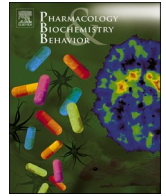


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Role of social context in addiction etiology and recovery

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ABSTRACT

While social context has long been considered central to substance use disorder prevention and treatment and many drug-taking events occur in social settings, experimental research on social context has historically been limited. Recent years have seen an emergence of concerted preclinical and human laboratory research documenting the direct impact of social context on substance use, delineating behavioral and neurobiological mechanisms underlying social influence's role. We review this emerging preclinical and human laboratory literature from a theoretical lens that considers distinct stages of the addiction process including drug initiation/acquisition, escalation, and recovery. A key conclusion of existing research is that the impact of the social environment is critically moderated by the drug-taking behavior and drug use history of a social peer. Specifically, while drug-free social contexts can reduce the likelihood of drug use initiation and act as a competitive non-drug alternative preventing escalation, drug-using peers can equally facilitate initiation and escalation through peer modeling as a contingent reward of use. Likewise, social context may facilitate recovery or serve as a barrier that increases the chances of a return to regular use. We conclude by discussing evidence-based treatments and recovery support services that explicitly target social mechanisms or that have identified social context as a mechanism of change within treatment. Ultimately, new areas for research including the expansion of drug classes studied and novel human laboratory designs are needed to further translate emerging findings into clinical practice.

1. Overview

The social environment is a complex and multifaceted modulator of substance use etiology and recovery. Prevalence rates of alcohol use, for example, show that most people report drinking primarily in social groups with only 14 % of adolescents and 15–24 % of young adults reporting solitary drinking (Christiansen et al., 2002; Creswell, 2021; Mason et al., 2020; O'Hare, 1990; Williams et al., 2015). While social context has long been considered central in substance use disorder prevention, treatment, and recovery and many drug-taking events occur in social settings (Creswell, 2021; Smith, 2021), little attention has been paid to understanding this context using experimental methods. Fortunately, recent years have seen an emergence of concerted preclinical and human laboratory research documenting these impacts, delineating behavioral and neurobiological mechanisms underlying social influence's role (de Wit and Sayette, 2018; Strickland and Smith, 2014). Some of this preclinical work has begun to show how the presence of a

social peer does not uniformly affect substance use propensity, but that this influence is critically moderated by the substance-related history of that peer (e.g., Hofford et al., 2020; Smith, 2012; Smith et al., 2014; Weiss et al., 2018). At the same time, proximal social reward can act as a potent alternative reinforcer leading to marked reductions in drug intake within discrete choice contexts, modeling the trajectory of recovery in clinical populations (e.g., Venniro and Shaham, 2020; Venniro et al., 2018).

Evidence from human research similarly highlights a complex relation between social context and substance use. Alcohol, for example, increases subjective feelings and objective indicators of social connection (Sayette et al., 2012), and people reporting a greater number of heavy drinking friends, in addition to having friends present during a specific drinking episode, also report greater heavy drinking (Murphy et al., 2006; Thrull and Kuntsche, 2015) and motivation to drink (Acuff et al., 2020a; Acuff et al., 2020b). On the other hand, solitary drinking is generally associated with increased alcohol-related problems, in

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addition to greater suicidal ideation, depression, and social anxiety (Bilevicius et al., 2018; Keough et al., 2018), illustrating the complex interaction between social context (or lack thereof), substance use, and accompanying risky behaviors.

Alternatively, human studies demonstrate that social context may be leveraged in support of successful recovery from substance use disorders. Greater support from non-substance using peers, and a shift away from substance-using peers, is associated with increased recovery success (Kelly et al., 2014), and critical, passive communication from closed loved ones during a recovery attempt appears to dampen recovery efforts (McCrary, 2004). These findings provide a foundation for targeting social context as a mechanism of substance use recovery. Social context has been identified as a mechanism for both recovery support services, such as mutual help groups (Kelly et al., 2012) and recovery coaches (Eddie et al., 2019), and psychosocial treatments, such as Alcohol Behavioral Couples Therapy (McCrary, 2012) and Community Reinforcement Approach and Family Training (Azrin, 1976).

Given the importance of social context in substance use and emerging research in this domain, several recent reviews have explored this connection, summarizing topics such as the impact of substance use on neural circuits underlying social engagement and isolation (Volkow et al., 2011), sensory modalities that may modulate the effect of social context on substance use (Pelloux et al., 2019), effects of social contact on conditioned drug reward (Zernig et al., 2013), animal models of social contact and drug self-administration (Strickland and Smith, 2015), non-pharmacological factors impacting substance use with an emphasis on social defeat stress (Ahmed et al., 2020), and the role of social exclusion and underlying neurobehavioral mechanisms in addiction (Heilig et al., 2016). In this narrative review and commentary, we sought to extend these recent reviews through a translationally framed discussion of the protective and risk-related impacts of social context as they apply within each stage of addiction and recovery. Borrowing from theoretical frameworks commonly applied in animal models of substance use, we organize our discussion around specific stages in the addiction process including (a) initiation (or acquisition) of substance use, (b) escalation to high levels of substance use in the development and

progression of substance use disorder, and (c) recovery, which entails a non-linear transition between periods of sustained abstinence and returns to use (i.e., relapse) (Fig. 1). We begin each section by describing extant preclinical literature that suggests interactions of social context with pharmacological variables in impacting substance-relevant behaviors. We then provide prototypic examples from human laboratory and clinical trial designs evidencing corresponding impacts of social context in each stage. In the context of recovery (where experimental studies are limited due to inherent ethical restrictions), we also discuss evidence-based interventions that explicitly target social mechanisms or consider social factors as a mechanism of change. We conclude with general directions for future research based on existing gaps and relevant clinical directions.

2. Substance use initiation

Experimentation with drugs is a normative process for many people (Sznitman and Taubman, 2016). In fact, substance use during adolescence and early adulthood can serve to achieve evolutionary beneficial goals related to belonging, status, and partnership (Ellis et al., 2012). From a prevention perspective, research should distinguish between these developmentally typical initial experiences with drugs from atypical experiences that rapidly transition to regular patterns of use and corresponding health consequences. A goal of public health policy is to identify factors related to those at risk for these transitions and introduce primary prevention programming to reduce use initiation and transition in these groups.

The role of social variables in substance use initiation (operationalized as a period, including initial use, prior to the establishment of regular patterns and escalation of that use) is widely documented in epidemiological research (Guisse et al., 2017; Kuntsche and Müller, 2012). Social factors are a logical target for such programming given the proximal influence that the social context plays in many first use experiences and the ability for social influence to encourage use experimentation. In the following section, we review research in preclinical and human laboratory models that provide experimental evidence

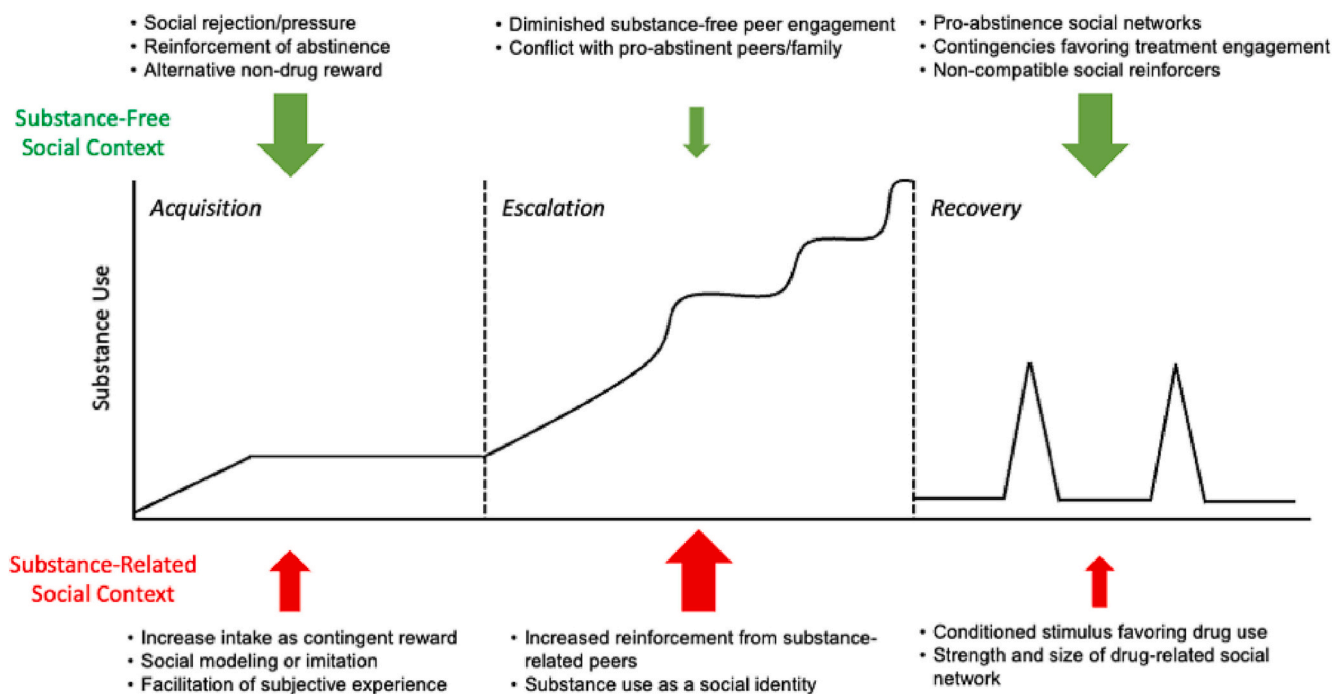


Fig. 1. Impact of substance-free and substance-related social context across the addiction lifespan. Depicted are examples of mechanisms by which social context can reduce or increase use across various drug acquisition/initiation, escalation of use, and recovery (and return to use). Size of the arrows reflects a hypothesized relative weight of factors in each stage.

supporting these epidemiological associations.

2.1. Preclinical evidence of social interaction and social stress in drug acquisition

Preclinical studies typically model the acquisition of substance use by measuring drug self-administration in free-operant arrangements following a period of non-contingent drug exposure or testing without prior behavioral training (e.g., autoshaping) (Carroll and Meisch, 2011). These studies provide a unique opportunity to evaluate biological and environmental processes that increase vulnerability to drug acquisition addressing the ethical constraints of experimentally measuring patterns of drug use in drug-naïve humans. Overall, these findings suggest that influence of social context on initiation of substance use is dependent upon the peer's relationship with the substance and may act as either a protective or risk factor.

Research conducted in rodent models demonstrates that social context can influence initial substance use decisions in a manner that is partner-specific and related to interactions between social and pharmacological rewards within these experimental arrangements. One study evaluated male pair-housed rats that were tested for cocaine acquisition in the presence of a social conspecific (i.e., social partner or socially proximal subject) that was either cocaine-experienced and self-administering cocaine or cocaine-naïve and self-administering saline (Smith et al., 2014). Subjects tested with a cocaine-experienced conspecific showed a faster rate of cocaine acquisition relative to those tested with a cocaine-naïve conspecific, with an isolated control group acquiring self-administration at a rate that fell between these two experimental groups. These findings demonstrated that a social peer could facilitate or inhibit drug acquisition depending on the drug use nature of that peer, a finding consistent with epidemiological work showing differences in risk based on social peer group use behaviors (Bahr et al., 2005; Walden et al., 2004).

Social stress is also a documented risk factor for the development of substance use in preclinical models. Social stress is often manipulated via factors including overcrowding or social defeat in which a subject is exposed to uncontrollable, intermittent confrontations with an aggressive resident rat (see reviews in Ahmed et al., 2020; Newman et al., 2018). One study, for example, demonstrated that male rats that underwent a social defeat stress paradigm acquired cocaine self-administration in approximately half the time as subjects that underwent control conditions suggesting an acute effect of the social stress on the development of drug-taking behavior (Tidey and Miczek, 1997).

Similar work has shown that the effects of proximal social contact on drug-taking behavior may relate to an interaction of social context reward and pharmacological parameters. Several studies have demonstrated that the rewarding effects of drugs and social context as measured by conditioned place preference procedures (i.e., use of conditioned pairing of a stimulus and context to evaluate the rewarding/aversive effects of the stimulus) are enhanced when co-conditioned/administered together (e.g., Thiel et al., 2008; Thiel et al., 2009; Watanabe, 2013), while social conspecifics can prevent or inhibit drug preference when conditioned separately (e.g., Fritz et al., 2011a; Fritz et al., 2011b). Extending this line of work, one study evaluated social preference using a partner preference procedure among adolescent male rats that underwent conditioning sessions with both cocaine and saline-treatment conspecifics (Smith et al., 2015). Test subjects treated with cocaine showed an increased preference for the cocaine-treated and conditioned partner following conditioning suggestive that shared history of drug exposure increased social preference and reward. These findings were in line with another study demonstrating that male rats self-administering cocaine in the presence of social conspecifics with and without access to cocaine emitted more responses on a lever proximal to the cocaine access partner than saline access partner (Smith and Pitts, 2014).

These data are further supported by data demonstrating that initial

cocaine intake is higher when responses emitted for cocaine also provide contingent social access (Smith et al., 2021). Notably, that study also found that cocaine intake increased in a control group exposed to a non-social stimulus when provided with a social partner during testing sessions (i.e., conditions were reversed), whereas cocaine intake did not reduce in the contingent-social group when this stimulus was replaced by the non-social control. Such outcomes support the notion that proximal social rewards may reinforce early substance use initiation and confer lasting impacts on drug reward even when the contingent social reward is removed.

Taken together, these studies experimentally demonstrate that the development of regular patterns of substance use (i.e., "acquisition") following first drug exposure can be facilitated by the proximal impact of social peers as well as social stressors experienced. Importantly, social influence is greatest when concordant with drug-taking behavior either through a peer's access to contingent self-administration or through a shared history of conditioned drug use. These findings also suggest that reinforcement provided through contingent access to a social reward upon substance use may confer lasting impacts on the likelihood of substance use and transition to regular patterns of use.

2.2. Peer presence, peer imitation, and social stress effects in the human laboratory

Few human laboratory studies have evaluated the effects of proximal social influence on drug use behavior precluding experimental evaluation of social context effects on substance use decisions. These gaps are in part due to the challenges in experimentally evaluating use initiation in drug-naïve populations (e.g., ethical concerns related to exposing drug-naïve participants to a novel substance). Some ancillary evidence may be found through studies exploring peer presence, peer imitation, and social stress effects among drug experienced individuals under controlled laboratory settings. This body of work supports the preclinical data reviewed above that drug use behavior can be influenced by the presence of others in a state-dependent manner.

The most abundant evidence for peer effects on laboratory consumption behavior comes from studies of alcohol self-administration. Other studies have shown that alcohol self-administration is greater when participants are offered the opportunity to self-administer in social compared to isolated contexts within controlled laboratory settings (e.g., Doty and de Wit, 1995). Research using confederates to specifically manipulate peer behavior in the laboratory have provided some evidence for a social facilitation and matching effects wherein participants self-administer more alcohol when exposed to a heavy-drinking confederate compared to a light or non-drinking one (Caudill and Kong, 2001; Caudill and Marlatt, 1975; Larsen et al., 2013; Larsen et al., 2009; Larsen et al., 2010; Larsen et al., 2012; Lied and Marlatt, 1979). Preliminary evidence for imitation is also observed in these studies insofar as participants show a greater likelihood of sip initiation following a confederate sipping and that this correspondence was greatest when both were consuming alcohol (Larsen et al., 2010). Regardless of alcohol consumption level, the peer environment may influence subjective experience: one study found participants rated higher levels of self-reported intoxication when tested with an alcohol-consuming social partner compared to a social partner without access to alcohol in the laboratory (Kirkpatrick and De Wit, 2013).

Laboratory smoking (i.e., combustible cigarette use) research also indicates a significant role for social context in smoking behavior and affective processes dependent on the behavior of a social peer (see review in Dimoff and Sayette, 2017). These studies have shown that exposure to a high rate smoking confederate compared to a low rate or non-smoking confederate increases cigarette self-administration and decreases inter-cigarette intervals (Antonuccio and Lichtenstein, 1980; Harakeh et al., 2007; Harakeh and Vollebergh, 2012, 2013; Kniskern et al., 1983). In contrast, exposure to a non-smoking social interaction (i.e., non-smoking research assistants) present during experimental

sessions served to reduce the number of puffs taken and puff duration in light smokers compared to an isolated experimental session, whereas heavy smokers' behavior was not impacted by the non-smoking context (Miller et al., 1979). Notably, another study also showed reductions when exposed to a non-smoking confederate irrespective of social pressure to not smoke under laboratory condition (Harakeh and Vollebergh, 2011). In addition to these studies showing an impact of social context on cigarette administration, other studies have shown that cigarette use can increase positively-rated emotions in romantic social dyads in which both partners smoke, but decrease positive emotions in those where only a single partner smokes in laboratory paradigms (Rohrbaugh et al., 2009; Shoham et al., 2007), consistent with preclinical studies reviewed above documenting the relevance of peer-use behavior correspondence.

Few studies have evaluated consumption of drugs other than alcohol and nicotine within social contexts. One study found that confederates instructed to appear intoxicated or not intoxicated did not differentially impact subjective ratings of intoxication following laboratory administration of 15 mg of THC, although the relevance here is limited by reliance on confederate modeling (Carlin et al., 1972). Another study suggested that among participants residing on a residential research unit, cannabis use increased when ad libitum access was provided in a common area (social context) compared to a private room (isolation) (Kelly et al., 1994). Several studies have evaluated the effects of social context on stimulant response including amphetamine and MDMA. Interestingly, two studies failed to observe differences in the subjective effects of amphetamine when participants received the drug in a social compared to isolated laboratory context (de Wit et al., 1997; Zacny et al., 1992). In contrast, MDMA increased subjective drug effects (e.g., "Feel Drug") when administered with another participant who also received MDMA as compared to when administered alone or in the presence of a research assistant (Kirkpatrick and de Wit, 2015). This latter finding is broadly consistent with the observation that the effect of social context is critically moderated by the use behavior of the social peer.

Social stressors applied in the human laboratory have also been shown to increase anxiety-like behavior and drug-related response in a manner similar to preclinical studies. In fact, one of the most widely applied human laboratory models of stress uses social stressors as a primary manipulation likely due to the powerful evolutionary relevance of social stress (i.e., the Trier Social Stress Test; Kirschbaum et al., 1993). One study, for example, found that social stress increased anxiety and negatively impacted self-efficacy to smoke in the human laboratory, although notably only the physiological effects on heart rate and effects on observer report predicted smoking abstinence 3 months later (Niaura et al., 2002). Another study found that social stress increased consumption of alcohol, but also increased consumption of a control beverage suggesting that the effects of social stress in that context may have been non-specific to the pharmacological effects of alcohol (de Wit et al., 2003). These findings collectively recognize the role of social stress in anxiogenic responses as well as the complex relationship between stress and substance use.

3. Escalation of use

Substance use disorder is often characterized by a progression of use over time, referred to as escalation of use. This increase in drug intake reflects a combination of behavioral and biological factors (e.g., tolerance) and is a cardinal symptom in diagnostic criteria applied to identify harmful substance use. Similar to the initiation of early substance use patterns, social factors can play a role in these progressive increases in use over time. In the following section, we review research in preclinical and human laboratory models that describe the role of social factors in substance use disorder development and progression.

3.1. Preclinical evidence of escalation and progression of use

Consistent with the role of the social environment in the acquisition of substance use, preclinical research also suggests that the impact of the social environment is moderated by the drug-taking behavior and history of a social peer. For example, socially-housed male rats show increased cocaine self-administration when tested with a partner that is also self-administering cocaine, but show inhibited self-administration when that social partner does not have cocaine access (i.e., is self-administering saline) (Smith, 2012). Similar results are observed in female rats (Robinson et al., 2017) with econometric analyses indicating that these effects are largely attributable to changes in consumption at unconstrained costs rather than sensitivity to price (Peitz et al., 2013). Within-session analyses suggest that facilitation of drug intake may be mechanistically related to imitation insofar as response profiles become increasingly similar between social dyads over days of testing (Lacy et al., 2014).

Studies specifically modeling cardinal features of substance use disorder such as escalations in use, binge use, and choice of drugs in the context of alternative reinforcers also demonstrate this moderating role for social context (Robinson et al., 2016; Smith et al., 2023). These studies further suggest a specific protective effect of a social partner that does not have access to cocaine in these clinically-relevant models. For instance, one study found that male rats tested with a social partner without cocaine access showed lower levels of cocaine intake over a 14-day escalation protocol as well as lower intake in 23-hour test sessions modeling extended-access binge consumption (Robinson et al., 2016). Another study evaluated behavioral economic demand for concurrently available cocaine and social rewards with manipulations of the intoxication state of the social partner (i.e., cocaine-treated or cocaine free) (Smith et al., 2023). Concurrent access to responding for a cocaine-free social partner reduced cocaine demand relative to cocaine tested in isolation, however, concurrent access to a cocaine-treated social partner failed to reduce responding. Taken together, these findings emphasize the relevance of the nature of social interaction in determining effects on progression of substance use in preclinical models as well as a potential protective role of non-drug social peers (a topic returned to in Addiction Recovery below).

Social stress during the acquisition of drug self-administration increases the maintenance and progression of drug-taking behavior in rodent models. For example, male rats exposed to a social stress paradigm show increased cocaine self-administration on FR5 schedules across a dose-response function compared to controls (Miczek and Mutschler, 1996) as well as greater "binge" responding for both male and female rats (Holly et al., 2012). These effects possibly follow a stress-related dose-response function wherein high levels of social stress can reduce general responsiveness to stimuli given that some studies document decreases in drug self-administration following exposure to social defeat given immediately prior to testing (e.g., Funk et al., 2005).

Variance in social dominance hierarchies may also contribute to the escalation of long-term substance use. Both preclinical and human studies have documented social dominance hierarchies for which positive health effects may be observed for social dominant organisms and negative health effects observed for social subordinates (Qu et al., 2017). In the context of substance use, Morgan et al. (2002) found that in socially housed male cynomolgus macaques, socially dominant monkeys showed an increase availability of dopamine D2 receptors compared to socially subordinate monkeys or individually housed ones. Relevant behavioral outcomes were also observed wherein cocaine failed to serve as a reinforcer in the socially dominant monkeys but robust self-administration was observed in the subordinate subjects. Interestingly, a follow-up study in socially housed female cynomolgus macaques also found that dominant monkeys showed an increase in D2 receptor availability but were also more vulnerable to cocaine self-administration compared to subordinate female subjects (Nader et al., 2012). These findings in addition to demonstrating the role of social hierarchies in

impacting drug-taking behavior emphasize the importance of evaluating sex differences in these processes.

3.2. Human laboratory evidence of escalation and progression of use

Several lines of evidence support the role of social context in maintaining and contributing to the progression of consequences experienced in substance use disorder. Behavioral economics provides a particularly cogent and novel means for evaluating this contribution (Acuff et al., 2023; Bickel et al., 2014; Chung and Herrnstein, 1967; Hursh, 1984; Rachlin and Green, 1972). This approach posits that decisions are cost-benefit analyses with preferences for drugs over alternatives varying relative to the availability of and constraints on those alternatives. A key metric within these procedures is behavioral economic demand which quantifies the relationship between consumption of a good and its cost (Hursh and Roma, 2013; Strickland and Lacy, 2020). These approaches can effectively separate behavioral mechanisms of reinforcement into behavior at unconstrained cost (i.e., demand intensity) and sensitivity to cost (i.e., demand elasticity).

Human laboratory work using these behavioral economic approaches suggests that social contexts can elicit specific patterns of use corresponding to greater alcohol-related consequences. Akin to the preclinical studies reviewed above, these studies have shown that participants who self-report a greater density of heavy drinking within their social network also report greater alcohol demand within simulated behavioral tasks (Acuff et al., 2020a). Another study evaluated alcohol demand in simulated conditions of solitary use or social use (Acuff et al., 2020b). Participants showed elevated demand in the social condition suggesting a proximal risk factor for heavy drinking events. On the other hand, greater relative solitary drinking demand was associated with greater drinks per week and physical dependence symptoms. Similar results were observed in a follow-up study evaluating cannabis demand wherein peer context increased cannabis demand and cannabis demand in simulated solitary conditions was associated with cannabis use severity (Acuff et al., 2022).

These findings were extended naturalistically in a recent daily diary study conducted in an observational setting (Acuff et al., 2021). In that study, participants with a higher proportion of social, relative to solitary, drinking occasions had an decreased odds of heavy drinking over the course of the full study, whereas the presence of others during discrete drinking events was associated with an increased odds of heavy drinking during that particular drinking occasion. Correspondingly, meta-analytic data from cross-sectional surveys and other self-report questionnaires support this finding insofar as showing that greater solitary drinking is associated with increased alcohol consumption and drinking problems in adolescents and young adults (Skrzynski and Creswell, 2020). Conceptually, the observation that solitary drinking relates to greater alcohol-related problems has been linked to the function of social context to enhance positive, but solitary contexts to address alleviation of negative emotions (Creswell, 2021) mirroring conceptual models of alcohol use that posit alcohol use disorder involves a transition from reward to relief drinking (e.g., Koob, 2013a, 2013b; Koob and Le Moal, 2001).

These findings broadly highlight an important observation concerning the proximal role of social context in the maintenance and progression of alcohol use disorder symptoms. Namely, that social context acts as a momentary or proximal risk factor for heavy drinking whereas greater solitary drinking can be indicative of a broader progression of alcohol use disorder. Such differences are consistent with a *Simpson's paradox* – an ecological fallacy for which population-level correlates are in an opposite direction of momentary correlates for a given variable (Kievit et al., 2013; Simpson, 1951). This finding underscores the clinical relevance of considering the specific pathways by which social context can influence substance use events. These findings should also be considered in the balance of other mechanisms that may explain the progression of alcohol use disorder and heavy drinking (e.g.,

drinking to cope with negative psychological symptoms) emphasizing the importance of studying social factors in the context of other biopsychosocial mechanisms.

4. Addiction recovery

The previous sections illustrate the value of social connection, and that social context partially facilitates the development and maintenance of addiction. Equally so, social context may facilitate recovery from addiction: social reinforcement can serve both as a complement or substitute to substance use. Recovery, therefore, is a process that often requires reducing reinforcement from peers who still use substances while attempting to maintain, or rebuild, mechanisms of substance-free social reinforcement. Recovery from substance use does not involve a single discrete event of cessation or abstinence and the end of recovery is not defined by a single return to substance use (or relapse) (Ashford et al., 2019; White, 2007; Witkiewitz et al., 2020). Instead, recovery is comprised of a continuum of experiences that may include (but are not limited to) experiences with initial abstinence, sustained abstinence or reductions in use, and relapse either as a discrete event or maintained return to use. Preclinical studies are well equipped to isolate these different mechanisms that underlie recovery and often focus on either the promotion of abstinence or the return to use (i.e., relapse). In the following section we review preclinical studies in these two core domains involved in recovery – cessation of use and relapse – that have begun to evaluate neurobehavioral mechanisms underlying the impact of social context. Clinical studies are ethically limited in the ability to directly manipulate social variables in treatment-seeking populations, however, research has begun to articulate how social factors influence the active ingredients of existing and novel forms of treatment. We therefore follow our review of preclinical studies with a discussion of these core treatments and recovery services and the role of social factors in their implementation.

4.1.1. Preclinical evidence on cessation of use

A key pathway to recovery is allocation of behavior from drugs to non-drug alternatives. Preclinical models have begun to explore the role of social context in serving as an alternative reinforcer within discrete-choice experiments among animals with a history of prior drug self-administration (also known as “voluntary abstinence models”). In these experimental arrangements, subjects are presented with the discrete choice of a drug reward or social access reward over a series of trials (Ramsey et al., 2023; Venniro and Shaham, 2020). One of the first of these studies showed that when provided a choice between a drug-free social partner and methamphetamine or heroin access rats reliably choose the social reward (Venniro et al., 2018). This effect has subsequently been shown to be sensitive to known behavioral mechanisms impacting reward value and choice like contingent punishment of the social reward, delay to social reward access, and social reward cost and duration (Chow et al., 2022; Venniro et al., 2021; Venniro et al., 2018). This preference for social rewards was not observed in another study evaluating alcohol versus social reward choice suggesting that this finding may not universally generalize across drug classes (Marchant et al., 2023). Notably, alcohol versus social reward choice was sensitive to alcohol response requirement, pre-session alcohol exposure (i.e., satiation), and alcohol dose suggesting that this process was similarly malleable to the environmental contingencies maintaining choice.

4.1.2. Preclinical evidence on relapse and return to substance use

While the above studies have shown a protective role that social context can play in substance use recovery, social context can also serve to precipitate relapse and a return to use. Consistent with the impact of social stress in other areas of the addiction process, olfactory cues

previously associated with social defeat stress can also reinstate cocaine seeking responses with the magnitude of coping behavior displayed in the social defeat paradigm associated with reinstatement magnitude (Manvich et al., 2016). Similar results were observed in the reinstatement of an alcohol seeking response following exposure to olfactory cues previously associated with social defeat (Funk et al., 2005). Consistent with data on the maintenance of use, direct acute exposure to social stress can also suppress responding for alcohol and cocaine associated responding representing more generalized reductions in behavior (Funk et al., 2005; Manvich et al., 2016).

Another study evaluated the ability of a social peer that was previously associated with cocaine self-administration sessions to reinstate extinguished responding that was previously associated with cocaine delivery (Weiss et al., 2018). That study found that this cocaine-associated social partner was able to reinstate responding on that cocaine-associated operant whereas a saline-associated social partner did not. A similar finding was not observed in another study that tested associative pairing with self-administering as compared to passive peers (Smith et al., 2016). These discrepant findings may be explained by the use of a compound stimulus in the latter study consisting of not only the social peer, but also non-social discriminative cues (e.g., infusion pump).

4.2. Human evidence of social context and recovery: social mechanisms in treatment and recovery support services

Evidence in humans for social mechanisms in recovery is consistent with those found in animal research. The majority of this research uses naturalistic and/or longitudinal data, rather than laboratory studies. For example, one study found that, among emerging adults enrolled in residential treatment, the average number of high-risk friends decreased, and low-risk friends increased, during the first few months following treatment (Kelly et al., 2014). These changes remained stable out to one year and were associated with greater abstinence and reduced heavy drinking days. Interestingly, the average number of low-risk friends was around two, suggesting that substance-free support from even a small cohort may be sufficient to bolster recovery. Another retrospective study utilizing social network analysis corroborated these findings in a sample of middle-aged adults, suggesting that a recovery network may replace a use network among those who successfully recover in addiction (Anderson et al., 2021). Consistent with pre-clinical initiation and escalation studies, substance-free social relationships are heterogeneous and may bolster or dampen recovery. There are non-drinking-specific social network factors that appear to predict better treatment outcomes, including being a part of a cohesive, active/recreational family unit that does not argue frequently, a strong marriage prior to treatment, and having relationships that, in general, communicate respect and worth to the individual (McCrary, 2004).

Although natural recovery is common (Heyman, 2013), many seek treatment for substance use disorders, and studies exploring the impact of clinician factors on recovery support the notion that the therapeutic alliance may also either bolster or dampen recovery efforts. Although the therapeutic relationship is atypical relative to relationships with peers or family members, the social processes described above remain critical, and the therapeutic relationship therefore emerges as a unique opportunity to leverage social factors to enhance recovery. A clinician's lack of care, respect, support, as perceived by the patient are among the most common reasons for discontinuing treatment (Laudet et al., 2009). Alternatively, patients are more likely to positively perceive treatment when clinicians are respectful, caring, available, and collaborative in the recovery process (Nordfjærn et al., 2010). Indeed, the therapeutic alliance is consistently among the strongest predictors of treatment engagement (e.g., Meier et al., 2005; Meier et al., 2006; van Benthem et al., 2020).

In addition to therapist factors, many evidence-based treatments for addiction specifically leverage or target the social environment, given the importance of social factors in the development, maintenance, and

recovery from substance use disorders. The following reviews common, evidence-based approaches that explicitly target social mechanisms, or that have identified the social context as a mechanism of change within treatment. Although the focus of all approaches below is the reduction of substance use behavior, these treatments differ mechanistically, spanning from peer-led approaches that leverage the social context through direct involvement in recovery to one-on-one psychotherapies that address social mechanisms indirectly through skill development and interpersonal training. Relevant to note is that each of these treatments address more than social factors alone.

4.2.1. Mutual-help groups

In many parts of the world, mutual-help groups are the most commonly sought form of help for addiction. In the context of addiction, mutual help groups refer to groups of two or more people sharing the experience of addiction who join together in mutual support to enhance recovery. Alcoholics Anonymous (AA) is the most well-known mutual-help group with mutual-help groups as a top cited form of substance use treatment in national surveys (Substance Abuse and Mental Health Services Administration, 2020). Other 12-step facilitation groups, typically at least partially modeled after AA, in addition to other mutual-help groups such as SMART Recovery and Women for Sobriety, have emerged over the years.

Research over the past few decades have established the efficacy of mutual-help groups in general, with a particular emphasis on AA in part due to its influence, engagement, and existing infrastructure (Kelly et al., 2020; Kelly and Yeterian, 2011). Changes in social network composition appears to be a primary mechanism of AA in facilitating recovery (Kelly et al., 2012; Martinelli et al., 2021). One study compared potential mechanisms mediating AA attendance effects on alcohol-related outcomes found that reductions in pro-drinking social network, and increases in the pro-abstinence social network, accounted for the most variance in the relationship between AA attendance and alcohol outcomes, more than depression and spiritual/religious practices (Kelly et al., 2012). This study also found that the effect of AA on alcohol outcomes was also explained partially through higher self-efficacy to abstain in high-risk social situations, suggesting a potential decoupling of reward from social relationships and alcohol.

Relevant to note is that, in addition to social mechanisms, other mechanisms of mutual-help groups have also been identified, including through increasing religiosity, coping skills, and engagement in protective, alternative activities, and motivation, and by reducing negative affect (Kelly et al., 2012; Kelly et al., 2009; Moos, 2008). Further, although changes in social network composition do appear to explain successful recovery among young adults, there is some evidence that mutual help group participation does not mediate this effect (Kelly et al., 2014), perhaps due to an overall older age composition among mutual help group attendees (Hai et al., 2022).

4.2.2. Peer recovery support services

Peer-recovery support services (PRSS) refer to a range of services provided by peers with lived experience with SUD, typically within the framework of ongoing medical care or treatment for SUD. Studies have explored a wide range of PRSS, ranging from brief referral sessions taking place in primary care settings to the accompaniment of peer support throughout formal treatment (Eddie et al., 2019). There is promising evidence supporting the utility of PRSS in bolstering abstinence rates, treatment retention, and treatment satisfaction (Bassuk et al., 2016; Eddie et al., 2019); however, some studies have found no effect of PRSS, and many studies have explored the effect of PRSS in conjunction with other recovery services, obfuscating the nature of the effect of PRSS. Although these data suggest at least variations of PRSS are helpful recovery tools, research on mechanisms of change is sparse. Mechanisms likely range depending upon contact with the PRSS; short-term or single session PRSS may inform the individual of available resources and increase motivation to change, whereas long-term,

integrated PRSS may operate by leveraging the substance-free relationship in support of recovery both day-to-day and in the context of high-risk situations.

Perhaps the most intensive form of PRSS are recovery coaches, or trained peers with lived experience with substance use disorder and recovery. Research has demonstrated that integration of peer recovery coaches in a general medical setting increases SUD treatment utilization, engagement with medication assisted treatments, and reductions in opioid use (Magidson et al., 2021). One study qualitatively explored the role and impact of recovery coaches among patients recently diagnosed with an SUD in a primary care setting and identified four primary “coach activities”: assistance in system navigation, behavior change support, harm reduction, and relationship building (Jack et al., 2018). Patients expressed several strengths of the recovery coach model, including accessibility in general and in high-risk situations, shared experiences, motivating behavior change, and linking the patient to important social services. These qualitative themes highlight several potential benefits of the recovery coach model and suggest that peer substance-free support may be a critical support that could be integrated across levels of care in the medical setting.

4.2.3. *The community reinforcement approach and family training (CRAFT)*

Often, individuals experiencing harm from alcohol or drugs report low motivation to engage in treatment or recovery. This may be for a variety of reasons, including that they don't feel they need treatment, they fear repercussions (losing a job, suspended professional licenses), or they don't want to experience the stigma associated with endorsing an addiction and subsequent treatment. Many report more than one of these reasons. Although several approaches have been developed that leverage the social network to increase motivation for treatment engagement, perhaps the most empirically supported has been the Community Reinforcement Approach and Family Training (CRAFT).

CRAFT grew out of the Community Reinforcement Approach (CRA) (Azrin, 1976; Meyers et al., 2011), which attempts to shift the contingencies in the individual's environment to reinforce substance-free activities and sobriety rather than substance use. CRAFT recognizes that spouses and significant others have significant access to powerful reinforcers and contingencies in the home that may be leveraged to encourage change (Meyers et al., 2005). This approach identifies the significant other, or other important members of the family or social network, as the client and trains them to change their own behavior at home to carefully shift contingencies in favor of reducing drinking and seeking treatment. The CRAFT program includes components such as enhancement of significant other motivation, functional analysis of the problem behavior, domestic violence precautions, communication skills training, life enhancement for the significant other, and treatment invitation for the partner. CRAFT is an active behavioral therapy that leverages positive reinforcement to help guide behavior change through role-plays and other behavioral skills-training exercises during sessions, and homework assignments between sessions. Across studies, significant others engaging in CRAFT consistently succeed in encouraging their loved ones struggling with substance use harms to seek treatment approximately 70 % of the time (Meyers et al., 1998; Miller et al., 1999).

An alternative approach commonly portrayed in popular media follows a method known as the Johnson Institute intervention. The Johnson Institute method is a confrontational model in which the person's social network colludes secretly to confront them about the harms of drinking or drug use and consequences that will occur if treatment is not sought. Unfortunately, most of the studies exploring the efficacy of the Johnson Institute intervention have been small, uncontrolled, and suffer from astounding dropout rates both before commencing the intervention and at follow up (Loneck et al., 1996a, 1996b). One controlled study found that of those randomized to the Johnson Institute intervention, 70 % did not commence the confrontation. Of those that did, 75 % of individuals entered substance treatment. This is compared to the CRAFT

intervention, which succeeded in helping 64 % of all randomly assigned to this condition seek treatment. Further, one of the uncontrolled studies found that individuals who had received the Johnson Institute intervention were more likely to relapse compared to those who had received other interventions (Loneck et al., 1996b). As a result of these empirical findings, the Johnson Institute confrontational intervention is not considered an empirically supported approach.

4.2.4. *Couples therapy for substance use disorders*

Other treatment approaches simultaneously engage significant others with the individual in treatment for substance use disorders. This approach, commonly known as Behavioral Couples Therapy for SUD (BCT) combine principles from cognitive behavioral therapies for substance use disorders with couples therapy (McCrary, 2012; Schumm and Renno, 2022). According to McCrary (2012), the primary aims of alcohol behavioral couples therapy are to (a) reduce drinking; (b) enhance both partners' motivation to make changes both in substance use and in interpersonal communication; (c) provide the partner with behavioral, cognitive, and interpersonal coping skills; and (d) enhance the quality of the intimate relationship as an incentive for change. Importantly, behavioral couples therapies for substance use disorders assume that, although interpersonal interactions do not typically “cause” harmful substance use, these interactions may serve as triggers or may behaviorally reinforce patterns of substance use, as demonstrated in previous discussion above (Fairbairn and Cranford, 2016). As a result, these interventions decrease attention to negative behaviors and decrease behaviors to cue use events by using sessions focused on training a supportive partner to identify contingent responses to partners' alcohol- or other substance-related behavior. Studies exploring in-session behavior illustrate several potentially important mechanisms of behavior change in behavioral couples therapy (McCrary et al., 2019). In a within-session analysis of language during the course of alcohol behavioral couples therapy, couples increased positive behaviors (e.g., collaborative language and general support), talked less about drinking, and decreased their amount of motivational language (i.e., change or sustain talk); although partner behaviors during treatment did account for significant variance in drinking outcomes, these effects were nonsignificant. Therapist behaviors were not associated with behaviors during treatment or drinking outcomes, and partner advice predicted poorer drinking outcomes.

5. Summary and conclusions

Social factors alone are unlikely to describe addiction completely, and many other factors may need to be addressed to enhance successful recovery. Nonetheless, throughout this review we have discussed distinct pathways by which social context may inhibit or facilitate the life history of addiction including early experiences with substances, the development of behavioral patterns hallmark to substance use disorder, and transitions involving cessation of use and relapse throughout the recovery process. Several broad conclusions may be reached that will ideally expedite future research in this area including i) the dual nature of social context across the addiction lifespan, ii) the value of behavioral economic models as a conceptual framework, and iii) significant gaps in the breadth of research conducted in the human laboratory and on individual differences.

First, as emphasized throughout and in Fig. 1, social context may act as both a key protective factor and a key risk factor depending on the nature of the social context and drug-taking behavior of social peers (e.g., Robinson et al., 2016; Smith, 2012; Smith et al., 2023; Venniro et al., 2021; Weiss et al., 2018). Similarly, as emphasized in clinical data on solitary versus social drinking, drinking in social environments can serve as a momentary risk factor while also being indicative of less harmful patterns of use (when contrasted with frequent solitary drinking) (e.g., Acuff et al., 2021). While complex behavioral phenotypes such as substance use and their interaction with social context are difficult to

ascribe to a dichotomous relationship, these findings broadly align with the idea that drug use is facilitated in environments where others are using drugs (which are likely more permissive to substance use and where social contact acts as a complement) but is inhibited in environments where others are not using drugs (which are relatively more incompatible with substance use). Such data demonstrate the relevance of not only considering social factors, but the nature of the social events when determining the effects on substance use likelihood, disorder progression, and treatment.

Second, data described throughout show the role that the broader contextual environment and moderating dimensions like reward delay, probability, and cost can have on the sum effects of social factors for drug-taking (or drug-avoiding) events (e.g., Acuff et al., 2020a; Acuff et al., 2023; Smith et al., 2023; Venniro et al., 2021). Such findings underscore a valuable role for behavioral economic conceptual models in studying social context in addiction. As noted above (see section Human Laboratory Evidence of Escalation and Progression of Use), behavioral economics provides a cogent framework for incorporating environmental determinants of choice into predictive models of risk and mechanistic models of intervention design. More recently, models of behavioral economics have further integrated the role of alternative reinforcers into a *contextualized reinforcer pathology model*, which posits that the combination of a lack of alternative reinforcers like drug-free social reward with the relative delay to and high cost of those rewards plays a major role in the progression and persistence of addiction (Acuff et al., 2023). The use of such models has also shown demonstrated value in advancing treatment development.

For example, the Substance-Free Activity Session (SFAS) is a single session intervention that combines motivational interviewing with behavioral economic principles to increase engagement in drug-free alternative behaviors consistent with long-term substance use reduction goals (Murphy et al., 2012). By combining insights from behavioral economics and the value of engagement in drug-free social behaviors, this intervention has shown promise in reducing alcohol use and increasing engagement in drug-free rewards in emerging adults and adults in alcohol treatment (Gex et al., 2022; Meshesha et al., 2020; Murphy et al., 2019; Murphy et al., 2012). Of course, other conceptual frameworks such as socio-cultural frameworks (Creswell, 2021; Sudhinaraset et al., 2016) or social learning theory (Smith, 2021) will likely prove valuable in advancing preclinical and laboratory insights on social context into intervention development, but these examples with behavioral economics broadly highlight the value of such a translational approach.

Third, research has historically been siloed to a select set of drugs and failed to include social context (particularly in the human laboratory). With respect to the substances studied, the majority of preclinical research has focused on stimulants (such as cocaine) while the majority of human laboratory research has focused on alcohol. The effects of social context likely vary not only by the nature of the social interaction, but also by the drugs considered. For example, preclinical research has shown that rodents exhibit a preference for heroin (over stimulants) when tested in a context that was the same as their home cage while a preference for stimulants (over heroin) was observed when tested in a context that was separate than their home cage (Badiani, 2013; Caprioli et al., 2009; Caprioli et al., 2008; Celentano et al., 2009). Similarly, these studies have also found that human participants who used both cocaine and heroin tended to report heroin use primarily in a home context and cocaine use primarily outside of their home (Caprioli et al., 2009). Similarly, while preclinical research on the experimental effects of social context manipulations on drug self-administration has soared in recent years, human laboratory research remains woefully behind. This has several ethical and logical reasons including the difficulty of maintaining experimental control in these designs (e.g., ensuring the validity of confederate behavior, variability in the behavior of experimental dyads). The challenges faced in conducting these kinds of designs can act as a deterrent to the conduct (as well as funding) of these lines of

research. Advances in bringing social context into the laboratory will instead likely require a recognition of the real-world complexity of social environments and contributions across research designs to address any single study's shortcomings.

Similarly, the characteristics of the individual and the individual in context being studied requires expansion. Although the role of sex and gender differences in substance use has been clearly recognized (Becker et al., 2017; Brady and Randall, 1999; McHugh et al., 2018; Robbins, 1989), studies are more limited in their systematic evaluation of these differences in the effect of social context on drug-taking behavior within laboratory designs. Preclinical studies have documented relevant differences such as the opposite effects observed for social dominance in cocaine self-administration for male and female subjects (i.e., increases in self-administration for female dominant monkeys, but decreases for male dominant monkeys; Morgan et al., 2002; Nader et al., 2012). Continued systematic evaluation in both same-sex and opposite-sex dyads are relevant given both sex and gender differences in substance use trajectories and in social behavior. Similarly, studies of social behavior have typically evaluated more molar patterns of behavior (e.g., session summaries) rather than molecular analysis of behavior within-session. Within-session recording can provide insights into more precise mechanisms of change. For example, drugs can also have a direct effect to enhance or inhibit social behavior that may, in turn, alter a drug's reinforcing effects dependent on factors like an individual's use history or context (de Wit and Sayette, 2018; Griffiths et al., 1977; Higgins et al., 1989; Ward et al., 1997).

These collective findings ultimately highlight the complexity of support for individual struggling with addiction, and the need for research identifying the most fruitful relational dynamics between substance-free social networks and patients with substance use disorder. There are many factors that may influence whether an interpersonal relationship bolsters recovery, including interpersonal communication style, history of co-use, degree of calibration between conceptualization of the addictive behavior, and whether the supporter has experienced any of the substance-related problems firsthand. Importantly, even in the most ideal scenarios, an individual's "closest" member of the substance-free support network may have the most difficulty in providing healthy, assertive, support that communicates care, value, and worth. Continued research across the addiction lifespan is needed to maximize the protective and minimize the risk factors stemming from the role of social context in addiction etiology and recovery.

Data availability

No data was used for the research described in the article.

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