for the larger study and were automatically emailed a link to the baseline survey. This email also included a message indicating that there was a limited number of study spots ($N = 320$), and inclusion in the larger study was dependent on them completing the survey. Capping the number of study spots at 320 was based on results from our power analysis and budget. All 320 study spots were filled within a week of sending the initial invites.

There were 309 participants from the larger study sample who also reported having an Instagram account, provided valid Instagram credentials in the baseline survey, and downloaded and installed RescueTime on all of their compatible devices (Android smartphones, all tablets and computers). These participants also had their newsfeeds sampled in August (pre-matriculation) and September (post-matriculation) 2017 (T1) using a macro (see Section 2.3.1). Each sampling period occurred either during the week (Monday-Thursday) or weekend (Friday-Sunday); a total of eight weekday and eight weekend samples were collected per participant, split evenly between the August and September collection periods. During this same period, RescueTime was used to track time spent on Instagram on devices that it had been installed. Because RescueTime was only compatible with Android smartphones and all tablets and computers, participants with iPhones were sent four email surveys, twice during each sampling period, to report the number of hours spent on Instagram over the past week (100% completion rate). Links to follow-up surveys were then sent to participants in October 2017 (T2) and March/April 2018 (T3). Participants could have received a total of $100 worth of gift cards if they completed all three surveys ($20 gift card per survey) and participated in the newsfeed sampling period ($40 gift card following this period).

2.2. Participants

There were 309 participants in the study who indicated having Instagram accounts, all of whom submitted valid Instagram credentials at T0 (62.1% female; M_{age} = 18.1, SD = 0.26). The racial and ethnic composition of this group was 46.9% White/Caucasian, 15.5% Asian, 10.0% Black/African American, 9.7% multi-racial or other, and 17.5% Hispanic (0.3% missing). Of these 309 participants, 294 (95.1%) completed all three assessments and had their Instagram newsfeeds sampled. Participants who missed one or more follow-ups did not significantly differ on any study variables from participants who completed both follow-ups and were excluded from the analyses.

2.3. Measures

2.3.1. Objectively assessed exposure to alcohol-related Instagram content (ARIC)—Because exposure to ARIC depends on both the presence of the content and having the opportunity to be exposed, the *objectively assessed* measure of this construct was created by calculating the product of the (a) *proportion of ARIC in newsfeed*, and (b) *quintile of daily minutes on Instagram*. To get the proportion of ARIC in newsfeeds, a Python macro logged into participants' Instagram accounts one by one and captured a series of 600x9000 pixel (px) PNG screenshots of posts in their newsfeed. The 600x9000px images captured, on average, ten individual posts. After capturing and saving an image, the macro scrolled down 9000px and captured another screenshot. This process was repeated until each participant had a total of ten PNGs per sampling period (approximately 100 posts per participant, per sample). Following the initial sampling procedure, a second script, written in the open-source GNU Image Manipulation Program (GIMP) platform, cropped the larger 600x9000px PNGs into individual posts and censored Instagram usernames, locations, and faces (when applicable). This procedure produced 89,917 codable posts (August: 47,335; September: 42,582). Two trained research assistants coded each image for the presence or absence of alcohol (1 = contains alcohol, 0 = no alcohol present). Coders were instructed to label images as containing alcohol if they included any of the following: beer, wine, or liquor bottles, alcohol-related containers such as beer mugs, wine or shot glasses, and Solo cups, and any objects that clearly displayed an alcohol brand. Because alcohol-related containers (e.g., Solo cups) do not always contain alcohol, coders were instructed to judge the contents of those containers based on the context (e.g., Solo cups in image were set up to play beer pong; Solo cups were being held by people who appear to be at a house party). Inter-rater reliability (Kappa > 0.92) indicated near-perfect agreement between coders with all discrepancies easily resolved after secondary review and discussion. A total of 1,421 (1.58%) images depicted alcohol. The *proportion of alcohol-related content in the newsfeed* was then calculated for each participant (total number of alcohol-related posts in newsfeed divided by total number of posts sampled in newsfeed). Proportions of alcohol-related posts ranged from 0.00 to 0.09 (M = 0.014; SD = 0.01).

Next, participants' average daily minutes of Instagram use logged on each of their devices were summed to derive average minutes per day spent using Instagram during the newsfeed sampling period (RescueTime was used to log daily minutes on Android smartphones and all tablets and computers, and the built-in Screen Time feature was used to do the same on iPhones). For RescueTime-compatible devices, the research team was automatically sent

reports on participants' Instagram usage. Participants with iPhones were instructed to submit their time spent over the past two weeks by checking their usage using the Screen Time feature, taking screenshots of the information, and uploading those screenshots into an online survey four times over the newsfeed sampling period. Average daily minutes of Instagram use ranged from 0 to 184 min (M = 34.63; SD = 30.80). Due to the large degree of variability and skewness in daily Instagram minutes, participants' minutes were recoded into 5 groups using quintiles as cut points: (1) ≤ 20th percentile (≤10.0 min); (2) 21st-40th percentile (10.1 to 21.0 min); (3) 41st-60th percentile (21.1 to 35.1 min); (4) 61st-80th percentile (35.2 to 53.2 min); and (5) 81st-100th percentile (53.3 to 184.0 min).

The proportions of alcohol-related content sampled from participants' newsfeeds were multiplied by quintile of Instagram minutes to create the objectively measured ARIC exposure variable. This variable reflects the likelihood of the participant being on Instagram to view these particular posts and is similar to a procedure used to calculate subjective exposure by Boyle and colleagues (2016). For instance, a participant who had a proportion of ARIC in their newsfeed equal to 0.02 and who was spending less than 5 min per day on Instagram (≤20th percentile = 1) during the sampling period would have a score of 0.02 for the objectively assessed ARIC exposure variable (0.02*1). In contrast, a participant with the same proportion of ARIC in their newsfeed (0.02) who was spending 55 min per day on Instagram (81st to 100th percentile = 5) would score 0.10 on the objectively assessed ARIC exposure variable (0.02*5).

2.3.2. Subjective frequency of exposure to alcohol-related Instagram content (ARIC) (Mediator)—Participants were asked at T2 to report how frequently in the past two months they saw posts from others that depicted or referenced alcohol, getting drunk, or being hungover on their Instagram newsfeeds (Boyle et al., 2016). Response options ranged from 1 (Never) to 5 (Always).

2.3.3. Cognitive variables (Mediators)—Four distinct and well-established measures of alcohol-specific cognitions were assessed at T2: (a) *descriptive drinking norms* (Drinking Norms Rating Form; Baer et al., 1991), (b) *injunctive drinking norms* (Boyle, Smith, et al., 2018), (c) *positive alcohol expectancies* (Fromme et al., 1993), and (d) *pro-alcohol beliefs* (College Life Alcohol Salience Scale; Osberg et al., 2010). Table 1 includes descriptive statistics for all four measures.

2.3.4. Alcohol use—Participants completed the Daily Drinking Questionnaire (DDQ; Collins et al., 1985) to assess typical weekly drinking during the past month at T0 and T3. Participants were asked to think about a typical week during the last 30 days and estimate the number of drinks they consumed on each day. Number of drinks reported on each day were summed to create a composite variable for weekly drinking at T0 (covariate) and T3 (outcome).

2.3.5. Subjective frequency of posting of alcohol content on SMSs (Covariate)—Participants reported *how often they posted content related to alcohol, getting drunk, and being hungover* across all SMS accounts at T0. Response options ranged from 1 (Never) to 5 (Always).

2.4. Analytic plan

First, correlations were computed between study variables to verify expected associations and direction of effects. The SPSS macro PROCESS (Hayes, 2018) was used to conduct sequential mediation analysis. As illustrated in the conceptual model (see Fig. 1), the sequential mediation model was conducted to test the following pattern of effects simultaneously: (a) subjective frequency of ARIC exposure (T2) as a mediator of the effects of objectively assessed exposure (T1) on descriptive and injunctive drinking norms, positive alcohol expectancies, and pro-alcohol beliefs (T2); and (b) alcohol-specific cognitions (T2) as a mediator of the effects of subjective frequency of exposure (T2) on alcohol use (T3). Baseline covariates included in the sequential model were alcohol use, self-reported posting of alcohol-related content, students' sex (female = 1), and age (all were assessed in T0).

Bootstrapping ($N = 5{,}000$) was conducted to generate 95% bias-corrected confidence intervals (CIs) for the indirect effects (Hayes, 2018). Thus, CIs that did not contain zero were significant at $p < .05$. Huber-White sandwich estimator, a robust estimator that adjusts standard errors in longitudinal data, was used to account for hetero-scedasticity (Huber, 1967; White, 1980).

3. Results

3.1. Correlations between variables included in sequential mediation model

All correlations were in the anticipated directions (see Table 1). There were significant positive correlations between objectively assessed ARIC exposure at T1 and drinking at T0 ($r = 0.26$) and T3 ($r = 0.19$). It is also worth noting the non-significant correlation between objectively measured ARIC exposure (T1) and injunctive drinking norms (T2).

3.2. Sequential mediation models

Results from the sequential model revealed that T2 subjective frequency of seeing ARIC significantly mediated the relationship between T1 objectively assessed exposure to ARIC and T3 drinking (indirect effect = 4.94, 95% CI[1.00, 11.12]), even when controlling for T0 drinking and participant subjective frequency of posting alcohol-related content. Objectively measured ARIC exposure was also indirectly related to students' drinking at T3 via two conjoining mediators: subjective frequency of exposure to ARIC mediated the effects of the objective measure on descriptive drinking norms, and descriptive norms mediated the effects of subjective exposure on drinking (indirect effect = 1.23, 95% CI[0.21, 3.31]). These pathways are illustrated in Fig. 2. All remaining effects associated with this model are located in Table 2.

4. Discussion

This is the first published study to prospectively investigate the direct and indirect effects of objectively measured exposure to ARIC during the transition into college on drinking throughout the first year of college. Results suggest that ARIC exposure during this period was correlated with later alcohol use (Hypothesis 1) and it was also associated with greater subjective frequency of exposure to ARIC, which, in turn, predicted heavier drinking

(Hypothesis 2). Moreover, reporting seeing ARIC more frequently was associated with perceiving peers as heavier drinkers, which, in turn, predicted heavier alcohol use (Hypothesis 3). These results offer initial support for the notion that exposure to ARIC on incoming students' newsfeeds was associated with increased alcohol consumption during the first year in college by making drinking more salient and normative. Additionally, the associations between subjective ARIC frequency, descriptive drinking norms, and alcohol use are consistent with prior research on subjective exposure to alcohol-related content on SMSs (e.g., Boyle et al., 2016; Davis et al., 2019) and models of SMS influence (e.g., Moreno & Whitehill, 2014). Findings also extend the previous work by providing evidence to support the use of objectively assessed ARIC exposure in order to better understand the development of cognitive predictors of alcohol use during college (e.g., subjective frequency of ARIC exposure; descriptive drinking norms, etc.).

An alternative explanation for the association between ARIC exposure during the transition and heavy drinking is that heavier drinking students may have friends who post more alcohol-related content. Given that there is a correlation between drinking identity and alcohol-related SMS posting (Rodriguez et al., 2016), tendencies for homophily in social networks (McPherson et al., 2001), and that individuals post risk behaviors that occur offline online (Baumgartner et al., 2012), heavier drinkers during the transition into college may have more peers who post alcohol-related content and/or peers who post more alcohol-related content than light or non-drinking students. If this were the case, it is plausible that the association between ARIC exposure and drinking may be an artifact of being a heavier drinker. However, the notion that friend selection effects played a role in this study seems unlikely given that students' own alcohol posting behavior and drinking pre-matriculation were controlled for in the mediation model. Future studies, however, should examine this type of selection effect, as there is some evidence from outside of the SMS literature that suggests that the effects of friend selection on drinking matter more with new friends than existing ones (Cheadle et al., 2015). Therefore, it is plausible that exposure to ARIC posts by new friends may be more impactful than ones by existing friends.

Findings from this study provide insight into the pervasiveness of exposure to alcohol-related content on Instagram relative to its perceived frequency. Prior to this study, the prevalence of exposure to alcohol-related content on SMSs was exclusively assessed with subjective measures (e.g., Boyle et al., 2016; Miller et al., 2014; Roberson et al., 2018; Steers et al., 2019; Westgate et al., 2014; Yang & Zhao, 2018), which may produce biased estimates (e.g., people often overestimate time spent on Facebook; Junco, 2013). Findings from these studies suggest that subjective exposure to any alcohol content on SMSs is upwards of 70% (e.g., Brunelle & Hopley, 2017; Fournier et al., 2013; Morgan et al., 2010). Examination of the current results reveals that the average proportion of ARIC sampled from newsfeeds appears small relative to the typical student's subjective frequency of ARIC. In fact, the correlation between the objective measure at T1 and the subjective measure at T2 that retrospectively looked back at the time of the objective assessment was only 0.23. The observed inconsistencies between the objective and subjective measures are consistent with Social Norms Approach's (SNA) formulation for the development of perceived norms. Specifically, the SNA posits that over-estimations of how much and how often peers drink are most likely to result from directly observing a minority of the peer group publicly

engaging in alcohol use. This is due to observations of peer drinking being remembered to a greater degree than behaviors that may be more common in the group but are less memorable (Berkowitz, 2004; Miller & Prentice, 2016). In the current study, it is plausible that peers' alcohol-related posts on Instagram, even when encountered infrequently, may "stand out" or stick in memory more than common, mundane types of posts, and thereby inflate perceptions of peer drinking norms. However, future studies are required to verify this given that we could not determine who the participants' peers were in their newsfeeds from the data that was collected.

4.1. Implications

The finding that alcohol exposure on Instagram is associated with increases in heavy drinking across the first year of college is important as problematic drinking patterns established during this period often perdure throughout college (Arria et al., 2016; Fromme et al., 2010). Students may be particularly influenced by alcohol and other similar content on Instagram during the transition into college because they are likely to use social media to understand the norms of their new social setting in college (Kitsantas et al., 2016). Importantly, the glamorization of drinking and normalization of alcohol use on popular SMSs such as Instagram potentially undermine popular personalized normative feedback (PNF) interventions and social norms marketing campaigns employed on college campuses to reduce student drinking risk. The current findings suggest that the peer drinking norms corrected in these interventions may be inflated/reinflated as a function of ARIC and encourage the development of novel strategies to address this issue. Suggestive of one potential avenue, pilot studies have revealed that the integration of social media-inspired copresence features (avatars and personal profiles) into PNF interventions may bolster norms correction among heavy drinking college students (LaBrie et al., 2019) and combat SMS-based alcohol influence (Boyle et al., 2021). In contrast to traditional PNF interventions that derive actual norms from existing university-specific or national datasets, these novel interventions are packaged as social media-inspired games with participating students digitally represented by avatars and personal profiles. Participants then browse the profiles of peers to inform their social perceptions, submit guesses about the average alcohol use and other behaviors of these "typical students", and report on their own corresponding behaviors. Actual norms for alcohol use and other behaviors presented in PNF are then transparently derived in real-time from the answers of visible classmates. Pilot findings suggest that such social media-inspired PNF formats reduce alcohol use more effectively in the short-term than traditional PNF among heavy drinkers self-reporting greater exposure to alcohol-related content across SMSs (Boyle et al., 2021). Thus, findings from this study specifically encourage longer-term trials that examine both objective and subjective ARIC exposure as potential moderators of social media-inspired PNF intervention efficacy among first-year students.

The current findings also speak to the potential value of creative campus-based efforts that aim to lessen the proportion of student newsfeed content that contains alcohol. For instance, today most universities maintain Instagram accounts to announce campus events and programs that may be of interest to students. Such accounts could sponsor campus-based photo challenges on Instagram during the initial month of the school year, inviting students

to compete for prizes by posting photos in response to substance-free weekly themes. Theoretically, at least, the influx of non-alcohol-related posts by followed classmates in response to such a challenge should work to drown out alcohol-related posts, thereby decreasing subjective ARIC frequency, perceptions of peer drinking norms, and subsequent alcohol use. Future research may want to evaluate this type of social media photo challenge on the risk variables above.

4.2. Strengths, limitations, and future directions

Strengths of the current study include the longitudinal design, use of an objective measure of exposure, and focus on Instagram, all of which address limitations of previous SMS research. Yet, this study has its own limitations. The current sample was made up of first-year students attending a mid-sized private university who lived on campus. Future studies are therefore needed to determine if the current findings generalize to first-year students at different types of institutions (e.g., larger public universities) and who reside in environments associated with less risky drinking than on-campus housing (e.g., at home or with parents; Simons-Morton et al., 2016; White et al., 2006). A second possible limitation of this study was that students concerned with their privacy on Instagram were less likely to participate. Although this is a reasonable assumption, findings that replicate well-established associations between subjective exposure, descriptive drinking norms, and alcohol use (e.g., Boyle et al., 2016; Davis et al., 2019; Erevik et al., 2018) cast doubt on privacy concerns as a source of major bias in this study. Further, the ability to replicate previous findings related to these constructs also provides some confidence that limitations inherent with self-report measures, such as recall bias, were not of concern; however, future studies should attempt to use more objective measures in an effort to determine the value of self-report measures in the context of this research. A third limitation of this study is that we do not know who posted in the participants' newsfeeds since the posts were anonymized. Newsfeeds can include more than peers and can also include influencers or celebrities that participants followed. Future studies should take this into consideration as different posters may exert different levels of influence.

Finally, focusing only on exposure to alcohol content on Instagram is a limitation given that college-aged individuals typically use more than one SMS (Perrin & Anderson, 2019; Villanti et al., 2017), and exposure to alcohol content is reported on other platforms, such as Twitter (Cabrera-Nguyen et al., 2016), Facebook (e.g., Beullens & Vandenbosch, 2016; Miller et al., 2014), Snapchat (Boyle et al., 2017), as well as newer platforms like TikTok. However, Instagram is used more widely and frequently by college students than the two other most commonly used SMSs that include newsfeeds, Facebook and Twitter (Alhabash & Ma, 2017), and exposure to alcohol use is reported to be more common on Instagram than both of the aforementioned platforms (Boyle et al., 2017; Moreno et al., 2016). Nonetheless, future studies should consider investigating the effects of objective exposure to alcohol-related content on college student drinking across multiple platforms simultaneously to provide a more comprehensive understanding of the effects of alcohol-related exposure on SMSs. Furthermore, future research should seek to develop more sophisticated objective methods to capture video and/or ephemeral content (e.g., Instagram stories; Snaps on Snapchat, TikTok videos), which have become common features on popular SMS platforms.

Snaps and stories, which disappear either after being viewed or after a certain amount of time, may contain more risky images because of their ephemeral nature and, thus, creative ways to research them need to emerge.

4.3. Conclusion

Findings from this study affirm that objectively measured alcohol-related content on Instagram is related to later drinking during the first year in college and that this relationship is mediated by subjective frequency of alcohol content on Instagram and descriptive drinking norms. These findings extend support for SMSs' potential influences on alcohol risk in young adults by focusing on Instagram, objectively measuring alcohol content in Instagram newsfeeds, and prospective sequential mediation analyses. Furthermore, they offer additional support to the notion that exposure to ARIC has the potential to undermine normative feedback interventions by creating a stream of inconsistent feedback. Recommendations provided here to reduce this risk include incorporating popular aspects of SMSs like virtual copresence and profiles into normative feedback interventions on college campuses and developing campus-wide SMS photo challenges, which may reduce the unique influence of Instagram on subsequent drinking and improve these prevention efforts.

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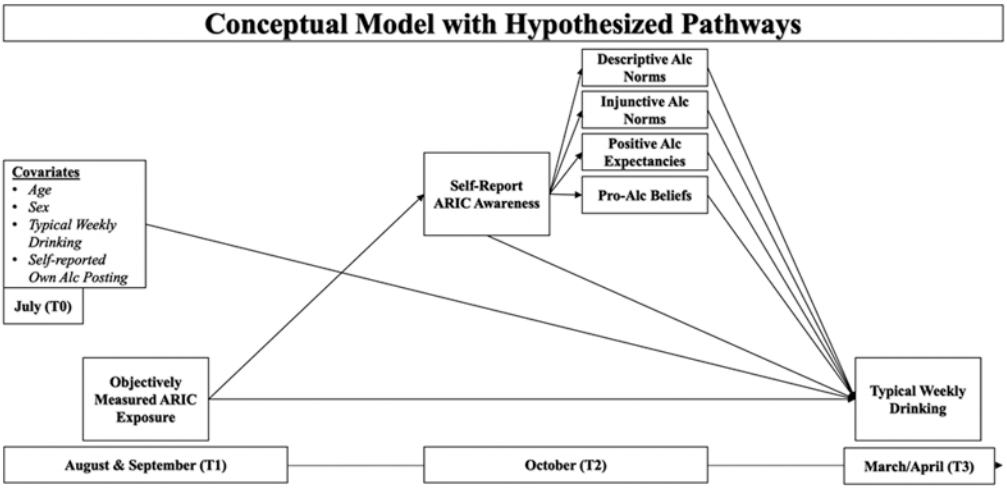

Figure 1.

Illustrated here are the hypothesized pathways in the sequential model. Not shown but included in the model are direct pathways between objective ARIC exposure and cognitive variables, and direct pathways between covariates and all mediators.

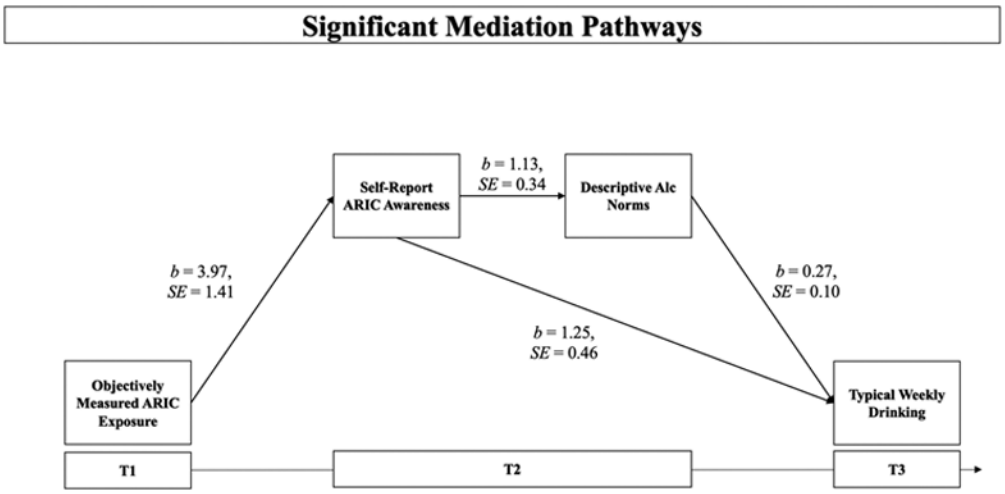

Figure 2.

Significant ($p < .05$) pathways reflecting mediation in the sequential model are illustrated; unstandardized beta coefficient = *b*, standard error = *SE*.

Table 1.

Descriptive statistics & correlations among study variables

		1	2	3	4	5	6	7	8	9	*M*	*SD*	*a*
1.	**Objectively Measured ARIC Exposure (T1)**	---									0.05	0.05	-
2.	**Subjective Frequency of ARIC Exposure (T2)**	**.23**	---								2.86	1.15	-
3.	**Subjective Own Alc Posting (T0)**	**.25**	**.21**	---							1.42	0.82	-
4.	**Descriptive Drinking Norms (T2)**	**.12**	**.24**	**.18**	---						11.60	6.01	-
5.	**Injunctive Drinking Norms (T2)**	.11	**.22**	**.13**	**.25**	---					4.57	1.07	0.88
6.	**Positive Alc Expectancies (T2)**	**.13**	**.21**	**.17**	.04	**.17**	---				54.74	11.38	0.93
7.	**Pro-Alc Beliefs (T2)**	**.21**	**.25**	**.35**	**.27**	**.23**	**.41**	---			2.47	0.63	0.84
8.	**Weekly Drinks (T0)**	**.26**	**.23**	**.44**	**.14**	**.15**	**.22**	**.31**	---		2.99	4.95	-
9.	**Weekly Drinks (T3)**	**.19**	**.30**	**.28**	**.30**	.09	**.24**	**.32**	**.37**	---	8.81	9.11	-

Note: Bold indicates $p < 0.05$

Table 2.

Sequential mediation effects

	b	*SE*	Bootstrapped 95% CI	
			LL	UL
Obj. ARIC T1 → Subj. ARIC T2 → Desc. Norms T2 → Drinking T3	1.23*	0.80	0.21	3.31
Obj. ARIC T1 → Subj. ARIC T2 → Inj. Norms T2 → Drinking T3	−0.32	0.44	−1.38	0.31
Obj. ARIC T1 → Subj. ARIC T2 → Pos. Expectancies T2 → Drinking T3	0.45	0.41	−0.009	1.53
Obj. ARIC T1 → Subj. ARIC T2 → Pro-alc. Beliefs T2 → Drinking T3	0.40	0.44	−0.29	1.46
	b (SE)	***p***	**95% CI**	
			LL	UL
Obj. ARIC T1 → Subj. ARIC T2	3.97 (1.41)*	.005	1.20	6.74
Age T0 → Subj. ARIC T2	−0.85 (0.14)*	<.001	−1.12	−0.58
Sex T0 → Subj. ARIC T2	0.25 (0.13)	.053	−0.004	0.51
Posting T0 → Subj. ARIC T2	0.15 (0.10)	.127	−0.04	0.33
Drinking T0 → Subj. ARIC T2	0.03 (0.02)*	.022	0.005	0.06
Subj. ARIC T2 → Desc. Norms T2	1.13 (0.34)*	<.001	0.47	1.80
Age T0 → Desc. Norms T2	0.36 (0.97)	.712	−1.56	2.28
Sex T0 → Desc. Norms T2	−1.81 (0.74)*	.016	−3.27	−0.34
Alc. Posting T0 → Desc. Norms T2	0.82 (0.43)	.056	−0.02	1.66
Drinking T0 → Desc. Norms T2	0.01 (0.07)	.879	−0.13	0.15
Subj. ARIC T2 → Inj. Drinking Norms T2	0.16 (0.06)*	.015	0.03	0.28
Age T0 → Inj. Norms T2	−0.01 (0.26)	.969	−0.53	0.51
Sex T0 → Inj. Norms T2	0.23 (0.13)	.088	−0.03	0.50
Alc. Posting T0 → Inj. Norms T2	0.07 (0.08)	.402	−0.09	0.23
Drinking T0 → Inj. Norms T2	0.02 (0.01)	.092	−0.003	0.04
Subj. ARIC T1 → Pos. Expectancies T2	1.32 (0.63)*	.037	0.08	2.56
Age T0 → Pos. Expectancies T2	−2.84 (2.89)	.327	−8.54	2.85
Sex T0 → Pos. Expectancies T2	0.85 (1.32)	.520	−1.74	3.44
Alc. Posting T0 → Pos. Expectancies T2	0.92 (0.79)	.240	−0.62	2.47
Drinking T0 → Pos. Expectancies T2	0.35 (0.14)*	.014	0.07	0.62
Subj. ARIC T2 → Pro-alc. Beliefs T2	0.09 (0.04)*	.016	0.02	0.16
Age T0 → Pro-alc. Beliefs T2	−0.05 (0.13)	.703	−0.32	0.21
Sex T0 → Pro-alc. Beliefs T2	−0.14 (0.07)*	.046	−0.29	−0.003
Alc. Posting T0 → Pro-alc. Beliefs T2	0.19 (0.04)*	<.001	0.10	0.27
Drinking T0 → Pro-alc. Beliefs T2	0.02 (0.01)*	.017	0.003	0.03
Obj. ARIC T1 → Drinking T3 (c')	8.33 (8.33)	.318	−8.07	24.73
Desc. Norms T2 → Drinking T3	0.27 (0.10)*	.008	0.07	0.47
Inj. Norms T2 → Drinking T3	−0.51 (0.49)	.293	−1.47	0.44
Pos. Expectancies T2 → Drinking T3	0.09 (0.04)*	.032	0.008	0.16

	b	*SE*	Bootstrapped 95% CI	
			LL	UL
Pro-alc. Beliefs T2 → Drinking T3	1.16 (0.88)	.188	−0.57	2.88
Age T0 → Drinking T3	−1.57 (1.09)	.151	−3.73	0.58
Sex T0 → Drinking T3	−2.85 (1.03) *	.006	−4.88	−0.82
Alc. Posting T0 → Drinking T3	0.81 (0.69)	.241	−0.54	2.16
Drinking T0 → Drinking T3	0.38 (0.12) *	.002	0.14	0.63

Note. Unstandardized beta = *b*; standard error = *SE*; confidence intervals (CI) that do not include zero denote significance at $p < .05$ (*). Bolded = hypothesized effects, Italicized = covariate effects. Obj. ARIC = Objectively Measured ARIC Exposure; Subj. ARIC = Subjective Frequency of ARIC Exposure; Desc. Norms = Descriptive Drinking Norms; Inj. Norms = Injunctive Drinking Norms; Pos. Expectancies = Positive Alcohol Expectancies; Pro-alc. Beliefs = Pro-alcohol Beliefs; Drinking = Typical Weekly Drinking. Effects of Objectively Measured ARIC Exposure on cognitive mediators (not displayed) were not significant ($p > .05$).