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Using ecological momentary assessment to identify common smoking situations among Korean American emerging adults

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Abstract

The present study provides detailed contextual information about smoking habits among young Korean American smokers with the goal of characterizing situations where they are most at risk for smoking. Relevant situational factors included location, social context, concurrent activities, time of day, affective states, and food and beverage consumption. Using ecological momentary assessment (EMA) over 7 days, participants (N=78) were instructed to respond to smoking prompts (n=2,614) and non-smoking prompts (n=2,136) randomly scheduled throughout the day. At each prompt, participants completed a short survey about immediate contextual factors. We used multilevel models to evaluate the association between contextual factors and smoking and further explored the distribution of smoking locations and concurrent activities across each social context and reason for smoking. Compared to non-smoking events, smoking events were associated with being outside, the presence of Korean friends, socializing, consuming alcohol, and experiencing more stress relative to one's average stress level (all p's < 0.01). Further analyses involving only smoking events showed that when participants smoked alone, they were most commonly at home (50%) and most often studying/working (28%). When smoking with Korean friends, participants were most often outside (38%) and socializing (54%). When smoking to reduce craving, participants were most often at home (39%) and studying/working (25%). To our knowledge, this is the first study to provide detailed descriptions of real-time smoking contexts among young Korean American smokers. Information with this level of granularity is needed to develop effective just-in-time adaptive interventions (JITAIs) for smoking cessation.

Keywords

ecological momentary assessment; smoking; emerging adults

Cigarette smoking among Korean Americans (KAs) is of concern because it represents a key cancer-related health disparity relative to other Asian Americans (Nguyen, Chawla, Noone, & Srinivasan, 2014). For example, available smoking prevalence estimates for KA men are

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Compliance with Ethical Standards

Ethical approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Informed consent. Informed consent was obtained from all individual participants included in the study.

as high as 36.7% relative to 14.6% for Chinese American men (An, Cochran, Mays, & McCarthy, 2008). Sociocultural factors have been highlighted in survey research on KA adults, including acculturation, gender, and social support for smoking (Hofstetter et al., 2007; Hofstetter et al., 2010). Another factor to consider is that relative to non-Hispanic Whites, KAs are more likely to be light and intermittent smokers (LITS) (Blanco et al., 2014). Because LITS are less likely to respond to smoking-related cues than heavy smokers and show symptoms of dependence (Thrul, Bühler, & Ferguson, 2014), they may require unique smoking reduction and/or cessation strategies. Thus, interventions tailored to this group may need to address antecedents of smoking that are relevant to both KAs and LITS.

KA emerging adults (KAEA, 18–25 y.o.) are at high risk for smoking initiation later in adolescence relative to their White counterparts and during their college years (Chen & Unger, 1999; Myers, Doran, Trinidad, Klonoff, & Wall, 2009). Indeed, emerging adulthood is part of a developmental period characterized by increased risk for substance abuse (Arnett, 2005). Currently available survey data on KAEA have also revealed between-person demographic and sociocultural correlates of smoking behavior, e.g. gender, perceived smoking prevalence among KA (Cerrada, Unger, & Huh, 2016), which represent unique barriers to smoking cessation for this group. However, little research exists to elucidate micro-level, dynamic processes and contexts surrounding smoking events among these individuals. Some attempts have recently been made to gather intensive, situation-specific data where presence of peers was shown to be associated with the likelihood of subsequent smoking (Huh et al., 2014). To the best of our knowledge, no other studies have unpacked this detail of contextual information about KAEA smoking habits. Investigation of when, how, and with whom KAEA smoke relative to when they do not smoke (within-subject) is needed to properly assess within-subject variation in contexts (those associated with smoking vs. not smoking). Data of this nature allows us to evaluate which factors are present immediately prior to smoking events and to develop appropriate intervention methods that maximize advantages of real-time assessments.

Ecological momentary assessment (EMA) allows for the capture of repeated, real-time information about health behaviors as they occur in naturalistic settings, thereby reducing recall bias and improving ecological validity (Shiffman, Stone, & Hufford, 2008). With regard to smoking, EMA methods can be used to investigate a variety of psychosocial and contextual variables that may lead up to or follow smoking events, such as affect, social contexts, concurrent activities, and locations. In combination, this information can provide a richer picture of smokers' inner states and environments and highlight opportunities for promoting cessation and relapse prevention. A number of studies have used EMA methodologies to explore between-and within-person contexts of smoking, including heterogeneity in smoking patterns among non-daily smokers (Shiffman, Kirchner, Ferguson, & Scharf, 2009), the influence of varying levels of nicotine dependence on contextual correlates of smoking among adolescents (Piasecki, Trela, Hedeker, & Mermelstein, 2014), immediate psychological antecedents among heavy smokers (Shiffman et al., 2002), and the role of negative affect on subsequent smoking lapse (Shiffman et al., 2007). Micro-level information of this nature is not readily captured using standard cross-sectional methods, which rely heavily on participants' ability to recall and synthesize information (e.g., "Do you smoke when you feel stressed?"). Efforts to implement EMA study designs to collect

time-intensive data continue to emerge for understudied subgroups (Otsuki, 2009), but additional research is needed to elucidate micro-level, dynamic processes and contexts related to KAEA smoking.

EMA studies using a within-subject design, where participants serve as their own "controls", enable researchers to assess relative associations between momentary contextual factors and smoking events (vs. non-smoking events). After identifying factors associated with smoking, we can also further characterize situations associated with smoking by analyzing multiple factors simultaneously, i.e. where and when they smoked, who they were with, and what they were doing. This added insight is useful in identifying certain contexts that may require specific types of interventions. For instance, smoking with friends while at a bar for socialization is likely to require a different kind of aid (e.g., cigarette refusal skills) than when an individual is tempted to have a cigarette at work by herself for stress relief (e.g., alternative stress coping strategies). Emerging mobile intervention designs are able to adapt to these individualized contexts (Nahum-Shani et al., 2014), but require empirical evidence to identify situations amenable to intervention.

Thus, the primary objective of the present study was to provide detailed descriptions of the range of contexts in which KAEA smoke: locations, presence of others, momentary affective and craving states, activities done concurrently with smoking, and temporal patterns (daytime vs. nighttime) and ultimately to provide empirically-informed insight on multiple layers of contexts that may be most relevant to building an intervention suitable for this population.

Methods

Participants

Daily KAEA smokers were recruited and included in the study based on the following criteria: 1) 18–25 years old Korean/Korean American, 2) daily smokers who smoked more than 4 cigarettes a day and did not use other nicotine products, and 3) who had been smoking for at least 2 years. A minimum of 4 cigarettes per day was chosen to ensure an equal balance between smoking and non-smoking (5 per day) prompts for data analysis. Poly-tobacco users were excluded since their smoking patterns may be different from those of cigarette-only smokers, e.g. more severe nicotine dependence, stronger association to binge drinking and marijuana use (Erickson, Lenk, & Forster, 2014). Recruitment methods included emails to KA cultural groups, word of mouth, flyers, and social media. Of the 126 individuals recruited, 15 did not meet the inclusion criteria due to age (n=5), ethnicity (n=4), location (n=2), smoking status (n=1), and device incompatibility (n=3). Additionally, 24 eligible participants lost interest before the start of the study, 8 participants dropped out mid-study, and 1 participant was excluded for failing to provide the minimum number of smoking prompts each day (~4 cigarettes/day). Two participants out of 78 showed significantly lower compliance for non-smoking prompts due to technical glitches with the app and research assistant error, but were included in the analyses given their sufficient daily reports of cigarette smoking. Thus, the effective analytic person-level sample size was 78. The excluded participants did not differ from those who completed the study protocol with

respect to age, nicotine dependence scores, preferred language, full-time employment status, or phone type (all p's >.05).

Procedure

The application (app) (mEMA, ilumivu Inc., Boston, MA) was installed on participants' own smartphones running iOS (5.1+) or Android (4.0+). Participants were excluded if they owned a smartphone not capable of running the app based on findings from our prior pilot study (Huh et al., 2014). In order to accommodate language preferences, research assistants translated and back-translated the app content from English to Korean. Data collection occurred between November 2013 and May 2014. During the 7-day observation period, participants were instructed to access the app on their device home screen and to record their smoking events (combustible cigarettes only) by clicking the "I'm about to smoke" icon, i.e., event-contingent prompts. In addition, five non-smoking (signal-contingent) prompts were scheduled in three-hour windows between 8:00 AM and 11:00 PM each day; the system generated random schedules for each participant at which non-smoking prompts were sent out.

Current models of smoking highlight the role of nicotine replacement in response to withdrawal symptoms as a primary motivation to smoke (Stolerman & Jarvis, 1995). However, emerging research suggests that certain situational antecedents to smoking differ markedly between LITS and heavy smokers. For example, smoking among LITS is associated with drinking alcohol, others smoking, socializing and relaxing, and other non-dependence motives (Piasecki, Richardson, & Smith, 2007; Thrul et al., 2014). Thus our study sought to explore situational antecedents of smoking events, e.g. location, social context, reasons for smoking, among KAEA. Each prompt alerted a participant to complete a short survey with situational context questions (100% frequency) and affect and craving scales (60% frequency). The actual delivery frequencies of affect/craving scales were inconsistent due to technical glitches. During smoking prompts only, participants were additionally asked to report their reason for smoking. At the end of each day, participants completed a survey where they reported the total number of cigarettes they smoked that day. The study procedures were approved by the Institutional Review Board at University of Southern California.

Baseline Measures

Prior to the start of the 7-day EMA protocol, participants provided basic demographic information and smoking history. Nicotine dependence was measured using the Fagerström Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) where higher scores, out of 10, indicate greater nicotine dependence.

Momentary EMA Measures

Location—Participants responded to "Where were you when the phone alerted you?" and chose from the following list of locations at the time of the prompt: home, dormitory, class, bar/restaurant, work, outside, car, or other (Cronk & Piasecki, 2010).

Concurrent activities—Participants were asked about what they were doing when they were prompted: socializing, studying/reading/working, TV/phone/hobby, exercising/walking, eating, sleeping, commuting, or other. If "other" was selected, participants were asked to specify their activity (Cronk & Piasecki, 2010).

Food and beverage consumption—Participants were asked "Have you had any of these in the past hour?" and could select up to nine boxes: alcohol, water, coffee, tea, soda, marijuana, meal/snack, other, or nothing (Cronk & Piasecki, 2010).

Social contexts—Participants reported with whom they had been with in the 15 minutes prior to the prompt. They were allowed to select all that apply from the response options: "No one, I was alone," "Korean Friend," "Non-Korean Friend," "Family," and "Other persons."

Positive and negative affect—Average scores of items adapted from the Positive Affect Negative Affect Scale (Cronk & Piasecki, 2010) were used. The 7 negative affect items were, "In the past 15 minutes, I have felt… anxious, distressed, upset, discouraged, sad, scared, irritated." (α=87). The 5 positive affect items were "happy, cheerful, enthusiastic, proud, interested" (α=.91). Responses ranged from *"Not at all"* (=1) to *"Extremely"* (=6).

Anhedonia—Average of scores from 3 items indicating the "reduced ability to experience pleasure in response to rewarding stimuli" (Leventhal et al., 2015, p. 1). Participants responded to "Indicate how much pleasure/enjoyment you would feel right now in response to…" spending time with people close to you", "personal hobbies", and "socializing" were used (α=.81). Responses range from *"No Pleasure"* (=1), to *"Extreme Pleasure"* (=5) (Leventhal et al., 2015).

Cigarette craving—Average scores of 3 items adapted from Wisconsin Smoking Withdrawal Scale were used (Cronk & Piasecki, 2010). Participants responded to "In the past 15 minutes, I had/was… "trouble getting cigarettes off my mind", "bothered by the desire to smoke, "frequent urges to smoke.") (α=86). Responses ranged from *"Not at all"* (=1) to *"Extremely"* (=6).

Perceived Stress—Average of 4 items that assessed school-, work-, interpersonal-, and financial-related stress in the past 15 minutes (Cronk & Piasecki, 2010) (α=64). Responses ranged from *"Not at all"* (=1) to *"Extremely"* (=6).

Reasons for smoking—Self-monitored reasons for smoking were derived from previous work on college-age smokers (Piasecki, et al., 2007). During smoking prompts, participants reported their reasons for smoking and could choose as many reasons as needed from the following nine choices: habit/automatic, reduce craving, break from work/studying, boredom/to kill time, cope with negative emotion, enhance positive emotion, opportunity to socialize, soon going where I cannot smoke, and other.

Temporal variables—Each prompt was time stamped and categorized by day of the week and by occurrence in four time windows: 12am −5:59am, 6am-11:59am, 12pm-5:59pm, and 6pm-11:59pm.

Data Analysis

Separate multilevel models (i.e., generalized linear mixed models) were used to assess whether each contextual factor was independently associated with smoking relative to nonsmoking (Singer & Willett, 2003). The binary dependent variable (i.e., whether a smoking or non-smoking prompt is reported) was captured repeatedly and was thus nested within individuals. Therefore, the outcome was modeled as a function of each individual contextual predictor with random intercepts to account for individual variation in baseline smoking probability (Piasecki et al., 2014). Data analysis was conducted using PROC GLIMMIX on SAS v. 9.4. Each contextual factor varied at each prompt, i.e. “prompt-level”, and was coded dichotomously as 1=the specific context, e.g. home, and 0=all other contexts. Contextual variables assessed with continuous measures (e.g., affect) were partitioned into between-subject (centered at grand mean) and within-subject (centered at person mean) variances. This approach allows us to differentiate which source of predictors’ variance (between- or within-subject variance) has effect on the outcome (Curran & Bauer 2011). To control for multiple comparisons, we conducted Holm’s step-down procedure to produce adjusted alpha values for each test (Holm, 1979). Further descriptive analyses were conducted using only the smoking prompts to better characterize smoking situations using multiple co-occurring contextual factors. In particular, frequencies for locations and activities during smoking events were examined across different social contexts (e.g., alone, Korean friend, non-Korean friend, family) and reasons for smoking (e.g., habit, craving, boredom).

Results

Person-level Characteristics

Table 1 summarizes sociodemographic characteristics for the sample. There were more male participants (n=56, 72%) and a majority of the sample was born in the US (n=49, 63%). With regard to employment, approximately one third was employed full time (n=25, 32%) while another 22% were full time students (n=17). The majority of participants used the application in English (n=62, 79%) and approximately two thirds were iPhone users (n=49, 63%, vs. Android users 37%). Furthermore, although all participants were daily smokers (at least 4 cigarettes/day), nicotine dependence scores assessed by FTND were overall low (M=2.10, SD=1.92).

Prompt-level Characteristics

There were a total of 4,750 prompts with at least one survey question answered. Seven non-smoking prompts were delivered during times where participants reported smoking as their concurrent activity and were thus re-classified as “smoking”, yielding a total of 2,614 smoking prompts and 2,136 non-smoking prompts. Daily compliance to the protocol was defined as the number of non-smoking (i.e., scheduled) surveys completed divided by 5 (i.e., maximum number of scheduled surveys per day). Each participant was paired up with a

research assistant and was encouraged to improve compliance via text messages or phone calls if rates were considerably lower than the minimum allowed (80%). Overall, participants responded to approximately 78% of the prompts (2,136 out of 2,724 prompts), with individual daily compliance ranging from 43% to 97% across participants. Once participants initiated a survey sequence, the system required completion of all items. Missingness for each predictor ranged from .4%-1% and may have been due to technological errors. Differential compliance analysis of this sample found that compliance was not associated with age, gender, nicotine dependence, language used, average number of cigarettes reported daily, or daily number of cigarettes (all *p's* >.05). However, participants were significantly less likely to respond to non-smoking prompts on weekend days relative to weekdays ($p<.001$).

Within-Subject Variations in Contexts Associated with Smoking (vs. Non-Smoking)

Table 2 presents raw frequencies and percentages of each context by prompt type and also compares relative distributions of location, social contexts, concurrent activities, and food/beverage consumption between smoking and non-smoking prompts. The *p*-values in the last column present results of multilevel models, demonstrating significant bivariate associations between a particular context with smoking (vs. non-smoking), relative to all other contexts. The contextual factors reported reflect only those that remained significant after controlling for multiple comparisons. With regard to location, participants were more likely to be outside ($p<.001$) when smoking and less likely to be at home ($p<.001$) and in class ($p<.001$). With respect to social contexts, participants were more likely to report smoking when they were with Korean friends ($p<.001$), but less likely to report smoking when they were with family ($p<.001$).

With regard to concurrent activities, participants were more likely to be socializing ($p<.001$), exercising/walking ($p=.002$), and commuting ($p=.001$) when smoking. In contrast, participants were less likely to be smoking when studying/reading/working ($p=<.001$) and sleeping ($p<.001$). Drinking alcohol ($p<.001$) was also associated with smoking. Conversely, participants were less likely to report smoking when they were consuming "nothing" ($p<.001$).

Table 3 compares self-reported momentary affect 15 minutes prior to smoking vs. not smoking. Adjusting for gender and nicotine dependence, smoking events were not associated with between-subject variation in any of the affect or craving scales (all *p's* >0.05). However, within-subject variation in perceived stress ($p=.009$) and cigarette craving ($p<.001$) was positively associated with reporting smoking events. In other words, when individuals experienced more stress or craving at a given moment compared to their average levels, they were more likely to report smoking.

Relevant Contexts When Smoking

Next, we conducted further analyses using only smoking prompts in order to gain descriptive understanding of various situations where participants were smoking. Table 4 shows temporal smoking patterns and reason for smoking for 2,614 reported smoking events. Time of day did indeed have an effect on cigarette use among KAEA smokers.

Across all participants, cigarette smoking was most frequently reported in the afternoon and evening, i.e. 12pm-5:59pm and 6pm-11:59pm, occurring at an almost identical rate (41–42%) across the two time windows. In contrast, early morning and morning cigarettes accounted for less than 18% of the total reported smoking events. Indeed, when asked about what they were doing when completing the survey, participants reported “sleeping” in only 5% of the smoking prompts. Smoking events were generally equally split across each day of the week (range=14%-15%). Further, over half of the reasons for smoking were because it was habit/automatic (54%) and over a third of participants’ smoking events were motivated by a desire to reduce craving (39%). Notably, smoking as an opportunity to socialize only accounted for less than 10% of the reasons for smoking.

The locations and concurrent activities during smoking events depending on with whom participants were are summarized in Table 5. Our results show that when KAEA smoked with Korean friends, which was the social context we identified to be positively associated with smoking (Table 2), they were most often outside (38%), at a bar/restaurant (19%), or at home (18%) and were socializing (54%). In contrast, when KAEA smoked alone, they were most commonly at home (50%) and outside (23%). With respect to concurrent activities when smoking alone, they were most often studying/working (28%) or watching TV/on the phone (24%). Smoking with non-Korean friends was the least common social context, accounting for less than 10% of participants’ prompts (Table 2). The majority of these smoking events tended to be at home (29%), outside (27%), and while participants were socializing (43%), which mirror the top locations and activities when KAEA smoked with Korean friends. When KAEA reported smoking with family members, the social context we identified to be negatively associated with smoking in Table 2, they were predominantly at home (76%) and while watching TV or using their phone (32%).

Table 6 shows the distribution of location and activity contexts across indicated reasons for smoking. As previously described, habit and craving were the two most common motivations for initiating a smoking event. The distributions of locations and activities for which habit and craving were a reason for smoking were similar. Specifically, when either habit or craving was the reason for smoking, participants were most often at home (38%-39%) or outside (24%-25%) and either socializing (19%-21%) or studying/working (20%-25%). Other common reasons for smoking included taking a break from work or studying (19%), enhancing positive emotion (13%), and relieving boredom (12%). Smoking as a break most often occurred at work (40%), whereas increasing positive affect and relieving boredom tended to occur at home (35%-39%) and outside (30%-33%). With respect to concurrent activity, participants most often smoked to increase positive emotion while socializing (34%); they most often smoked to relieve boredom when watching TV/on the phone (26%). Interestingly, the opportunity to socialize as a reason to smoke was endorsed for only one in ten of smoking events and this was most often reported at a bar/restaurant (25%).

Discussion

Previous studies on KAEA have emphasized strong influences of social and cultural contexts on cigarette smoking, including being with friends and perceived smoking norms (Huh et al.,

2014; Cerrada et al., 2016). In contrast, few studies have focused on personal and psychological factors of smoking among KA in detail (Kim, Son, & Nam, 2005). In the present study, we provide empirical evidence for how within-subject variation in contextual factors relates to smoking behavior among KAEA. Finally, by further assessing relevant contexts associated with smoking concurrently with other contextual factors, we provide a multi-layered picture of KAEA smoking habits.

In summary, our findings demonstrate that relative to their own non-smoking events (i.e., "control moments"), KAEA participants were more likely to smoke when outside, in the presence of Korean friends but in the absence of family members, and while socializing, studying/working or commuting. Smoking was also more likely to occur with the consumption of alcohol. When experiencing greater craving and stress at a given moment relative to one's average levels, KAEA were more likely to smoke. Negative and positive affect were not significantly associated with smoking events, even after parsing out within-subject effects of these predictors (Curran & Bauer, 2011). That is, experiencing more positive or negative affect relative to one's average levels was not associated with smoking.

Looking more closely at only smoking prompts (Table 4), we observed that the majority of participants' smoking events occurred either outside or at home. With regard to concurrent activities, approximately one out of four smoking events occurred while studying or working and a fifth were while participants were socializing. Results in Tables 5 and 6 show that when KAEA were smoking with Korean friends, they were usually outside, at a bar/restaurant, and socializing. Furthermore, smoking for habit/automatic and craving reasons tended to occur most when participants were smoking at home and while they were studying/working. By exploring EMA data using multiple concurrent situational factors to characterize individual smoking events, we extend the current literature on KAEA by highlighting situational variation during these events. Specifically, reason for smoking may vary across locations and social contexts previously identified from cross-sectional studies.

Finally, the distribution of smoking prompts was similar across weekends and weekdays, which may suggest that on average, the numbers of cigarettes smoked do not differ across weekdays and weekends. Alternatively, it could represent a source of EMA compliance bias. Their weekend data may be downwardly biased likely due to non-routine activities and events more frequently present during weekends, which could not be tested with the EMA protocol used for the current study.

Our findings show that KAEA smoking habits and behaviors are consistent with LITS, e.g. low levels of nicotine dependence and emphasis on social motives (Thrul et al., 2014), and align with other studies on intermittent smokers (Shiffman et al., 2002; Shiffman et al., 2009; Cronk & Piasecki, 2010). For instance, Shiffman et al. (2009) demonstrated that among intermittent, non-daily smokers, the majority of cigarettes were smoked while socializing, consuming alcohol, at home, and during transition activities, e.g. commuting. Our results also mirrored findings that on average, affective cues, i.e. positive and negative affect, were not associated with smoking (Shiffman et al., 2002; Cronk & Piasecki, 2010). One major point of departure between our findings and those of Shiffman et al. (2009) is the prevalence of dependence-related smoking cues, namely habit and craving. While these

motivations were rarely endorsed in their study population, both habit and craving were the modal motivations to smoke in our sample of KAEA daily smokers. Smoking to reduce craving, despite reporting low levels of nicotine dependence (FTND), is consistent with other research on adolescent, light smokers (Rubinstein, Benowitz, Auerback, & Moscicki, 2009). Only 18% of participants' cigarettes were smoked in the morning hours, which is consistent with lower levels of nicotine dependence; smoking cigarettes within the first 30 minutes of waking is considered an indicator of nicotine dependence (Heatherton et al., 1991). These findings highlight the variability in perceived smoking motivation across developmental stages of smoking behavior (Weinstein & Mermelstein, 2013). Smoking motivations could also be attributed to cultural influences. For instance, being with ethnically-similar friends in pro-smoking settings (e.g., bars that allow indoor cigarette use) might trigger cigarette craving for certain individuals.

Our findings have important implications for developing interventions tailored for this population. Specifically, interventions promoting smoking cessation and relapse prevention should account for two broad types of social situations: being alone (most common social context while smoking) and being around Korean friends (positive association with smoking). Furthermore, intervention strategies targeting moments where KAEA are smoking alone must be applicable to specific location and activity contexts, e.g. at home, watching TV, and working. In contrast, smoking with Korean friends may require a different set of intervention strategies that are relevant to being outside, at a bar/restaurant, and socializing with others. With respect to reasons for smoking, our findings provide insight on which kinds of relapse prevention strategies may be most effective across different location and activity contexts (cigarette substitution vs. stress management when smoking because of craving). Finally, interventions need to address habit and craving using strategies that account for a wide variety of location and activity contexts whereas strategies that target smoking as a break may only need to be tailored to work and class contexts.

Given the wide variability in locations, social contexts, concurrent activities, and smoking motivations associated with lighting up a cigarette, it is likely that KAEA require appropriately-tailored, real-time interventions that are adapted to their specific cessation needs and related contexts. The design and development of mobile health interventions, such as just-in-time adaptive interventions (JITAI), is extremely challenging (Spruijt-Metz & Nilsen, 2014) and requires thorough examination of micro-dynamic data such as the ones we demonstrate in the current study. JITAIs allow for adaptive delivery of intervention components, e.g. motivating messages or information, with consideration of moderating variables ("tailoring variables") and criteria for deciding whether and how to implement individual intervention components ("decision rules") (Nahum-Shani et al., 2014). For instance, JITAIs can adapt to an individuals' immediate context (e.g., whether KAEA is alone or with Korean friend at a given moment) by delivering specific, situation-appropriate intervention strategies.

Currently, behavioral theory and within-subject randomization methods (e.g., micro-randomized trials) are used to identify appropriate tailoring variables and decision rules for JITAI (Liao, Klasnja, Tewari, & Murphy, 2015). Although we did not randomize participants to specific contexts in the present study, since such a design would be implausible, our

within-subjects design allowed us to estimate the proximal association of various contextual factors with smoking. First, we explored contextual factors associated with smoking and then further characterized these high-risk situations using co-occurring contextual factors (e.g., social contexts and reasons for smoking). In doing so, we have delineated combinations of contexts (e.g., smoking at a bar/restaurant with Korean friends), as potential tailoring variables from which we can derive decision rules (e.g. deliver cigarette refusal skills prompt). Information of this nature is critical in the development of a JITAI for smoking cessation among KAEA.

A few aspects regarding our study findings warrant further discussion. First, because participants initiated smoking prompts themselves, the number of smoking events may be under-reported due to burden. Indeed, post hoc analysis revealed a weak correlation between the number of smoking events reported and number of self-reported cigarettes smoked during a day at the end of each day (r=0.26). This may be the case especially if participants were “chain smoking”, where cigarettes are smoked in rapid succession and we were unable to properly detect such smoking patterns. Still, a previous EMA study on this this sample population have generally shown participants to comply with study procedures (Huh et al., 2014) and the present participants logged more than the minimum of four smoking events per day required of the protocol (range=1 to12, M=4.8, SD=1.8). In fact, at least 4 smoking prompts were recorded for 78% of study days across participants (total n=426 out of 78×7=546). Second, our study represents a subpopulation of a specific ethnic and cultural group, Korean American emerging adults. Thus, our findings may not generalize to all smokers or perhaps to other Asian American groups. Furthermore, our focus on emerging adulthood excludes certain age groups, e.g. 26–35, which have been identified as peak ages for smoking prevalence among KA men (Allem et al., 2012). Finally, our results reflect antecedents of only a portion of LITS smokers, i.e. light smokers (vs. heavy), and may not represent behaviors of non-daily smokers or poly-tobacco users (Soneji, Sargent, & Tanski, 2016). Nonetheless, the current work represents highly-detailed empirical insight that will be used to build properly-tailored intervention programs for a group who may be exposed to elevated smoking-related health disparities.

Finally, our study protocols were designed to capture contextual information leading up to smoking and non-smoking events. Understanding contexts that immediately follow a smoking event may also be important for developing cessation and relapse prevention methods. Future EMA studies might consider assessing immediate effects of smoking.

Conclusion

Our study supplements existing work on cigarette smoking among KAEA by providing detailed contextual information during smoking episodes, including locations, concurrent activities, temporal patterns, food and beverage consumption, and within-subject variations of these contexts across smoking and non-smoking events. Specifically, this study allows us to identify situations where and when KAEA smoked most often, who they were with, and what they were doing. With regard to social influences on smoking, our findings have provided additional data on the social contexts associated with lighting up a cigarette, e.g., being with Korean friends as a risk factor as opposed to just “friends”. While there has

previously been strong emphasis on exploring social contexts of smoking among Korean Americans, our results contribute additional insight into KAEA's smoking behavior when they are alone and how reasons for smoking a cigarette at a given moment may differ depending on location and concurrent activities. By (1) first determining which location and activity contexts were positively associated with smoking and (2) further exploring each context with other co-occurring factors, we have identified common smoking situations among KAEA. Information with this level of granularity will help to supplement the use of behavioral theory in the development of real-time adaptive interventions (JITAI) that can account for a variety of settings and situations in which smokers may find themselves.

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Table 1

Sociodemographic Characteristics

	N	%
Sex		
Male	56	72
Female	22	28
Age (*M/SD*)	22.40	1.76
Nicotine Dependence (*M/SD*)	2.10	1.92
Current job		
Full-time student	17	22
Part-time student, part-time employed	12	15
Full-time student, part-time employed	11	14
Employed part-time	5	6
Employed full-time	25	32
Not employed, looking for work	8	10
Education		
High school or equivalent	30	38
2-year junior or community college	17	22
4-year college or university	28	36
Vocational, business, or trade school	1	1
Graduate or professional school	1	1
Other	1	1
US born		
Yes	49	63
No	29	37
EMA Language		
English	62	79
Korean	16	21
Type of smartphone		
iPhone	49	63
Android	29	37

Table 2

Relative distribution of contexts across non-smoking (n=2,136) and smoking (n=2,614) prompts

	Non-smoking		Smoking			
	N	%	N	%	OR (95% CI)	*p* value
Location						
Home	1001	45	953	35	.66 (.58, .74)	<.001 *
Dormitory	17	1	18	1	.86 (.44, 1.69)	.664
Class	83	4	48	2	.63 (.32, .66)	<.001 *
Bar/restaurant	150	7	186	7	1.01 (.81, 1.27)	.913
Work	379	18	387	15	.79 (.67, .93)	.004
Outside	259	12	665	25	2.56 (2.18, 3.00)	<.001 *
Car	153	7	237	9	1.29 (1.04, 1.60)	.018
Other location	90	4	103	4	.93 (.69, 1.24)	.619
Social contexts						
Alone	976	46	1204	46	1.04 (.925, 1.17)	.513
Korean Friends	478	22	762	29	1.46 (1.23, 1.67)	<.001 *
Non-Korean friends	193	9	217	8	.92 (.75, 1.13)	.439
Family	277	13	247	9	.70 (.58, .84)	<.001 *
Other persons	318	15	292	11	.71 (.59, .85)	<.001 *
Concurrent Activity						
Socializing	305	14	528	20	1.55 (1.32, 1.81)	<.001 *
Studying/reading/working	639	30	662	25	.79 (.70, .90)	<.001 *
TV/hobby/phone	386	18	438	17	.91 (.78, 1.06)	.231
Exercise/walking	66	3	127	5	1.60 (1.18, 2.18)	.002 *
Eating	215	10	279	11	1.07 (.89, 1.29)	.489
Sleeping	230	11	129	5	.42 (.34, .53)	<.001 *
Commuting	125	6	220	8	1.48 (1.18, 1.85)	.001 *
Other	166	8	187	7	.91 (.73, 1.13)	.384
Food and Beverage						

	Non-smoking		Smoking			
	N	%	N	%	OR (95% CI)	*p* value
Alcohol	98	5	204	8	1.76 (1.37, 2.26)	<.001 *
Water	1303	61	1611	62	1.03 (.91, 1.16)	.629
Coffee	219	10	289	11	1.09 (.91, 1.32)	.362
Tea	99	5	100	4	.82, (.62, 1.09)	.175
Soda	119	6	189	7	1.32 (1.04, 1.68)	.021
Marijuana	56	3	65	2	.95 (.66, 1.37)	.778
Meal/snack	565	26	781	30	1.19 (1.05, 1.35)	.008
Other	32	1	56	2	1.43 (.92, 2.22)	.110
Nothing	402	19	361	14	.68 (.58, .79)	<.001 *

Note:

* Significant after Holm's step-down procedure; Results remained the same after adjustment for recruitment method and are not reported.

Table 3

Between- and within-subject variation in momentary affect and craving

	Between-subject (BS)		Within-subject (WS)	
	OR (95% CI)	***p* value**	**OR (95% CI)**	***p* value**
Positive Affect	.99 (.87, 1.12)	.846	1.04 (.94, 1.15)	.483
Negative Affect	.96 (.78, 1.18)	.692	1.02 (.85, 1.22)	.853
Perceived Stress	1.03 (.91, 1.17)	.609	1.22 (1.05, 1.43)	.009 *
Cigarette Craving	.91 (.81, 1.03)	.134	1.72 (1.51, 1.97)	<.001 *
Anhedonia	1.04 (.94, 1.15)	.447	1.11 (.99, 1.24)	.067

Note: BS variable centered at grand mean (0=grand mean); WS variable centered at person-mean (0=person-mean);

* Significant after Holm's step-down procedure; All models adjust for gender and nicotine dependence; Results remained the same after adjustment for recruitment method and are not reported.

Table 4

Temporal smoking patterns and reason for smoking (n=2,614)

Time of day	**N**	**%**
Time quarter 1 (0:00–5:59)	69	3
Time quarter 2 (6:00–11:59)	399	15
Time quarter 3 (12:00–17:59)	1085	42
Time quarter 4 (18:00–22:59)	1061	41
Day of week		
Monday	380	15
Tuesday	384	15
Wednesday	384	15
Thursday	376	14
Friday	355	14
Saturday	382	15
Sunday	353	14
Reason for smoking		
Boredom/to kill time	298	11
Break from work/studying	493	19
Reduce craving	1025	39
Soon going where I cannot smoke	162	6
Habit/ automatic	1405	54
Cope with negative emotion	262	10
Enhance positive emotion	333	13
Opportunity to socialize	242	9
Other reason	42	2

Table 5

Location and Activity by Social Context (n=2,559)

	Alone N=1184 (46%)	Korean Friend N=759 (30%)	Non- Korean Friend N=216 (8%)	Family N=247 (10%)
Location				
Home	593 (50%)	135 (18%)	62 (29%)	187 (76%)
Dormitory	8 (1%)	4 (1%)	6 (3%)	0 (0%)
Class	23 (2%)	6 (1%)	2 (1%)	0 (0%)
Bar/restaurant	4 (0%)	144 (19%)	37 (17%)	11 (4%)
Work	121 (10%)	64 (8%)	30 (14%)	7 (3%)
Outside	267 (23%)	287 (38%)	58 (27%)	24 (10%)
Car	134 (11%)	64 (8%)	10 (5%)	15 (6%)
Other location	34 (3%)	55 (7%)	11 (5%)	3 (1%)
Concurrent Activity				
Socializing	27 (2%)	412 (54%)	92 (43%)	26 (11%)
Studying/reading/working	327 (28%)	100 (13%)	56 (26%)	28 (11%)
TV/hobby/phone	284 (24%)	49 (6%)	24 (11%)	80 (32%)
Exercise/walking	78 (7%)	33 (4%)	8 (4%)	6 (2%)
Eating	94 (8%)	100 (13%)	23 (11%)	61 (25%)
Sleeping	104 (9%)	9 (1%)	0 (0%)	13 (5%)
Commuting	157 (13%)	27 (4%)	7 (3%)	17 (7%)
Other	113 (10%)	29 (4%)	6 (3%)	16 (6%)

Note: Percentages reflect column percent. Row totals do not necessarily total up to 100% since participants could choose all social contexts that applied. Only prompts where location and concurrent activity were non-missing were included.

Table 6

Location and activity by reason for smoking (*n*=2,559)

	Reduce craving N=1005 (39%)	Habit/ Automatic N=1405 (55%)	Break from work/ studying N=493 (19%)	Opportunity to socialize N=242 (9%)	Enhance positive emotions N=333 (13%)	Cope with negative emotions N=262 (10%)	Soon going where I cannot smoke N=162 (6%)	Boredom/to kill time N=298 (12%)
Location								
Home	392 (39%)	534 (38%)	124 (25%)	47 (19%)	115 (35%)	88(34%)	27 (17%)	117 (39%)
Dormitory	12 (1%)	3 (0%)	2 (0%)	3 (1%)	5 (2%)	5 (2%)	1 (1%)	2 (1%)
Class	21 (2%)	19 (1%)	27 (5%)	1 (0%)	1 (0%)	2 (1%)	9 (6%)	6 (2%)
Bar/restaurant	61 (6%)	125 (9%)	12 (2%)	60 (25%)	43 (13%)	9 (3%)	5 (3%)	15 (5%)
Work	154 (15%)	178 (13%)	197 (40%)	15 (6%)	17 (5%)	58 (22%)	30 (19%)	25 (8%)
Outside	240 (24%)	355 (25%)	84 (17%)	90 (37%)	111 (33%)	61 (23%)	51 (31%)	90 (30%)
Car	105 (10%)	149 (11%)	16 (3%)	16 (7%)	31 (9%)	31 (12%)	38 (23%)	33 (11%)
Other location	20 (2%)	42 (3%)	31 (6%)	10 (4%)	10 (3%)	8 (3%)	1 (1%)	10 (3%)
Concurrent Activity								
Socializing	207 (21%)	266 (19%)	28 (6%)	175 (72%)	114 (34%)	33 (13%)	22 (14%)	63 (21%)
Studying/reading/working	249 (25%)	278 (20%)	350 (71%)	15 (6%)	43 (13%)	92 (35%)	38 (23%)	42 (14%)
TV/hobby/phone	203 (20%)	260 (19%)	26 (5%)	14 (6%)	57 (17%)	52 (20%)	17 (10%)	76 (26%)
Exercise/walking	47 (5%)	77 (5%)	16 (3%)	4 (2%)	27 (8%)	20 (8%)	12 (7%)	19 (6%)
Eating	104 (10%)	206 (15%)	25 (5%)	21 (9%)	40 (12%)	10 (4%)	14 (9%)	22 (7%)
Sleeping	53 (5%)	82 (6%)	4 (1%)	0 (0%)	14 (4%)	14 (5%)	10 (6%)	5 (2%)
Commuting	92 (9%)	145 (10%)	17 (3%)	8 (3%)	28 (8%)	25 (10%)	41 (25%)	31 (10%)
Other	50 (5%)	91 (6%)	27 (5%)	5 (2%)	10 (3%)	16 (6%)	8 (5%)	40 (13%)

Note: Percentages reflect column percent. Row totals do not necessarily total up to 100% since participants could choose all reasons for smoking that applied. Only prompts where location and concurrent activity were non-missing were included.