THESIS

TELL ME WHY: AN ECOLOGICAL MOMENTARY ASSESSMENT STUDY OF UNKNOWN SUBSTANCE USE MOTIVES

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ABSTRACT

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Theoretical models of motivations for substance use emphasize the role of contextual information (e.g., affect) when making decisions about use. These theories explicitly propose that there are moments during which individuals may make decisions about use outside of their conscious awareness. That is, decisions to use can happen quickly, without much thought (Cooper et al., 2015; McCarthy et al., 2010; Wiers et al., 2007). However, to our knowledge, no previous research has examined the frequency and phenomenology (i.e., its predictors and consequences) of this motivational state at the event level. This study sought to fill this gap in the literature by introducing an "I don't know" option to a substance use motive questionnaire (i.e., an unknown motive) assessed using ecological momentary assessment (EMA), a micro longitudinal research technique. The aims of this study included 1) characterizing the occurrences of unknown substance use motives, 2) investigating the prospective relationship between unknown substance use motives and affect, and 3) understanding the prospective association between unknown substance use motives and problems. We hypothesized that participants would endorse the unknown substance use motive and the endorsement of an unknown motive would be more likely at high and low levels of affect (both positive and negative), indicating a potential quadratic relationship. We also hypothesized that an unknown substance use motive endorsement would be associated with experiencing more problems. Results demonstrated that the probability of unknown motive endorsement varied as a function

of previous moment affect, such that lower (-1SD) and higher levels (+1SD) of negative affect were associated with an increased probability of endorsing "I don't know" compared to mean levels of negative affect. In contrast, mean levels of positive affect were associated with higher probabilities of endorsing "I don't know" compared to lower and higher levels of positive affect. No association was found between "I don't know" motive endorsement and number of problems. Results confirm a non-linear association of affect demonstrated in previous studies and suggest unique patterns of awareness for use motivation across the affective valences. Results also continue to highlight the pivotal role of affect in substance use at the moment-level. This study was innovative in both method and concept, leveraging EMA's strengths to investigate a fleeting and dynamic process that may inform future intervention efforts aimed at changing use patterns. Future research should continue to investigate this phenomenon to better understand its impact on functioning and develop prevention and intervention strategies.

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Introduction

Young adults aged 18 – 25 are the age group with the highest percentage (about 27%) of individuals meeting DSM-5 criteria for a substance use disorder (SUD; American Psychiatric Association [APA], 2022), with alcohol use disorder (AUD; 16.4%) and cannabis use disorder (CUD; 16.6%) being the most common (Center for Behavioral Health Statistics and Quality [CBHSQ], 2024). As such, gaining a clearer understanding of modifiable characteristics and contexts in which young people with SUDs are using and experiencing associated consequences is critical. One such factor with clear clinical implications is motives for substance use. Understanding why individuals with SUDs use substances can create new targets for prevention and intervention.

Motives are thought to be the most proximal mechanisms to individual decisions to use through which other factors operate and reflect the functional significance of substance use for people (Adams et al., 2012; Cooper et al., 2015; Studer et al., 2016). While several models of substance use motives have been put forth (e.g., Cox & Klinger, 1988; Koob & Le Moal, 2001; McCarthy et al., 2010) the current consensus is that motives vary along two key dimensions: valence (positive or negative) and context (internal or external; Cooper et al., 2015). The two dimensions can be crossed to yield four types of motives (and an additional fifth type for cannabis use [i.e., expansion]; Simons et al., 1998) each with differing functions and goals: 1) Coping (internal negative) suggests that substances function to deal with aversive affective states (e.g., coping with sadness), 2) Enhancement and expansion (internal positive) suggest that substances work to amplify positive affect (enhancement) or alter one's consciousness (expansion), 3) Social (external positive) suggests that substances serve a means to connect with

others in social contexts (e.g., parties), and 4) Conformity (external negative) suggests that substances function to avoid feeling left out of social situations (e.g., peer pressure).

Substantial evidence supports the existence of these theoretically predicted trait-level motives for substance use, as well as the motivational model more broadly (Cooper et al., 2015; J. Simons et al., 1998). Cooper and colleagues (2015) provide five key premises embedded within the motivational model of substance use: 1) People use substances to alter affective states, 2) People have beliefs and expectations about substance use that mold their motivational profiles, 3) People choose (both inside and outside of conscious awareness and rationality) whether and how much to use in order to attain their affectively related goals, 4) Substance use motivated by different needs or serving different functions ultimately are characterized by distinct and unique contextual factors and internal experiences, and 5) Motives are the "final common pathway" through which distal factors impact people's decisions. Importantly, these premises are ultimately linked by one's awareness of their own internal affective and cognitive landscape as they make individual decisions to use. Factors that impact decisions about use may occur outside of one's conscious awareness (e.g., McCarthy et al., 2010), and, as such, it is plausible that individuals may not be completely aware of their motives for substance use before every use event (Premise 3, Cooper et al., 2015) even though they are able to articulate their motivation for substance use in general at the trait-level. These premises also provide a justification for measurement of substance use motives at the event-level, since contextual factors are foundational to motivational model (Premise 4, Cooper et al., 2015) and motives have been shown to vary within-person across time (e.g., Votaw & Witkiewitz, 2021).

The embedded role of awareness in the above motivational model and the variability of motives for use at the event-level pose an important set of unanswered questions: 1) how often

do people not know what is motivating their substance use (referred to as unknown motives hereafter), 2) what contextual factors are associated with unknown motives, and 3) are unknown motives associated with increased consequences from use at the event-level?

Dual process theory (Wiers et al., 2007) and related empirical research (e.g., Ostafin & Palfai, 2006) support the notion that implicit information processing has an impact on explicit behavior (e.g., substance use) outside of conscious awareness. Specifically in the context of substance use motives, when the learned effects of substance use (i.e., emotional payoff of substance use) are coupled with internal affective experiences and other contextual factors (e.g., heightened negative affect), implicit, "hot" processing might give rise to substance use directed at altering one's affect without concrete understanding or awareness of exact motivation for use (McCarthy et al., 2010; Simons et al., 2015a; Wiers et al., 2007). When these theories and related evidence are taken together with premises 3 and 4 outlined by Cooper et al. (2015), they suggest the existence and occurrence of an unknown motive at the event-level, but this phenomenon has not yet been explored. This lack of empirical investigation makes sense, given most of the previous literature and foundational motivational models of substance use are centered around trait-level motivations. However, not having a clear understanding of what is motivating a person's substance use in the moment might place them at unique risk for substance-related harms. Thus, it is critical that research establish if and how often unknown motives are present at the event-level. Furthermore, it is important to have a clear understanding of the factors that are associated with greater likelihood of endorsing unknown motives in the moment and if unknown motives linked to increased problems prospectively within-person.

For evolutionary purposes, the processing of affective information often takes precedence over non-affective information (McCarthy et al., 2010; Murphy et al., 1995; Wiers et al., 2007)

and consequently mood repair is prioritized over other more adaptive long-term goals (Tice et al., 2001), resulting in behavior aimed to alter one's current affective state. Given motives represent affectively laden mechanisms by which people assign an incentive value to a substance's ability to relieve or amplify affective states (Cooper et al., 2015), both positive and negative affect may provide information about for whom and under what conditions individuals endorse an unknown motive.

Negative Affect. McCarthy et al. (2010) posit that an individual's appraisal of incentive value and reliability of using substances to relieve negative affect (NA) plays a critical role in their motivation for use. When deciding whether to use, individuals experiencing low NA will use habitually, with little awareness about their reason for use, while individuals experiencing high NA will likely use because of the learned reliability of use to relieve NA. NA has been shown to attenuate the top–down information processing and decision-making processes, resulting in impulsive actions where behavior is not based on careful consideration of the situational demands (i.e., negative urgency; Cyders & Smith, 2008). This suggests that individuals might be more likely to use at high levels of NA with little consideration for why. Meanwhile. individuals exert the most cognitive control resources at moderate levels of NA making this the level of NA where people are most likely to have a clear understanding of their motives for use. In this model, awareness is foundational in determining reasons for use, cognitive control, and subsequent behavior**.** Therefore, it is reasonable to hypothesize that individuals would be more likely to endorse unknown motives when experiencing particularly low or high NA.

Positive Affect. Positive reinforcement models of substance use (i.e., using to enjoy pleasurable effects of substances) and positive affective functioning broadly are particularly

relevant constructs among young people who use substances (Emery et al., 2023; Emery & Simons, 2020). Previous work has demonstrated an inverse association between positive affect (PA) and substance use (Emery et al., 2021, 2023) suggesting people are more likely to use when PA is low. When PA is low, individuals may not have a clear understanding of what their internal emotional experience is, as evidenced by a lower ability to label positive emotion states when PA is low (e.g., Emery et al., 2022). As such, assigning a motive for substance use may be challenging, and individuals may act without conscious thought (Shishido et al., 2013). Additionally, like NA, acting impulsively when PA is high (i.e., implicit, "hot" processing) is associated with greater substance use (Cyders et al., 2009; Cyders & Smith, 2008). Given the nature of "hot" processing, people experiencing high PA may also use substances without awareness of a discrete motive (i.e., endorsement of unknown motive). As such, enhancement motives may not be an all-encompassing substance use motive across all levels of PA (Emery et al., 2024) or varying contexts, but may mirror the cognitive control and awareness states posed by the negative reinforcement and dual processing theories mentioned above.

In both cases, if an unknown motive exists, we may find that the greatest likelihood of endorsement occurs at the extremes of the respective NA and PA continua (i.e., high and low NA or PA). That is, these associations may not be linear; instead, they may exhibit a quadratic relationship – such that the lowest likelihood of endorsing an unknown motive occurs at moderate levels of NA and PA, respectively. To our knowledge, no previous work has examined non-linear affective associations with substance use motives.

Previous findings on trait-level motives suggest that internally geared motives (i.e., coping and enhancement / expansion) for both alcohol and cannabis use are associated with more consequences from use (see Cooper et al., 2015 for a review) with some even exhibiting direct

associations with problems regardless of how often or how much a person uses. Yet, when assessed at the event-level using with ecological momentary assessment (EMA), motives do not appear to consistently predict consequences (see Votaw & Witkiewitz, 2021 for a review). However, none of these studies assessed for unknown motives. It is plausible to expect endorsing an unknown motive to be associated with more consequences given the inherent nature of acting without awareness of a clear motivation. People endorsing an unknown motive may be less prepared to protect themselves from problems due to this lowered awareness. A better understanding of prospective relationship between the fluctuations in awareness of motivation at problems at the event-level is an important gap in the literature. As such, this reflects an important direction for further investigation at more granular levels of analysis.

Overall, we sought to better understand the frequency of unknown motive endorsement, what predicts unknown motives, and how this endorsement is linked to use consequences. To our knowledge, this was the first study examining an unknown substance use motive at the event-level and is innovative in both method and theory. In summary, this study sought to: 1) characterize the frequency of unknown motive endorsement in clinical sample of young adult with AUD and/or CUD; 2) test if momentary NA and PA exhibit quadratic relationships with unknown motive endorsement, such that experiencing lower or higher levels of NA than average is associated with a greater likelihood of endorsing an unknown motive (H_1) and experiencing lower or higher levels of PA than average is associated with a greater likelihood of endorsing an unknown motive (H_2); and 3) test if endorsing unknown motives would be associated with increased problems prospectively (H_3).

The literature review below is organized into five main sections. First, it will review SUDs. Second, substance use motives are covered. Third, dual process theory is explored. Fourth,

models of positive and negative reinforcement are discussed. Finally, research on the advantages of EMA is reviewed.

Substance Use Disorders

An estimated 292 million people or 5.6% of the world's population aged 15 to 64 endorsed using at least one substance in 2022 (United Nations: Office on Drugs and Crime [UNODC], 2024). As many as 64% of Americans use at least one substance (Bailey & McHugh, 2023), and about 10% of Americans meet DSM-5 criteria for a substance use disorder (SUD; American Psychiatric Association [APA], 2022), with 17.5% meeting criteria for a severe SUD (i.e., presence of 6 or more symptoms; Johnson et al., 2020). Moreover, SUD is a leading cause of death, disability, and health care costs globally (World Health Organization, 2024; UNODC, 2024). A review of 192 epidemiological studies revealed the average age of onset and peak prevalence of first SUD symptoms at 15.5 years and first diagnosis at 20.5 years (McGrath et al., 2023; Solmi et al., 2022), highlighting the disproportionate effects of substance use and SUDs in youth. As such, SUD among young people has been a major public health concern for decades.

The American College Health Association's (ACHA) 2024 National College Health Assessment reports that about 56% of college students reported using alcohol and 23% reported using cannabis in the past 3 months. Among these individuals, 3.1% of alcohol users and 7% of cannabis users endorsed experiencing a negative impact to academic performance. Young adults aged 18 – 25 appear to be the group of people with the highest percentage (about 27%) of individuals meeting DSM-5 criteria for SUD, with alcohol use disorder (AUD; 16.4%) and cannabis use disorder (CUD; 16.6%) being the most common (Center for Behavioral Health Statistics and Quality [CBHSQ], 2024). People with AUD, CUD and co-occurring AUD and CUD are at higher risk for interpersonal problems, legal problems, and health related problems, though specific problem-profiles vary across diagnostic combinations and are still not well understood (Gutkind et al., 2021). As such, gaining a clearer understanding of modifiable

characteristics and contexts in which young people with SUDs are using and experiencing associated consequences is critical.

Changes in legalization and decriminalization of certain substances in different states across the United States have given rise to a diverse landscape of use. Young people use more cannabis than before recreational legalization (McCabe et al., 2021), and a recent study found that in 2022, past-month cannabis users were nearly four times as likely to report daily or near daily cannabis use (42.3%) compared to past-month alcohol users (10.9%; Caulkins, 2024). Similarly, AUD and CUD symptoms have been exacerbated from pre- to post-COVID-19 university closures (Schepis et al., 2021). Better understanding how situational and contextual factors impact the development and prognosis of SUDs has important implications for intervention and prevention efforts.

Certain groups of individuals, including those with co-occurring psychopathology, may be at particular high risk for using substances and developing a SUD. Young adults aged 18-25 have the highest prevalence rates of any mental illness (33.8%) compared to other age groups, and 14.1% had a co-occurring mental illness and SUD (CBHSQ, 2024). Meta-analyses report associations between depression and anxiety and alcohol, cannabis, and/or tobacco use in adolescents and young people (Esmaeelzadeh et al., 2018). Individuals with a co-occurring mental health diagnosis are about twice as likely to develop a SUD, and individuals with a SUD are more likely to develop a mental health diagnosis – indicating a bidirectional relationship (see Volkow & Blanco, 2023 for a review).

Underlying and linking components between different mental health disorders may provide important information about transdiagnostic associations with substance use, particularly reasons for use. Specifically, gaining understanding on how basic transdiagnostic components (e.g.,

affect, context) impact reasons for substance use can help provide clear avenues for intervention and prevention efforts rooted in empirical study. Understanding what overarching trait and contextual factors drive individuals with SUD to use substances despite unwanted consequences, as well as how those traits and contexts contribute to reasons for using substances, is a keystone component of substance use motives literature and SUD study more broadly.

Substance Use Motives

Substance use motives refer to an individual's reason(s) for using substances. People often conflate substance use motives with substance use expectancies. Substance use expectancies are specific beliefs about what will happen if an individual uses a substance, while motives are value-laden reasons that *motivate* individuals to use to achieve a desired effect (Cox & Klinger, 2011). In other words, expectancies are the culmination of previously learned effects and beliefs about substances, which can be both positive and negative, while substance use motives provide direct justification for using substances to achieve some goal. Though both are important for understanding addiction in a broader sense, motives may represent the functional significance of substance use for people and are the proximal mechanisms through which other factors operate (Adams et al., 2012; Cooper et al., 2015; Cox & Klinger, 2011; Studer et al., 2016).

Motivational Models

Early models of addiction and substance use motivation suggested that the primary reason for continued use is negative reinforcement from relieving aversive withdrawal symptoms (e.g., low blood sugar; see Baker et al., 2004). Later, the Cox and Klinger (1988, 2011) model of substance use suggested that individuals use for a specific incentive, or goal, whether implicit (i.e., outside of conscious awareness) or explicit (i.e., within conscious awareness). This model emphasizes the important interactions between distal and proximal contextual factors in producing an

individual's motivation for alcohol use. Specifically, the model denotes a pathway through which distal factors (e.g., previous experiences with substances, sociocultural and environmental factors, biological predisposition) lead to cognitive factors (e.g., expectations about substances) which are then considered in the current context (e.g., substance availability) when determining the net positive or negative effect(s) of using substances at any given moment. The complex interplay between these factors generates in a person an approach (i.e., moving towards a desired goal) or avoidance (i.e., moving away from an undesired outcome) motivation for use. This model also specifically highlights the importance of incentive salience in use motivation. That is, if an individual perceives use as a highly incentivized activity, the probability of seeking other activities is likely to be diminished. When use has become a reliable method to achieve an individual's current goals (e.g., mood repair), use is reinforced, and other activities are often not considered. Notably, this model emphasizes the importance of both implicit and explicit affective states (Cox & Klinger, 2011), suggesting that individuals make decisions about use both outside of and within conscious awareness. In all, the Cox and Klinger (1988, 2011) motivational model provided foundational aspects for future models of substance use motivation – particularly with regards to affect and other contextual factors.

Cooper and colleagues (2015) built on the Cox and Klinger (1998, 2011) model by pinpointing two key dimensions along which substance use motives vary: valence (positive or negative) and context (internal or external; Cooper et al., 2015). The two dimensions can be crossed to yield four types of motives (and an additional type for cannabis use, developed by Simons et al., 1998) each with differing functions and goals:

1. Coping (internal negative) suggests that substances function to deal with aversive affective states (e.g., coping with sadness),

2. Enhancement (internal positive) suggests that substances work to amplify positive affect (e.g., celebrations),
3. Expansion (internal positive), suggests that substances work to alter or broaden one's consciousness,
4. Social (external positive) suggests that substances serve a means to connect with others in social contexts (e.g., parties, bars), and
5. Conformity (external negative) suggests that substances function to avoid feeling left out of social situations (e.g., peer pressure).

Substantial evidence supports the existence of the theoretically predicted trait-level motives for substance use, as well as the motivational model more broadly (Cooper et al., 2015; Simons et al., 1998). A recent factor analytic study with young adults supported the dimensions of the motivational model apart from conformity (which was subsequently coined the social reduction scale) and seems to have similar predictive validity to the original Drinking Motives Questionnaire (King et al., 2023). Research has also demonstrated the mediating or moderating effect of motives in the relationship between a variety of personality traits (e.g., impulsivity, anxiety) and problematic substance use (Adams et al., 2012; Comeau et al., 2001; Cooper et al., 2015; Gillen et al., 2016; Lammers et al., 2013). Some macro-longitudinal work across 17 years also suggests that individuals' motives for substance use as adolescents predicts problems in adulthood (Patrick et al., 2011). Additionally, research supports that different motives are preceded by different contexts and followed by different consequences. For example, previous work has demonstrated that individuals who use to cope may experience problems over and above quantity used, while the same may not be true for individuals who use for enhancement purposes (e.g., Stevenson et al., 2019). Overall, the extant literature supports the structure of the

motivational model at the trait level and provides evidence that different motives are associated with varied risk profiles and problems. As such, a focal aim of this study was to test if endorsing unknown motives is associated with increased problems (H_3).

Cooper and colleagues (2015) provide five key premises embedded within the motivational model of substance use: 1) People use substances to alter affective states, 2) People have beliefs and expectations about substance use that mold their motivational profiles, 3) People choose (both inside and outside of conscious awareness and rationality) whether and how much to use in order to attain their affectively-related goals, 4) Substance use motivated by different needs or serving different functions ultimately are characterized by distinct and unique contextual factors and internal experiences, and 5) Motives are the "final common pathway" through which distal factors impact people's decisions. The central tenets of this model communicate the importance of awareness, affect, and context when making individual decisions about use and motives represent large patterns in a person's reasons for using in general. As such, motives have been historically studied at the trait-level (Cooper et al., 2015; Votaw & Witkiewitz, 2021) and empirical research supports the notion that people are aware of why they use substances overall, and their reasons tend to fall in line with the motives outlined above (Cooper et al., 2015). However, this model's emphasis on important contextual factors give rise to the ideas that people's motives for substance use vary, and those variations provide information about how motives are a culmination of an individual's experiences leading up to a use event. That is, given the dynamic nature of affect, context, and substance use within a person's daily life, variability may also exist at the state-level – such that people that endorse a particular trait-level motivation for use may exhibit variability in motivation for a specific use episode that deviates from their typical pattern (Votaw & Witkiewitz, 2021) after accounting for both internal and external

contextual factors or waver in their ability to assign motivation to their behaviors in the heat of the moment. Evidence suggests that individual decisions about use can occur outside of one's conscious awareness (e.g., McCarthy et al., 2010; Ostafin & Palfai, 2006; Wiers et al., 2007), and, as such, it is plausible that individuals may not be completely aware of their motives for use before every use event (Premise 3, Cooper et al., 2015) even though they are able to articulate their motivation for substance use *in general* at the trait-level. Though this model suggests the theoretical occurrence of people using substances without knowing their motivation (i.e., existence of an unknown motive), to our knowledge no previous work has investigated this phenomenon. As such, the first aim of this study is to quantify how often people endorse an unknown motive, and the characteristics of these occurrences.

Decision Making

Decision making is a complex process with many constituent parts and inputs. Many theoretical frameworks have been put forth to help explain this ubiquitous phenomenon. One such model is the dual process model. This is a theoretical framework for cognition that suggests decision making is governed by two processing systems: a deliberate, "reflective" system and a fast acting, "reflexive" system that are each governed by distinct neurocognitive systems (Lieberman, 2007; Satpute & Lieberman, 2006; Wiers et al., 2007). This theory emphasizes the importance of both systems, suggesting that some actions require deeper, calculated thought, while others require swift action, with little thought. This makes sense from an evolutionarily perspective – as not all decisions in the primal world could have happened in a calculated manner, and this "reflexive" system is evolutionarily older than the reflective system (Satpute & Lieberman, 2006). These systems, while semi-independent (Wiers et al., 2007), are linked by an individual's awareness of the contextual factors at hand that may be triggering one system or the

other. In other words, there are cues that are thought to trigger the explicit, "reflective" system versus the implicit, "reflexive" system.

Emotions tune our decision-making, both within and outside of our conscious awareness (Lerner et al., 2015). Affective functioning also plays an impactful role in cognition, such as information processing (Stavraki et al., 2021), attention, and memory (Forgas & Koch, 2013; Murray et al., 2013; Yiend et al., 2013). Importantly, for evolutionary purposes, the processing of affective information takes precedence over non-affective information, and oftentimes outside of the explicit information processing stream (McCarthy et al., 2010; Murphy et al., 1995; Wiers et al., 2007). Consequently, mood repair is prioritized over other more adaptive long-term goals (McCarthy et al., 2010; Tice et al., 2001), resulting in behavior aimed to alter one's current affective state.

Given the role of emotions in the experience of day-to-day life, it would make sense that much of human behavior is tailored to reducing uncomfortable emotions or amplifying enjoyable ones, whether one is aware (i.e., "reflective", "cold" processing) or not (i.e., "reflexive", "hot" processing). Urgency is a facet of impulsivity that entails acting rashly while experiencing intense emotions. Positive urgency describes the tendency to act rashly when experiencing high PA, typically with an aim to amplify PA, and negative urgency describes the tendency to act rashly when experiencing high NA, typically with an aim to attenuate NA (Cyders et al., 2009; Cyders & Smith, 2008). As such, urgency is thought to reflect the implicit, "hot" processing that operates under the "reflexive" system. Accordingly, high NA or PA can impact decision making without conscious awareness or thought through urgency or implicit, "hot" processing (Cyders & Smith, 2008; Smith & Cyders, 2016). Since mood repair is given priority over other goals (McCarthy et al., 2010; Tice et al., 2001), individuals often operate under "hot" processing when

NA or PA is outside of one's own tolerable or average levels, and actions occur quickly and without much thought. This has clear implications on how people make decisions about using substances, and one's level of awareness about what is motivating their actions.

Positive and negative urgency have both been associated with risky behavior, including substance use (Cyders & Smith, 2008; Smith & Cyders, 2016). Urgency has also emerged as a significant predictor of problematic substance use (Stautz & Cooper, 2014) and a unique predictor of substance related problems (Hildebrandt et al., 2021). In the context of substance use motives, when the learned effects of substance use (i.e., emotional payoff of substance use) are coupled with internal affective experiences and other contextual factors (e.g., heightened affect), implicit, "hot", "reflexive" processing might give rise to substance use directed at altering one's affect without concrete understanding or awareness of an exact motivation for use (McCarthy et al., 2010; Simons et al., 2015a; Wiers et al., 2007). That is, there are conditions, contexts (e.g., affect) and cues that may plausibly give rise to substance use (i.e., an explicit behavior) without a clear understanding of one's motivation for doing so (i.e., an unknown motive) at the event-level. Indeed, research has shown that when self-control resources are depleted (e.g., times of high affect), implicit measures of substance use motivation (i.e., an implicit association test) are associated with use despite intention to abstain (e.g., Ostafin et al., 2008). In other words, implicit (i.e., reflexive) measures of substance use motivation have appeared more predictive of likelihood to use *despite the desire to abstain*. This suggests that substance use sometimes occurs for reasons that are outside of one's conscious awareness and are automatic (or reflexive) in nature.

In sum, dual process theory and urgency literature provide theoretical and empirical foundations that would suggest the existence and occurrence of an unknown substance use

motive in certain moments, particularly those characterized by intense NA or PA. Taken together, the dual process theory and urgency literature suggests that higher than average levels of NA (H_1) or PA (H_2) may be associated with a greater likelihood of endorsing an unknown substance use motive. This literature also provides foundational evidence that when endorsing an unknown substance use motive, individuals may also experience more problems (H_3). When thinking about affect, specifically, the mechanisms of action by which substances propel continued use are of relevant nature. Specifically, positive and negative reinforcement models of addiction provide more support the above linked hypotheses and for other levels of affect that may also be associated with a greater likelihood of an unknown substance use motive endorsement.

Positive and Negative Reinforcement Models of Addiction

The principles of motivational and decision-making models of substance use (e.g., Cooper et al., 2015; Wiers et al., 2007) provide important contextual information about the roles of positive and negative reinforcement in substance use. Rooted in operant conditioning, some models of addiction pose that individuals begin using substances for the positive reinforcement and later transition into negative reinforcement (e.g., Koob & Le Moal, 2001; Robinson & Berridge, 1993, 2008). That is, people initially use substances to experience their enjoyable euphorigenic effects (e.g., getting high or "liking"), but repeated use brings about withdrawal and craving which, in turn, propels use to alleviate these aversive states (Robinson & Berridge, 1993, 2008). Conversely, individuals may have initial expectancies about a substance's ability to relieve NA (i.e., coping) which may produce individual motivations to begin using for negative reinforcement purposes (Boyle et al., 2022; Crutzen et al., 2013). In either case, people take specific contextual information into account when making decisions about use (Cooper et al.,

2015; Cox & Klinger, 2011; McCarthy et al., 2010; Votaw & Witkiewitz, 2021). Given the dynamic nature of affect moment-to-moment, there are nuanced, event-level patterns of engaging in substance use in response to its positive reinforcement and negative reinforcement properties.

Individuals often use substances due to their pleasurable effects (e.g., getting high, euphoria) which mirror positive affective states experienced during naturally rewarding activities (e.g., sexual activity), and make drug use positively reinforcing (de Wit & Phan, 2010). Self-report measures also confirm that the induction of positive affective states functions as a motivator for continued use, especially in young people (i.e., the effects are not exclusively rooted in neurobiological circuits; de Wit & Phan, 2010; Emery et al., 2023; Emery & Simons, 2020). Specifically, substances work by stimulating the dopaminergic system in the brain, particularly in neural structures involved in reward circuitry, and therefore produce reward-motivated behavior (i.e., substance use; de Wit & Phan, 2010; Koob & Le Moal, 2001). When an individual is not using, they may desire the positive affective states produced by a substance, or experiencing positive affective states can result in craving given the repeated pairing of PA and use, which is turn gives rise to drug-seeking behavior (de Wit & Phan, 2010; Tiffany, 2010). In all, this suggests that positive affect and positive reinforcement provide a critical foundation for continued substance use. As use progresses, models postulate that this positive reinforcing effect (i.e., "liking") diminishes, and substance use occurs out of craving (e.g., Robinson & Berridge, 1993, 2008). In these cases, use often happens habitually and without much thought, due to its intricately linked relationship with affect, its learned reliability to achieve desired affective states, and the priority given to processing affective information (Wiers et al., 2007).

In response to repeated and chronic substance use, a series of neuroadaptations are produced that alter an individual's baseline reward functioning (Koob & Le Moal, 2001). Cortisol levels

become greater and dopamine levels drop during times of non-use in an attempt offset the chronically elevated levels of dopamine and diminished levels of cortisol during use; this dysregulation plays a role in maintaining sensitivity to the rewarding effects of substances, thereby reinforcing continued use and perpetuating the cycle (Koob & Le Moal, 2001). This also produces aversive physiological and affective states (i.e., increased NA) during times of non-use that are learned to be reliably alleviated by substance use. In tandem, non-use activities, including naturally rewarding activities (e.g., eating, sex), that were once pleasurable do not produce the same enjoyable effects as substance use, and more time becomes dedicated to use and use-related tasks. Over time, dysregulated reward circuitry produces a state of anhedonia (i.e., low PA), such that non-use activities, and to a lesser extent use, are not as enjoyable as they once were. Importantly, *despite* the lessened pleasure derived from substance use, it is still appraised as the most reliable mechanism by which to achieve one's adjusted homeostatic point (i.e., allostatic point) that has developed in response to this dysregulated reward system (e.g., elevated cortisol, decreased dopamine). That is, chronic substance use induces shifts in one's physiological and psychological functioning away from one's baseline (or homeostatic point) to offset the impact of chronic use on an individual's reward system. This opponent process then adjusts an individual's baseline level of functioning (i.e., allostatic points) in times of non-use that produces states of low arousal, dysphoria and dysregulated reward such that substance use becomes the only viable option to bring an individual back to their new level of functioning (Koob, 2015, 2022). Substance use also becomes the most reliable means to alleviate aversive affective states (i.e., high NA).

Put simply, with repeated substance use, crucial deviations from one's baseline functioning (i.e., homeostasis) occur in one's body and brain that propel continued substance use. People

develop a series of neuroadaptations in response to repeated use that disturbs their reward system and dopaminergic functioning, increasing their reward threshold (i.e., it is more difficult to attain rewarding effects) and producing allostatic points to oppose the dysregulation induced by substance use. Substances ultimately become the only dependable means to 1) bring a person back to their allostatic point (or new "normal" feeling state) and 2) alleviate aversive feeling states (e.g., high NA; Koob, 2015; Koob & Le Moal, 2001; Robinson & Berridge, 2008), thereby functioning as both a positive and negative reinforcer (Koob, 2022; Koob & Volkow, 2010). This applies across physiological, neurological, and psychological domains, such that demands on the body and mind adjust to the chronic levels of substances in the bloodstream and produce a "downward spiral" of addiction (Koob & Le Moal, 2001). In other words, the lack of pleasurable effects of both use and non-use activities produce a state of low arousal, characterized by anhedonia, which is simultaneously a response to a dysregulated reward system *and* a motivator for continued use (i.e., cause and consequence). It also produces a stronger link between substance use and attenuation of negatively appraised stressors, such that substance use becomes an automatic and "reflexive" behavior under specific affective conditions (in this case, high NA).

Overall, this suggests that addiction is impacted by both positive and negative reinforcement processes, whereby what was once done consistently as a pleasurable activity is now done to remove aversive feelings, sensations, or emotions, including physical withdrawal symptoms, because of the learned reliability for substances to achieve this goal, and the lessened interest in non-use activities (de Wit & Phan, 2010; Koob & Le Moal, 2001; McCarthy et al., 2010; Robinson & Berridge, 2008). Considering the effects of both positive and negative reinforcement are critical due to their seemingly interrelated nature – particularly as it relates to low PA (i.e., anhedonia).

Anhedonia is defined as the inability to experience pleasure and is a key transdiagnostic component of many DSM-5 disorders (e.g., Major Depressive Disorder (APA, 2022). A core component of anhedonia is experiencing low PA; that is the *lack* of PA. Repeated substance use may contribute to an individual experiencing greater anhedonia over time, such that non-use activities that were once considered pleasurable are no longer as rewarding due to continued dysregulation in reward circuitry that is impacted by substance use (de Wit & Phan, 2010; Koob & Le Moal, 2001).

While anhedonia may be a consequence of the positively reinforcing effects of substance use (Koob, 2022; Koob & Le Moal, 2001), it may also serve as a motivator for use. In fact, anhedonia is a commonly overlooked experience among individuals who chronically use substances but appears to be a common experience and motivator for continued use (see Boden et al., 2017 for a review). Positive reinforcement, and positive affective functioning more broadly, appear to be a primary mechanism facilitating use among young people 6/16/2025 9:42:00 PM . Previous work has demonstrated an inverse within-person association between PA and substance use (Emery et al., 2021, 2023) showing young people are more likely to use at the next moment when PA is low at the previous moment. When PA is low, individuals may not have a clear understanding of what their internal emotional experience is, as evidenced by a lower ability to label positive emotion states (e.g., Emery et al., 2022). As such, assigning a motive for substance use may be challenging, and individuals may act without conscious thought (Shishido et al., 2013). This suggests that in moments of low PA, individuals may endorse an unknown substance use motive. However, this is a yet untested hypothesis and thus, a major aim of the current study.

Additionally, acting impulsively when PA is high (i.e., implicit, "hot" processing) is associated with greater substance use (Cyders et al., 2009; Cyders & Smith, 2008). Given the nature of "hot" processing, people experiencing high PA may also endorse an unknown motive (see decision making section above). As such, enhancement motives may not be an all-encompassing substance use motive across all levels of PA (Emery et al., 2024) or varying contexts, but may mirror the cognitive control and awareness states posed by dual processing theory and negative reinforcement theory of addiction, which is discussed in greater detail below.

Affective processing models of addiction proposed Baker et al. (2004) and reformulated McCarthy et al. (2010) serve as seminal works in understanding negative reinforcement models of substance use. These models suggest that individuals use substances beyond the simple motivation to relieve the aversive effects of withdrawal, and people take other contextual factors (e.g., NA, stressors) into account. That is, these models posit that alongside the aversive effects of physical interoceptive cues of withdrawal, an individual's appraisal of incentive value of using drugs to relieve NA plays a pivotal role in their motivation for use. In other words, people evaluate if using a substance to relieve the aversiveness of an experience is "worth it."

When making the decision to use, individuals experiencing low NA will use habitually, in response to dropping blood levels and other early signs of drug withdrawal that do not cross the threshold into the individual's consciousness (McCarthy et al., 2010). Implicit processes facilitate automatic drug use before cues of distress cross into one's conscious awareness, including interoceptive conditioning (i.e., internal states serve as conditioned stimuli for other internal states). That is, internal states themselves (e.g., affective states) that have previously been successfully relieved with use can now serve cues for substance use (Stasiewicz & Maisto,

1993). These associative links strengthen with chronic substance use, such that individuals become able to automatically and preconsciously detect these states and use occurs before distress increases or aversive withdrawal symptoms set in (McCarthy et al., 2010). Under these circumstances, individuals are likely not entirely aware of what is motivating their behavior and thus may have difficulty assigning a clear motive for use. Individuals experiencing high NA will likely use because of the learned reliability of use to relieve NA. In these instances, the model suggests that individuals would be aware of these levels of NA and their motivation for use would be to alleviate this NA (i.e., coping), and finding alternative behaviors becomes more difficult because of the learned reliability of substances to achieve this goal (Cox & Klinger, 1988, 2011). As a result, use occurs "reflexively" and automatically. This also means that individuals recruit the most cognitive control resources to decide whether to use when experiencing moderate NA; that is, when the level of NA is aversive such that individuals become aware of it, but it is not intolerable, they will think more thoroughly about the decision to use. Additionally, these models suggest that when individuals are seeking to change their use behaviors, this moderate level of NA provides the most optimal space to make decisions about engaging in activities that are not related to substance use. In all, this suggests that there is a particular level of internal mindful awareness that is necessary and conducive for intervening before and understanding use moments; conversely, this also suggests that there are levels of NA (i.e., low and high) that supersede cognitive control resources and substance use is more likely to occur automatically and outside of conscious awareness.

Affect, Unknown Motive Endorsement, and Problems

In sum, positive and negative reinforcement models, decision making, and urgency literature all provide important information about the affective factors that may contribute to an unknown

use motive. Positive and negative reinforcement models provide support for potential unknown substance use motive endorsement at low levels of PA or NA, while decision making and urgency literature introduce the possibility of an unknown substance use motive endorsement at high levels of PA or NA. This provides the foundation for the second aim of our study, which was to investigate the association between affect (PA and NA) and the likelihood of endorsing an unknown substance use motive. Taken together, the literature supports a likely non-linear relationship, such that moments characterized by higher or lower than average NA or PA predict a greater likelihood of unknown motive endorsement (i.e., a quadratic relationship). As such, we predicted that NA and PA would exhibit quadratic relationships with unknown motive endorsement, such that experiencing lower or higher levels of NA than average are associated with a greater likelihood of endorsing an unknown motive (H_1) and experiencing lower or higher levels of PA than average would be associated with greater odds of endorsing an unknown motive (H_2).

Similarly, previous work has demonstrated the variable risk profiles associated with different substance use motives (Cooper et al., 2015; Votaw & Witkiewitz, 2021). Additionally, research on urgency suggests that acting without conscious thought in moments of heightened affect contributes to consequences from riskier behavior (e.g., problematic substance use; Adams et al., 2012; Hildebrandt et al., 2021; Stautz & Cooper, 2014). Taken together, if specific affective states contribute to endorsing an unknown substance use motive, this might suggest that individuals who are using without conscious awareness about their motivation for doing so may also experience more problems. As such, we predicted that an endorsement of an unknown motive would be associated with increased problems (H_3).

Given the moment-to-moment fluctuations and within-person variability of affect, substance use decisions, levels of awareness, and consequences, investigating these relationships at the event-level requires research methods that are designed to gather self-report information from individuals in real time. Ecological Momentary Assessment (EMA) is specifically designed to capture within-person variability in this way.

Ecological Momentary Assessment (EMA)

Ecological Momentary Assessment (EMA) is an intensive, micro-longitudinal research technique that allows researchers to collect data about real-time events in participants' real-world environments (Shiffman, 2014; Shiffman et al., 2008). Rooted in experience sampling methodology, EMA allows researchers to gain a fine-tuned view on a participant's experience in their day-to-day lives, which diminishes autobiographical recall bias that may be present in cross-sectional or macro-longitudinal work (Shiffman, 2014; Shiffman et al., 2008). Collecting data at this level allows researchers to gain a more wholistic view of a participant's experience across internal and external contexts, which may be particularly relevant for exploring dynamic research questions. This is especially relevant for research questions aimed at understanding affect and substance use, given the inherent fluctuations in the occurrence and quality of these events.

In EMA research designs, participants will often be asked to complete multiple surveys within- or across-days for some period on their phones or computers. Questions asked in these surveys are often centered around a participant's experience in this moment or temporally close to any given moment (e.g., the previous 30 minutes) to capture the phenomenology of their experience. There are a variety of survey types, including event-contingent reports (i.e., participants initiate a survey when an event has or is about to happen), signal-contingent reports

(i.e., participants receive a notification or reminder to complete a survey at random times), and interval-contingent reports (i.e., participants complete a survey at the same time or interval; Shiffman et al., 2008). As such, EMA allows researchers to gain ecological validity by understanding moment-to-moment (i.e., event-level) fluctuations in participant experience in their day-to-day lives. EMA also allows researchers to temporally sequence the occurrence of events throughout the course of a day or across days in the research study, which can provide a more nuanced understanding of how events are related in time (Shiffman et al., 2008). That is, researchers can temporally sequence events such that certain events in one moment prospectively predict the occurrence of an event in future moments (i.e., lagged effects). Similarly, researchers can investigate relationships concurrently between different constructs at one moment of interest (e.g., use moments). EMA also allows for statistical techniques that are designed to parse out variability between- and within-persons. Research questions aimed at understanding natural fluctuations over time benefit from EMA, since each person can be statistically utilized with their own mean (e.g., mean NA). Put simply, EMA data allows researchers to understand within-person deviations from their own mean for variables of interest. In this way, people serve as their own controls, and phenomena that occur at the event-level can be investigated.

There is growing evidence that substance use motives vary at the event-level, and EMA studies reveal variety in substance use motive endorsement and associated contexts and consequences within-person (see Votaw & Witkiewitz, 2021 for a review). In fact, some research has suggested that 50% or more of variability in motives may occur at the within-person level (e.g., Dvorak et al., 2014). Since individuals take contextual factors into account when making decisions about use (Cooper et al., 2015; Wiers et al., 2007), using EMA to understand the time-course, event-level characteristics and frequency of substance use events and their associated

motives and consequences is impactful (Wray et al., 2014). Especially with the consideration of an unknown substance use motive, and the fleeting, momentary nature of reflexive decision making (Satpute & Lieberman, 2006), EMA serves as a meaningful and appropriate research technique to capture the occurrence of this theoretically predicted phenomenon as it occurs and varies within-person.

Study Overview

The current study sought to advance the extant research on substance use motives by providing empirical support for a theoretically predicted phenomenon of an unknown substance use motive. Therefore, the aims of this study were threefold. First, it was imperative to understand the frequency of the occurrence of an unknown substance use motive endorsement. Both theory (Satpute & Lieberman, 2006) and empirical evidence (e.g., Lieberman, 2007; Ostafin & Palfai, 2006) support the notion that individuals sometimes make decisions, including substance use decisions (Cooper et al., 2015; Cyders & Smith, 2008; McCarthy et al., 2010; Wiers et al., 2007), outside of conscious awareness or reflexively, without much deliberation. Much of the previous research exploring substance use motives has occurred at the trait-level (Cooper et al., 2015; Votaw & Witkiewitz, 2021), and a lack of exploration of an unknown substance use motive at this level makes sense. However, with the growing utility, accessibility and known benefits of utilizing EMA to answer momentary research questions, empirical exploration of this theorized construct at the event-level was timely and impactful to the literature.

Second, determining specific contextual factors, particularly affective experiences, that are concurrently associated with unknown motive endorsement during use moments was prudent. Previous work has demonstrated that affect plays a fundamental role in decision making (Lerner

et al., 2015; Stavraki et al., 2021). As such, mood repair is prioritized (McCarthy et al., 2010; Tice et al., 2001), and people act quickly, without much thought (i.e., "hot" processing) when experiencing heightened positive and negative affect (Cyders et al., 2009; McCarthy et al., 2010; Wiers et al., 2007). Additionally, individuals experiencing low NA, such that it is outside of one's awareness, will likely use substances habitually, without much thought about their motivation to do so (McCarthy et al., 2010; Wiers et al., 2007). Similarly, individuals experiencing low PA (i.e., anhedonia), which is associated with greater substance use (Boden et al., 2017; Emery et al., 2021, 2023) may have a more difficult time labeling their internal emotional experiences (e.g., Emery et al., 2022) and may, in turn, make articulating their motivations more difficult (Shishido et al., 2013). Taken together, we hypothesized that affect would display a quadratic association with unknown substance use motive endorsement, such that low and high levels of negative or positive affect (compared to one's mean) at the previous moment (time 1 [T1]) would be prospectively associated with a greater likelihood of endorsing an unknown motive during a use event at the next moment (time 2 [T2]). In other words, individuals would be more likely to endorse an unknown motive during use moments that follow moments characterized by low or high negative or positive affect (as compared to their own mean level of NA or PA).

Finally, understanding how endorsement of an unknown substance use motive predicts consequences prospectively can provide a clear avenue for intervention. Previous work has demonstrated the role of urgency (Adams et al., 2012; Cyders et al., 2009), awareness (Cyders & Smith, 2008; Wiers et al., 2007), and varying substance use motives (Cooper et al., 2015; Votaw & Witkiewitz, 2021) in experiencing problems. Taken together, the literature supports the idea that when individuals act habitually (McCarthy et al., 2010) or without much clarity (Shishido et

al., 2013) in response to low affect, or when individuals act rashly in response to high affect (Gmel et al., 2012b), they may experience greater problems. In these cases, individuals act without much reflective, deliberate, and explicit thought. Thus, we predicted that individuals who endorse an unknown substance use motive the previous moment would experience more problems at the next moment.

Method

Participants

Participants for this study were part of a parent EMA study on alcohol and cannabis use disorders. Inclusion criteria for the parent study include college students aged 18-25 who met criteria for current AUD, CUD or both and have a smart phone. Participants were recruited from the university research participation pool (subject pool), receiving partial course credit for participation per survey completed. Participants received up to 5 course credits for completing every possible survey during the study period.

Participants were 68 undergraduate college students aged 18 – 25 (M = 19.1, SD = 1.41). Of these, 15 participants were dropped due to having no use moments throughout the sampling period. For the affect model (H_1 and H_2), 3 additional participants were removed from the sample due to lack of item pairs necessary for the analyses. Overall, 50 participants were included in the final analytic sample (age: M = 19.2, SD = 1.49). This sample was predominantly assigned female at birth (86%) and identified as cisgender women (86%). The sample was 86% White, 2% Asian, 2% Black, 6% Native American, 2% Another, 2% Multiracial and 76% Non-Hispanic / Latine. For the problems model (H_3), 10 individuals were dropped due to lack of item pairs necessary for the analyses. This analytic sample was comprised of 40 participants (age: M = 19.2, SD = 1.58), predominantly assigned female at birth (85%) and identified as cisgender women (85%). This sample was 82.5% White, 2.5% Asian, 2.5% Black, 7.5% Native American, 2.5% Another, 2.5% Multiracial and 77.5% Non-Hispanic / Latine.

Procedure

Participants completed an online screening survey to determine eligibility criteria for participating in the study (see Baseline and Trait measures section). If they met the eligibility criteria for this study (i.e., 2 or more AUD or CUD symptoms endorsed in the past 12 months, age 18-24), they were invited to attend an in-person initial enrollment session where they completed informed consent, as well as installed and were trained to use an EMA application on their personal phone. EMA training included discussion of the application's functions, assessment timing, and survey questions. The EMA protocol was delivered using mEMA (Tuomenoksa, 2013), a cross-platform smartphone application (iOS and Android) developed by ilumivu Inc.

The EMA program generated prompts for participants to complete five momentary assessments at random times within 3-hour blocks from 9am-Midnight (random assessments; e.g., 9:00am-12:00pm), a morning assessment between 9:00am and noon each day, and begin and end use assessments, initiated by participants before and after use events, respectively for 14 days. Random assessments presented brief (~2 min) surveys asking for participants to report on their emotions and behavior during a specified period (e.g., past 30 minutes, since your last survey); if they endorsed having used substances in this time, participants were asked about their motives for use. Morning assessments inquired about behavior during the waking hours yesterday (i.e., from when they awaken to when they go to sleep). The parent study also contained two event contingent reports that participants are asked to fill out before and after use events. Begin use assessments inquired about what substances participants plan on using, their motives for use, and their emotions and behavior during the same specified periods as the random assessments. End use assessments asked questions regarding current affective state and

any problems experienced since their last survey. Participants received partial research credit for the initial enrollment session and each morning and random assessment they completed.

Data for the current set of analyses were drawn from the random assessments. Data that was collected from the morning survey will not be used, since it did not ask participants about substance use motives, and our aims were momentary in nature. Data from the begin and end use surveys were not used but were collected to better gauge the feasibility of using this methodology in the future. The study was approved by the Colorado State University Institutional Review Board (#2888).

Measures

Screening, Baseline and Trait Measures

Demographic information was collected on participants' sex assigned at birth, age, race, and ethnicity. Demographic information was used to describe the sample.

Current alcohol and cannabis use disorder were assessed with the Alcohol Symptom Checklist (Hallgren et al., 2022b) and an adapted version for Cannabis Use Disorder. These checklists are 11-item self-report measures that inquire whether participants have experienced each of the 11 DSM-5 AUD/CUD criteria within the past year, a timeframe consistent with diagnostic standards. Summed scores reflect criteria counts and severity as defined in DSM-5 (mild: 2–3 criteria; moderate: 4–5 criteria; severe: 6–11 criteria). Psychometric analyses support the reliability and validity (Hallgren et al., 2022a, 2022b) of the Alcohol Symptom Checklist. It has been shown to measure AUD criteria consistently over time (Hallgren et al., 2022b), along a unidimensional continuum of severity (consistent with DSM-5 conceptualization; Hallgren et al., 2022a, 2022b), and similarly across sex, age, race, and ethnicity subgroups when it is completed

in routine care by patients with high-risk drinking (Hallgren et al., 2022a). SUD symptoms were used for descriptive purposes.

Ecological Momentary Assessment Measures

Positive and negative affect in the previous 30 minutes was assessed during random surveys by items from subscales of the PANAS-X (Clark & Watson, 1994) and Larsen and Diener's affect circumplex model (Larsen & Diener, 1992) on an 11-point scale (0 = *Not at all*, 10 = *Extremely*). Five items assess PA: happy, excited, calm, relaxed, and grateful. Five items assess NA: sad, anxious, angry, lonely, and stressed. Previous research supports the internal consistency and criterion validity of these affective items assessed using EMA (e.g., Emery & Simons, 2020). Positive and negative affect items were averaged into moment- and person- mean composite scores for their respective valence.

We calculated reliability of the positive and negative affect scales for this sample at the within- and between-person level using McDonald's Omega (McDonald, 2013) following procedures of Geldhof et al. (2014). McDonald's omega (ω) is an index of internal consistency that uses a factor analytic approach to partition the common variance among the items from the unique variance and determine the general factor saturation of the test. It is the ratio of the common variance to the total variance (common and unique; Dunn et al., 2014). Guidelines for ω follow those for Cronbach's alpha. The positive affect scale exhibited acceptable reliability (ω = 0.79) at the within-person level, and excellent reliability at the between-person level (ω = 0.93). The negative affect scale also demonstrated acceptable reliability (ω = 0.79) at the within-person level, and excellent reliability at the between-person level (ω = 0.88).

Substance use (i.e., alcohol or cannabis use) was assessed during the random surveys by either number of drinks consumed over the last 30 minutes on an 11-point scale (*0* to *10 or more*

drinks) or a single item asking if they have used any THC-containing cannabis products within the last 30 minutes (i.e., *yes* (1) or *no* (0)). Alcohol and cannabis use moments were collapsed into a single indicator given substance use motives did not ask participants to specify which substance they were using and to maximize the number of observations. Use moments were not included in the analyses overtly but were used for descriptive purposes to determine how many use moments there were across the sampling period.

Substance use motives were assessed with a 7-item checklist representing the five types of substance use motives (Cooper et al., 2015; Simons et al., 1998) and an added "I don't know" response choice (i.e., unknown motive). Participants were only asked about their substance use motives if they endorse using substances in the past 30 minutes. Participants can select multiple motives. Checklists to examine substance use motives are common (Votaw & Witkiewitz, 2021) and may allow for exploration of co-occurring motivations for use and unique motive profiles across a variety of contexts. Unknown motive endorsement was a dichotomous momentary indicator (present = 1 or absent = 0). This was the outcome variable in the affect model (H_1, H_2), and a predictor variable in the problems model (H_3).

Problems were assessed during random surveys with a checklist of 12 problems adapted from the Young Adult Alcohol Consequences Questionnaire (YAACQ; Read et al., 2006) – a well-established measure of alcohol-related problems. This approach is commonly used in EMA research. Participants selected any problems they experienced since their last survey and included the following options: 1) *got into a fight*, 2) *did something embarrassing*, 3) *got injured*, 4) *felt confused*, 5) *blacked out*, 6) *felt sick to your stomach*, 7) *passed out*, 8) *did something impulsive*, 9) *did something you regret*, 10) *neglected responsibilities*, 11) *damaged property*, and 12) *drove intoxicated*. **Importantly, the stem question does not ask participants to link**

the problems they are experiencing to their substance use. The rationale behind this approach is that any moment-to-moment observed changes in problems that are associated with drinking would reflect more or less than would be expected during their daily life; as such, the magnitude of the effect of substance use on problems is less biased (Gmel et al., 2012). Previous research with the YAACQ supports the criterion validity of these items when incorporated into self-report measures (Bravo et al., 2019). A count of the number of problems endorsed at each moment was used in the model (H_3).

Planned Analysis

Data Cleaning and Preparation

All analyses were conducted in Stata (StataCorp, 2023). Preliminary analysis determined variable distributions, including skew and kurtosis. Descriptive statistics were used to characterize the distribution of participants' SUD symptoms, frequency of use moments, frequency of unknown substance use motive endorsement, and associative relationships between variables of interest.

Primary Analysis

Data were analyzed with a series of multilevel models (MLMs), where moments (level 1 [L1]) are nested within persons (level 2 [L2]). MLMs account for the non-independence of observations that results from the nesting of time-varying observations via momentary random assessments within persons (L1). Each model included random intercepts and fixed slopes to account for and explore within-person variability, while constraining the effect between-persons. Since the aims of this study were focused in L1, models with random intercepts and fixed slopes targeted the study aims while balancing analytic parsimony. All models included sex at L2 and day of the week and day at L1 as covariates. Previous work has demonstrated sex differences in

both subjective experiences of substances and use-related outcomes (see McHugh et al., 2018 for a review). Day of the week was included to control for any daily variation in use patterns and affect while reducing potential serial auto-correlation across days (Mohr et al., 2001). Day in the study was included to account for any change over time not accounted for by the predictors of interest.

Initial intercept-only models (without any predictors) estimated intraclass correlations (ICC) to determine the proportion of variability in the focal variables that can be attributed to between-person influences, relative to within-person influences. To test the hypothesized quadratic prospective momentary relationship between affect and unknown motive endorsement, unknown motive endorsement at the next moment was regressed on NA and PA at the previous moment using a multilevel logistic regression (i.e., lagged effects). NA and PA were person-mean centered at L1 by calculating each participant's momentary mean NA and PA across the sampling period and subtracting each moment's NA and PA rating from their mean. At L2, each participant's mean NA and PA was grand mean centered by calculating the entire sample's mean NA and PA across the sampling period and subtracting each person's mean NA and PA. Mean centering these variables at both L1 and L2 aided in more meaningful interpretation and best fulfilled the needs of these hypotheses. This allows for purposeful comparisons about probabilities within-person, since deviations from the mean represent changes from an individual's own typical level of affect (i.e., each individual act as their own control). Due to the item pairs required for this analysis (i.e., previous moment affect paired with next moment unknown motive endorsement), and the momentary pairings are within-day, some unknown motive endorsement observations were not included in these analyses.

To probe the hypothesized quadratic interaction of affect whereby the prospective association between unknown motive endorsement and NA or PA depends on the level of NA or PA at the previous moment, we took a marginal effects at representative values approach (Williams, 2012). Marginal effects at representative values for continuous variables estimate partial derivatives (i.e., slope at a specific point or infinitesimally small changes) in the predictor variable across the range of the moderator variable (Mize, 2019). This approach is akin to a simple slopes approach (Aiken et al., 1991); however, instead of comparing the slope values to zero, tests of second differences, or linear comparisons, after marginal effect estimations allows us to investigate how the slopes at values of interest (i.e., ± 1 *SD,* mean) differ from one another (Mize, 2019). Since we hypothesized a quadratic effect, we compared the slopes at ± 1 *SD* to the slope value at the mean level of NA and PA. A significant difference between the slopes at ± 1 *SD* and the mean would suggest that both higher than average and lower than average affect is associated with a significantly greater probability of endorsing an unknown substance use motive. If these hypotheses are confirmed, we would observe a significantly greater probability of endorsing an unknown substance use motive at *both* ± 1 *SD* of NA and PA compared to one's mean NA or PA.

To test the hypothesized prospective relationship between unknown motive endorsement and problems, number of problems at the next moment was regressed on unknown motive endorsement at the previous moment using a multilevel negative binomial model. Negative binomial models are specifically designed for variables that are 1) count variables and 2) have a low base-rate with meaningful zeros. Previous work has demonstrated that reporting zero problems from substance use is common among this population (Atkins et al., 2013), and as such, a negative binomial regression is appropriate. If the hypothesis is confirmed, unknown

substance use motive endorsement would be associated with a significant percentage ($p < .05$) increase in the number of problems experienced (expressed as an incident rate ratio [*IRR*]). Due to the item pairs required for this analysis (i.e., previous moment unknown motive endorsement paired with next moment problems) and the momentary pairings are within-day, some observations were not included in these analyses.

Statistical Power and Minimum Detectable Effect Sizes

Power is complex in MLM analyses, as multiple within- and between-person parameters influence the ability to detect effects. Following the approach of Lane and Hennes (2018, 2019), we assessed minimum detectable effect sizes from expected number of observations using the Monte Carlo simulation feature of Mplus 8.5 with repeated sampling (Muthén & Muthén, 2017). Consistent with previous research, 50% of the variance in affect was specified at the within-person level with the remaining variance specified at the between-person level (e.g., Dvorak et al., 2014; Emery & Simons, 2020). Due to the novelty of this study's proposed variables and analyses, there were no literature recommendations for minimum detectable effect sizes for the variables of interest. However, when looking at the substance use motives literature broadly, effect sizes were, on average, between $\beta = 0.06$ and $\beta = 0.25$ at the within-person level, and between $\beta = 0.09$ and $\beta = 0.36$ at the between-person level. Since the aims of this study were momentary in nature, we focused our power simulations on the minimum detectable effect sizes at the within-person level. Results from 10,000 simulations indicated that a sample of 50 individuals with 293 observations was ≥80% powered to detect within-person effects of $\beta = 0.20$ or higher. It is important to note that the final models had more observations and a series of covariates which accounted for additional residual variance not estimated in this model,

effectively increasing power above what was seen here. Accordingly, the models were adequately powered to detect any clinically meaningful effects.

Results

Descriptive Statistics

At baseline, 34% of participants endorsed 2 or more symptoms of AUD, 36% endorsed 2 or more symptoms of CUD, and 30% endorsed 2 or more symptoms of both. Participants completed 3,163 random surveys of the possible 4,200 across the sampling period, indicating a 75.3% compliance rate, which is standard for individuals in this population (Jones et al., 2019). There were 373 individual use moments across the sampling period. Unknown motive endorsement occurred during 149 use moments (39.95%) and was the endorsed as the **only** motive 115 times (30.83%). In the overall sample, individuals reported 6.14 use moments on average across the sampling period (Median = 5, Range = 0 - 25, *SD* = 6.49). On average, individuals endorsed unknown motives about 2.3 times across the sampling period (Median = 1 Range = 0 – 18, *SD* = 3.48) and reported experiencing 6.72 problems (Median = 4, Range = 0 - 49 *SD* = 8.85). Due to the item pairs required for the affect analysis (i.e., previous moment affect and next moment endorsement), 293 use moments were included; of these, individuals endorsed "I don't know" 103 times (35.15%). Due to the item pairs required for the lagged analyses, 167 use moments were included; of these, individuals endorsed "I don't know" 78 times (46.7%). See Table 1 for more descriptive statistics and bivariate correlation matrix.

Intraclass correlations (ICC) were estimated to determine the proportion of variance in the focal variables that is attributable to within- and between-person differences. The ICC for unknown motive endorsement was 0.21, denoting that about 21% of the variance in probability of selecting "I don't know" at the event level was attributed to between-person differences (i.e., some individuals may be more or less likely to endorse "I don't know" than others). Conversely,

this demonstrates that **79% of this propensity varied at the within-person level**, suggesting that, largely, momentary factors make all individuals more or less likely to select "I don't know" at any given moment. In other words, one's probability of endorsement varies significantly across time. The ICCs were 0.44 and 0.41 for PA and NA, respectively, denoting that about 60% of the variability in affective experiences were due to within-person factors. Finally, the ICC for problems was 0.14, also demonstrating a large percentage (86%) of variability in experiencing substance-use related problems occurred at the moment-level. In all, ICCs for all focal variables supported utilization of and emphasis on event-level analyses.

Multilevel Model Results

Multilevel models were estimated to test the hypothesized prospective associations. Multilevel logistic regression was used to test the expected quadratic associations between PA, NA at the previous moment and the odds of unknown motive endorsement at the next moment. Quadratic interactions were probed utilizing a marginal effects at representative values approach (Williams, 2012) followed by a test of second differences to determine significant differences between slopes (Mize, 2019). Multilevel negative binomial regression was used to test the expected prospective association between unknown motive endorsement and problems. See Table 1 for bivariate correlations.

Table 1. Correlation matrix and descriptive statistics

Variable	*M*	(*SD*)	2	3	4	5	6
1. Sex			.22***	–.24***	.07***	–.10***	–.02
2. Age	19.1	1.4		–.22***	–.16***	.07***	.004
3. Negative Affect	2.4	1.3			–.25***	.10***	.34***
4. Positive Affect	5.4	1.3		–.50***		–.16***	–.20***
5. Unknown Motive Endorsement	2.3	3.5		.11*	–.09		.21***

6. Problems	5.9	7.6	.12***	–.10***	–.04

Note. ***Means*** and ***SD***s are either person-level aggregates over the sampling period or baseline measures. To the left of the diagonal are the within-person level correlations and to the right are the between-person level correlations. *Within-person note.* Observations 4,980 person-moments. Problems = number of problems since last survey. Positive and negative affect = mean in past 30 mins. *Between-person note. N* = 68. Sex (male = 0, female = 1). Problems = total number of problems over the sampling period. Positive and negative affect = person-average aggregates over the sampling period. * $p < .05$, ** $p < .01$, *** $p < .001$.

Unknown motive endorsement

At the within-person level (L1), neither PA nor NA at the previous moment exhibited any significant linear effect on odds of unknown motive endorsement (*p*s > .052). However, both PA (*OR* = 0.73, SE = 0.06, $p < .001$) and NA (*OR* = 1.20, SE = 0.07, $p = .002$) at the previous moment exhibited a significant quadratic effect on odds of endorsing an unknown motive at the next moment as hypothesized (see Table 2 for full model results). NA demonstrated a positive quadratic association, such that the highest likelihood of unknown motive endorsement occurred when the previous moment was characterized by higher- or lower-than average levels of NA (see Figure 1). On the other hand, and contrary to our hypotheses, PA demonstrated a negative quadratic association, such that the highest likelihood of unknown motive endorsement occurred when the previous moment was characterized by mean levels of PA (see Figure 2).

Table 2. Multilevel logistic regression model of affect and unknown motive endorsement

	OR	*SE*	*z*	*p*-value	*95% CI*
Within-Person (L1; Time-Varying)					
Monday	1.26	1.08	0.64	.521	0.40, 6.05
Tuesday	1.72	1.23	0.76	.445	0.42, 6.99
Wednesday	1.03	0.74	0.04	.971	0.25, 4.19
Thursday	1.49	0.97	0.60	.548	0.41, 5.45

Friday	0.86	0.55	-0.23	.816	0.25, 3.01
Saturday	1.46	0.91	0.62	.536	0.44, 4.89
Day in the Study	**1.26**	**0.06**	**4.87**	**<.001**	1.14, 1.38
Lagged Negative Affect (NA)	0.73	0.16	0.28	.783	0.78, 1.40
Quadratic Lagged NA	**1.20**	**0.07**	**3.13**	**.002**	**1.07, 1.35**
Lagged Positive Affect (PA)	**1.37**	**0.22**	**1.95**	**0.05**	**0.94, 1.05**
Quadratic Lagged PA	**0.72**	**0.06**	**-3.62**	**<.001**	**0.61, 0.86**
Between-Person (L2; Time-Invariant)					
Sex	0.57	0.53	-0.61	.544	0.09, 3.48

Note: *N* = 50. Level 1 observations = 293 person use-moments. *OR* = Odds ratio. Level 1 variables were person-mean centered and Level 2 variables were grand-mean centered. Sex (female = 0, male = 1). Sunday was the reference group for day-of-the-week indicators.

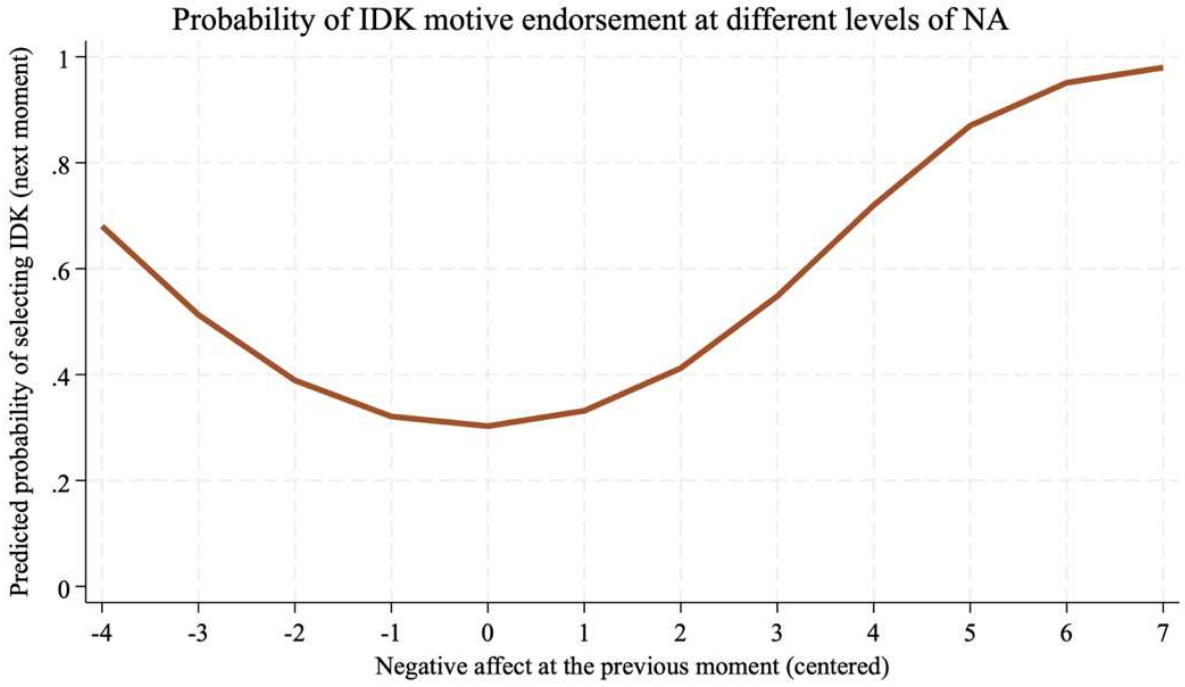

Figure 1. Predicted probabilities of prospective unknown motive endorsement and negative affect

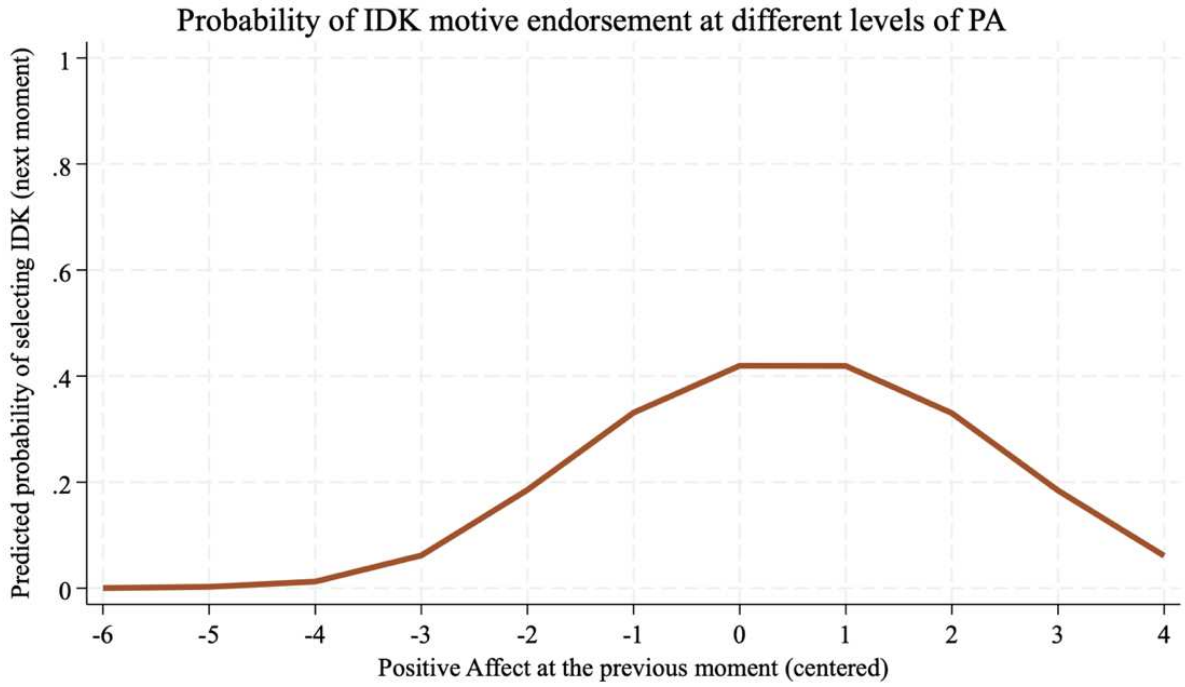

Figure 2. Predicted probabilities of prospective unknown motive endorsement and positive affect

Marginal effects at representative values (i.e., ±1 *SD*, mean) were used to probe the NA quadratic interaction statistically. A test of second differences (i.e., linear comparisons) was used to determine significant differences between slopes (Mize, 2019). Results from test of second differences demonstrated that slope values at lower-than-average NA (difference = -0.07, p = .002) and higher-than-average NA (difference = -0.08, p = .001) were significantly different from the slope at the mean. That is, the direction of the curve significantly changed from a negative slope at -1 *SD* to a positive slope at +1 *SD*, demonstrating a quadratic relationship. See Table 3a for marginal effect values and Table 3b for linear comparisons. See Figure 3 for slope plot.

Table 3a. Marginal Effects – Negative Affect

	dy/dx	*SE*	*p*-value	*95% CI*
Negative Affect (Lagged)				

-1.496 (- 1SD)	-.068	.034	.051	-.135, .000
0 (Mean)	.005	.019	.784	-0.32, .043
1.496 (+1SD)	**.080**	**.029**	**.007**	**.022, .138**

Note: $N = 50$. Level 1 observations = 293 person use-moments. *Dy/dx* = slope or rate of change value for every 1 unit change in NA.

Table 3b. Linear Comparisons – Negative Affect

	lincom	*SE*	*p*-value
Negative Affect (Lagged)			
-1SD compared to Mean	**-.073**	**.024**	**.002**
+1SD compared to Mean	**-.075**	**.023**	**.001**

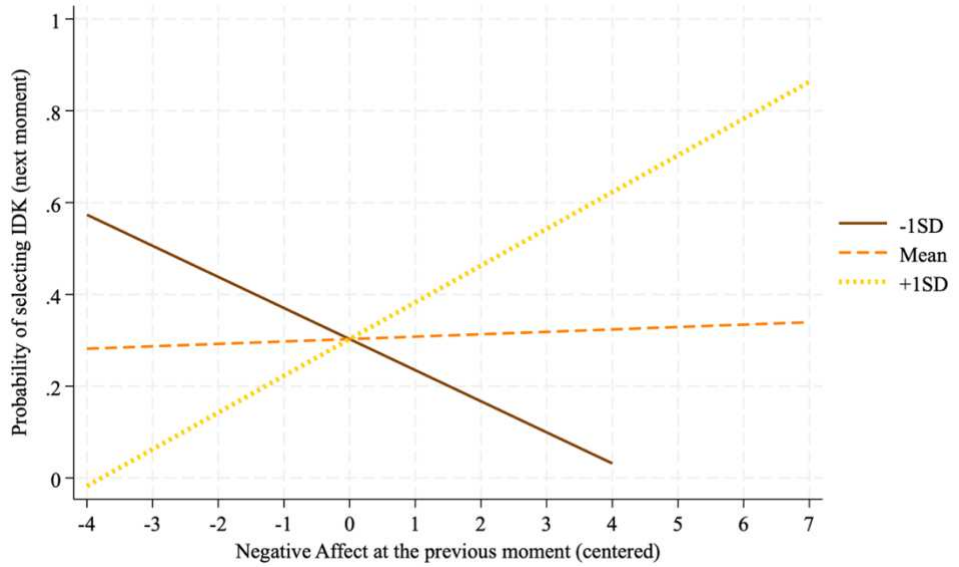

Figure 3. Slopes at representative values (negative affect)

To probe the PA quadratic interaction, marginal effects at representative values (i.e., ±1 *SD*, mean) and subsequent test of second differences results revealed that slope values at lower-than-average PA (difference = 0.10, $p = .001$) and higher-than-average PA (difference = 0.14, $p < .001$) were significantly different from the slope at the mean. That is, the direction of the curve

significantly changed from a positive slope (i.e., at -1 *SD*) to about zero (i.e., at the mean) to a negative slope (i.e., at -1 *SD*), demonstrating a quadratic relationship. See Table 4a for marginal effects values and Table 4b for linear comparisons. See Figure 4 for slope plot.

Table 4a. Marginal Effects – Positive Affect

	dy/dx	*SE*	*p*-value	*95% CI*
Positive Affect (Lagged)				
-1.517 (- 1SD)	**.150**	**.031**	**< .001**	**0.09, .211**
0 (Mean)	.045	.023	.051	.000, .092
1.517 (+1SD)	**-.091**	**.039**	**.019**	**-.168, -.015**

Note: *N* = 50. Level 1 observations = 293 person use-moments. *Dy/dx* = slope or rate of change value for every 1 unit change in PA.

Table 4b. Linear Comparisons – Positive Affect

	lincom	*SE*	*p*-value
Positive Affect (Lagged)			
-1SD compared to Mean	**.104**	**.031**	**.001**
+1SD compared to Mean	**.137**	**.037**	**<.001**

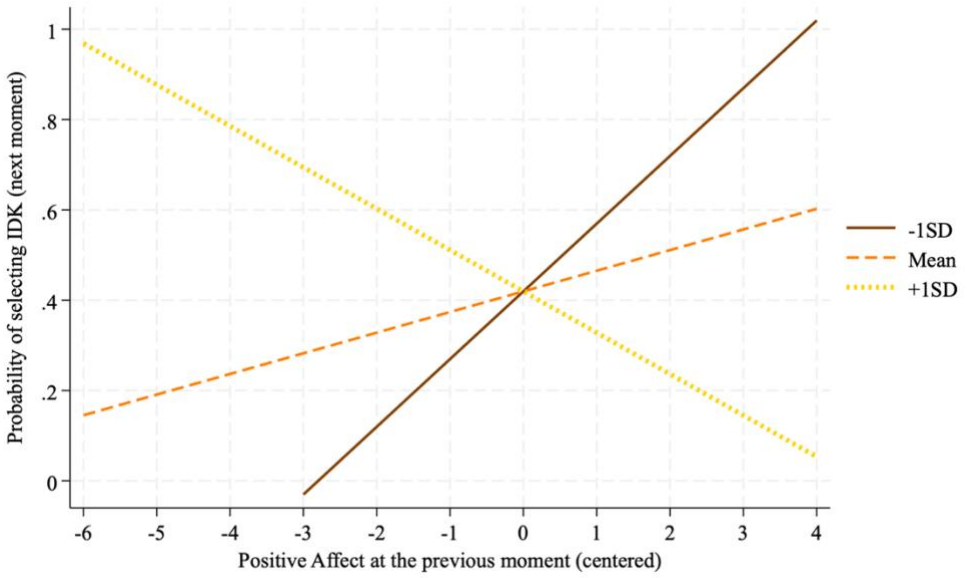

Figure 4. Slopes at representative values (positive affect)

Problems

To test the hypothesized prospective predictive relationship between unknown motive endorsement and number of problems experienced at the next moment, we utilized a multilevel negative binomial regression. Results demonstrated that unknown motive endorsement at the previous moment was not significantly associated with number of problems experienced at the next moment (p = .69). See Table 5 for regression results.

Table 5. Multilevel negative binomial regression model of unknown motive endorsement and problems

	IRR	*SE*	*z*	*p*-value	*95% CI*
Within-Person (L1; Time-Varying)					
Day of the week	1.35	.270	1.54	.122	0.92, 2.00
Day in the Study	0.95	0.09	-0.57	.570	0.78, 1.14
Lagged Unknown Motive Endorsement	1.47	1.34	0.43	.688	0.25, 8.81
Between-Person (L2; Time-Invariant)					
Sex	0.83	1.13	-0.13	.896	0.06, 11.8

Person-Average Number of Unknown Motive Endorsements	1.07	.075	0.96	.338	0.93, 1.23

Note: $N = 40$. Level 1 observations = 167 person use-moments. *IRR* = incident rate ratio. Level 1 variables were person-mean centered and Level 2 variables were grand-mean centered. Sex (female = 0, male = 1). Sunday was the reference group for day-of-the-week indicators.

Discussion

Overall, the current study sought to empirically test the theoretically proposed construct of unknown substance use motive endorsement. Multiple models of addiction, including the affective motivational model (Cooper et al., 2015) emphasize the importance of contextual factors for making moment-to-moment decisions about substance use. These models also outline the role of awareness in decision-making, stating that decisions about use may happen within *and* outside of conscious awareness depending on important contextual information (e.g., affect; Cooper et al., 2015; McCarthy et al., 2010; Wiers et al., 2007). Despite longstanding theoretical conceptualization and discussion of this construct in the literature, to our knowledge, this is the first empirical work to test this phenomenon. Results from this study suggest that unknown motive endorsement occurs quite often (i.e., roughly 30-40% of use moments). The high frequency of its occurrence suggests that individuals are engaging in substance use without clear or conscious knowledge about why. This represents an important and novel contribution to the substance use motives literature, providing preliminary empirical evidence for a theoretically predicted phenomenon. The study also sought to fill this gap in the literature by investigating under what conditions individuals endorse unknown substance use motives. Given the centrality of affective functioning in both addiction (e.g., Cooper et al., 2015; Koob, 2015) and decision making (Lerner et al., 2015), we examined the prospective impact of how individuals felt before use on unknown motive endorsement. Here, we found that NA and PA exhibited quadratic associations with unknown motive endorsement. Lastly, we set out to test if unknown motive endorsement would be prospectively linked with higher problems after use and were not able to

produce evidence supporting this hypothesized link. Below each of the findings are discussed with respect to the theoretical rationale that formed the hypotheses.

As hypothesized, NA at the previous moment displayed a quadratic relationship with unknown motive endorsement at the next moment, such that the highest probability of unknown motive endorsement occurred when the previous moment was characterized by higher- or lower-than average levels of NA. As demonstrated by the marginal effects analyses, the quadratic pattern of endorsement is supported by these data, as a significant change from a negative to positive slope through the mean was observed. These results are consistent with predictions set forth by negative reinforcement theories of addiction (e.g., McCarthy et al., 2010) and negative urgency (Cyders & Smith, 2008). It appears that the habitual and reflexive processing in response to low NA was predictive of substance use without clear articulation about why, hinting at the role of interoceptive and subconscious awareness about early withdrawal symptoms (Wiers et al., 2007) or learned and ingrained consequences of use (McCarthy et al., 2010). Additionally, high NA preceded unknown motive endorsement, suggesting that impulsive and quick-fix substance use behaviors are likely aimed at alleviating this NA without much deliberate thought (Cyders & Smith, 2008; McCarthy et al., 2010; Wiers et al., 2007). Future work should continue to examine the moment-to-moment predictive relationship between NA and unknown motive endorsement, and potentially explore patterns of co-motive endorsement across the spectrum of NA. That is, is an endorsement of unknown motives co-occurring with other substance use motives, and how does that co-occurrence vary at different levels of NA? Importantly, future work should also examine this association at the between-person (L2) level to better understand if people who experience lower and higher than average NA also endorse unknown motives more often.

Additionally, PA displayed a statistically significant quadratic relationship with unknown motive endorsement at the next moment. However, the pattern of endorsement was contrary to our hypotheses. Here, the highest predicted probability of endorsing an unknown motive at the next moment occurred at average levels of PA and decreased on either side of the mean. More specifically, lower- and higher-than-average PA were prospectively associated with lower probabilities of unknown motive endorsement. While contrary to our hypotheses, this effect may make sense in the context of the overarching PA literature. As PA increases, an individual's ability to differentiate positive emotions increases (Emery et al., 2022). As such, at high levels PA, individuals may have a better grasp on what they are feeling and thus are better able to articulate why they are using, as well. At low levels of PA, though individuals may have a diminished ability to differentiate their emotions, they may be consciously aware of the lack of PA and, therefore, use this as a cue to mobilize and engage in use behavior to boost their mood. This would be consistent with the priority afforded to mood repair and affective information processing, broadly (Tice et al., 2001). Additionally, it appears that the habitual or reflexive processing (i.e., implicit processing) might be occurring when individuals are at their mean level of PA, such that there may be a lack of interoceptive cues suggesting that an affective shift is desired or required (which may be present at lower and higher than average levels of PA). In this case, people are less likely to understand why they are engaging in use behaviors since they are not linked to any explicit or internal context. This may be characteristic of SUD, whereby individuals use substances at mean levels of PA without explicit knowledge of why (i.e., habitually and reflexively) rather than intentionally and with clear understanding. As such, this relationship could look different in a non-clinical sample, potentially more in line with the hypothesized association. Results from this study are also somewhat inconsistent with research

on the association between positive urgency and substance use, which posits substance use behavior is engaged in with little deliberate thought to amplify PA (e.g., Cyders & Smith, 2008). It is possible that this pattern of effects might emerge if PA arousal level were taken into consideration. Our composite score of PA included low arousal positive affect (i.e., calm, relaxed) as well as high arousal PA (i.e., happy, excited). However, positive urgency may not apply to individuals experiencing high levels of low arousal PA (e.g., calmness) in the same way that it would to individuals experiencing high levels of high arousal PA (e.g., excitement). Thus, future work may consider disentangling affective arousal *and* valence to see if results are more consistent with the above hypotheses. Similarly to NA, future studies should examine how these results replicate, the unique motive profiles endorsed moment-to-moment, and their relationship with PA. Future work should also consider examining this association at the between-person (L2) level to characterize individual differences in PA and unknown motive endorsement.

Future work should also consider examining how craving may impact the relationship between affect and unknown motive endorsement. Though certain models of addiction specify craving as a potential motivation for use (e.g., wanting; Robinson & Berridge, 2008), affective-motivation models and associated questionnaires do not include craving specifically as a separate motive for substance use (e.g., Cooper et al., 2015; Simons et al., 1998). Instead, craving might be conceptualized as a cue to use via negative reinforcement (i.e., alleviating craving; Koob & Le Moal, 2001; Robinson & Berridge, 1998); however, it is possible that individuals are not experiencing craving as an aversive state. For example, repeated use followed by positive affective states prospectively induces craving for positive affective states achieved through substance use (Tiffany, 2010). As such, craving may, in fact, act as a positively reinforcing signal that something good is to come and encourage individuals to engage in approach

behaviors associated with substance use. While the substance use trait-motive model is largely supported by empirical work (Cooper et al., 2015), substance use motives have been shown to vary within-person and moment-to-moment (Votaw & Witkiewitz, 2021). Due to the salient, yet transient nature of craving, it is possible that, at least some of the time, individuals endorsing unknown substance use motives are using substances due to craving but are not explicitly or consciously conceptualizing this as "coping" or alleviating craving. Future studies should investigate if and how craving changes the pattern observed in this study and if craving interacts with affect to produce different effects across the spectrum of PA and NA.

Taken together, the pattern of unknown motive endorsement observed here underscores the importance in understanding the affective circumstances that precede use. Additionally, these results provide evidence that affect may have non-linear (potentially quadratic) associations with use variables, due to the prioritization of mood repair (Tice et al., 2001). Highlighting these conditions provides a framework for prevention and intervention efforts in substance use treatment. The results of this study stress the importance of emotion up- and down-regulation when making decisions to use- such that mindfulness-based treatment protocols to increase interoceptive awareness of affective states to an optimal level for making critical, intentional decisions about use may be providing many mechanisms of change. In tandem, substance use motives may be modifiable (Crutzen et al., 2013), thus providing a direct target for treatment.

Contrary to our hypothesis, unknown motive endorsement was not associated with an increased number of problems at the next moment. It is important to note that the results of our analyses are somewhat inconclusive due to the statistical complexity of our model. However, the effect of this motive endorsement may be small at the within-person level, and we may have been underpowered in its detection. Additionally, the nature of the problems included in the

YAACQ (Read et al., 2006) may not be representative of potential consequences of using without a clear understanding of why. For example, problems due to unknown motive endorsement may be affective in nature rather than behavioral. Future work might consider investigating how unknown motive endorsement is associated to a variety of problems or consequences or seek to identify what specific problems stem from unknown motive endorsement. Similarly, due to the timing of the random assessments and the necessity of previous moment – next moment item pairs, it is possible that use or problem observations were missed and/or were dropped from the analytic sample. This would impact our ability to observe a small effect. Alternatively, this relationship may be observable at the person-level (L2), such that individuals that endorse an unknown motive more often experience more problems across the sampling period, rather than at the moment-level (i.e., Simpson's paradox; Simpson, 1951). Indeed, bivariate correlations demonstrated a significant association between between-person unknown motive endorsement and problems (see Table 1), and future work specifically aimed at and adequately powered for investigating between-person relationships should study this association further. Problems are also a low frequency event in this population (Atkins et al., 2013) and given the distribution of SUD symptom severity (see descriptive statistics section above), it is possible that this relationship may look different in a community sample with individuals that have more severe SUD. Future work should investigate this phenomenon in a community sample, experiencing a wider variety of SUD severity and its relationship to problems to bolster understanding and generalizability.

Importantly, conceptualization of unknown motives makes most sense to occur at the state level. In this way, unknown motive endorsement does not represent an independently occurring motive, per se, so much as it is descriptive of an underlying lack of awareness for any motive for

use that is likely a time-limited state that is contextually bound. That is, responding "I don't know" to the substance use motive question represents an experiential state that is dynamic rather than a discrete motive for use. While individuals can articulate why they use at the trait level (i.e., motives for use broadly), this study demonstrated that unknown motive endorsement occurs at the momentary level. Much of the work investigating substance use motives has occurred at the trait-level (Votaw & Witkiewitz, 2021), and, as such, unknown substance use motive investigation did not make sense in this context. However, theoretical models discuss this fleeting state such that articulation for a discrete motive is not possible or is inaccessible (e.g., occurs implicitly or habitually; Cooper et al., 2015; Wiers et al., 2007). Supported by dual process theory (Lieberman, 2007; Satpute & Lieberman, 2006), individuals endorsing "I don't know" at the moment-level may be experiencing tension in explicit and implicit processing systems – such that their explicit motive for use is unknown while an implicit process is occurring. For example, as theorized by McCarthy et al. (2010), moments characterized by low NA were associated with a greater probability of unknown motive endorsement; in this way, implicit processing suggests that individuals are using habitually to avoid aversive withdrawal stimuli (akin to a coping motive), yet are explicitly unaware or cannot articulate this reasoning – thus manifesting as an "I don't know" response. In this way, unknown motives are unlikely to be discrete motivational states insofar as they represent a unique and separate motive for use; rather, this endorsement is an explicit manifestation of quick and implicit processes representative of a time-limited (i.e., momentary) **state** that is contextually bound. Future work should continue expanding on this occurrence by investigating co-occurring motives with an "I don't know" endorsement and mapping the contextual similarities and differences and how unknown motive

endorsement varies within- and between-persons to better understand its contextual and person-level boundary conditions.

This study was novel in both theoretical application and methodology. We leveraged EMA to investigate a phenomenon that is predicted in prominent theories of substance use motivations (e.g., McCarthy et al., 2010; Wiers et al., 2007) yet has not been investigated empirically. This study provides proof-of-concept for better understanding substance use motive momentary fluctuations, particularly as they relate to affective experiences. The novelty and important contributions of this study should be balanced against its limitations. Firstly, we ran separate statistical models, with unknown motive endorsement as an outcome variable in the first model (H_1, H_2) and as a predictor variable in the second model (H_3). Previous work has demonstrated a mediation (e.g., Adams et al., 2012; Hildebrandt et al., 2021) relationship between affect, motives and outcomes; as such, it may be plausible to conduct a mediation analysis in the future. Our rationale for utilizing separate models was, primarily, to fundamentally understand the nature of this phenomenon, since, to our knowledge, it is the first empirical study of this construct before including them all in a mediation analysis. In other words, we first sought to understand if or how affect is related to unknown motive endorsement *and* if or how unknown motive endorsement is related to experiencing problems before hypothesizing a mediation model. Once each component of the mediation is explored and better understood, placing each variable in a mediation model may make sense in future studies. Indeed, evidence from this study does not support a mediation model in this context specifically due to the lack of significant association between unknown motive endorsement and problems. Additionally, though individuals were able to select multiple substance use motives at the event level, we did not include or control for endorsement of other motives in our models. Similarly to the point

above, we sought to foundationally understand if the associations between an unknown motive endorsement, affect and problems exist before determining if unknown motive endorsement accounts for any unique variance when tested in tandem with other motives. Future work should include other motives relevant to the research question to better understand how much unique variance is accounted for by an unknown motive endorsement. In addition, while using EMA allows for greater ecological validity by asking participants questions about their experiences in real-time and real-world contexts (Shiffman et al., 2008), we cannot assume causality from our methodology. The events can be ordered in an appropriate temporal sequence (e.g., identifying use moments from one survey and predicting outcomes from the following survey), but due to the lack of direct manipulation, these relationships are associative in nature. Finally, our momentary assessments ask about an individual's experience from the past 30 minutes, and the surveys may be delivered hours apart. As such, we may potentially be missing substance use events and associated motives that occur outside of this time window. One potential solution to this would be to introduce event-contingent surveys, such that individuals initiate a survey before and after use events, to increase temporal validity. This type of survey comes with a host of other challenges, including more difficulty with compliance (Shiffman et al., 2008). Future work should consider utilizing both signal- and event-contingent surveys to gain a more wholistic, fine-grained and closer temporal view of individuals' use patterns and motives. Future work that is adequately powered with a larger sample could also examine the magnitude of these probability differences – that is, how *much greater* is the probability of endorsing an unknown motive at ±1 *SD* compared to the probability at the mean?

In sum, this study provided seminal empirical support and a proof-of-concept study for a theoretically predicted occurrence in the substance use motive literature. Individuals are selecting

an unknown motive when the option to do so is presented, which provides critical next steps in exploring this phenomenon. Additionally, this motive endorsement is contextualized by specific levels of affect; particularly, both affective valence *and* intensity have varying relationships with unknown motive endorsement. this study sought to fill an important gap in the literature at the intersection between substance use motives, affect, awareness and consequences. Theory regarding motivation for substance use has predicted the event-level occurrence of this phenomenon, yet to our knowledge no empirical work has explored it thus far. As such, this study serves as a seminal and foundational empirical work in the literature. Understanding how awareness of one's actions is impacted by contextual factors (e.g., affect) and how that awareness effects the consequences of one's decision-making is prudent and has potential implications for prevention and intervention efforts in the field of substance use treatment, particularly in the context of mindfulness-based treatment efforts, which inherently outline the role of awareness in decision-making.

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