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"You Have to Want It": A Pervasive Mental Model of Addiction Recovery and Its Implications for Sustaining Change

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Table of Contents

List of Figures

<u>List of Tables</u>

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Dedicated to Graham

ABSTRACT OF THE DISSERTATION

"You Have to Want It": A Pervasive Mental Model of Addiction Recovery

and Its Implications for Sustaining Change

by

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Background: Addiction to illicit drugs is a complex phenomenon characterized by cyclical patterns of relapse, remission, and, for some, a full recovery. People who use drugs (PWUD) and their loved ones form 'mental models' of recovery that develop over time through experience and observation. The role of these mental models and how they interact to undermine or support recovery is poorly understood. Therefore, this study asks: 1) What do people who use drugs and their loved ones believe it takes to successfully recover from addiction? and 2) Given these beliefs about recovery and the available evidence on remission, relapse, and recovery, what places to intervene and leverage points would support recovery and prevent relapse?

Methods: Data were collected from in-depth qualitative interviews with 14 people who use drugs (PWUD) and 10 loved ones of PWUD ("loved ones") in a rural county in Missouri to elicit their mental models of addiction recovery. A grounded theory was developed and translated into mathematical equations to build a system dynamics model. System dynamics is a method to understand systems in terms of their interacting reinforcing and balancing feedback loops. The

model was calibrated to replicate a prototypical pattern of addiction relapse, remission, and recovery. The grounded theory and model experiments were used to identify leverage points for sustaining positive change (i.e., recovery).

Results: Participants believed that "you have to want it" to recover from addiction, where "wanting it" means improved social role functioning, seeking support, and abstinence. Insufficient proof of "wanting it" leads some loved ones to withdraw their support, which reinforces the addiction cycle. Model simulations show that expectations for social role functioning are a key driver of addiction and recovery. Changing the model structure so that support is not contingent on proof of "wanting it" has negligible immediate impact on drug use but creates the strongest eventual recovery. Support that is no longer contingent increases expectations for social role functioning, the benefits of which accumulate over time. When these benefits combine with strong balancing feedback loops, the recovery is stronger.

Discussion: Increasing expectations for social role functioning is a key leverage point for recovery from addiction (i.e., for sustaining change). Support can be a critical factor that increases expectations. However, "wanting it" is, in effect, to no longer be addicted, meaning that many PWUD do not get support when they need it most because they have not yet proven to others that they can respond rationally to negative consequences. Thus, expectations must also be increased through means other than support from loved ones, including connecting with others who have similar lived experiences, and sustainable, meaningful changes in social role functioning. This requires social welfare, health, and criminal justice policies and programs that reverse, not merely slow down or even strengthen, the reinforcing loops that drive addiction.

Chapter 1: Introduction

Overview of the Dissertation

This study presents a theory of addiction relapse, remission, and recovery and uses that theory to identify leverage points for sustainable change and recovery. The key constructs used in the theory were derived from in-depth qualitative interviews with people who use drugs (PWUD) or people who are concerned about their loved one's use of drugs ("loved ones") in a rural county of Missouri (Charmaz, 2014; Glaser, 1978). Emerging concepts were compared to extant literature on addiction. The theory focuses on the dynamic interactions that underlie transitions between addiction relapse, remission, and recovery. This grounded, dynamic theory was translated into a system dynamics model (Forrester, 1961; Sterman, 2000), which was used as an experimental "testing ground" to learn how changing key dynamics could impact recovery.

The fundamental thesis guiding the study was that people's mental models (Doyle & Ford, 1998, 1999) of addiction recovery, or their personal theories about how addiction recovery "works," affect the sustainability of interventions. This is because mental models shape beliefs and actions (Glanz, Rimer, & Viswanath, 2008) and therefore have the potential to regulate or amplify change via feedback loops (Richardson, 1999). Thus, learning how people think addiction recovery works points to critical psychosocial dynamics that affect people's success, or lack thereof, in achieving recovery. Implications for research, practice, and policy are discussed in two ways: first, in terms of the mental model that "you have to want it," and second, based on the leverage points identified in model experiments.

Statement of the Problem

There is a common, albeit cynical, adage regarding addictive behaviors: "I know how to quit; I've done it a thousand times." There is some truth to this statement. Qualitative (Biernacki, 1986; Dean, Saunders, & Bell, 2011; Shewan & Dalgarno, 2005; Warburton, Turnbull, & Hough, 2005; Zinberg, 1984) and epidemiological (Y.-I. Hser, Evans, Huang, Brecht, & Li, 2008; B Nosyk et al., 2014) studies on drug use find that people move in and out of periods of heavy and frequent use, less intense use, and abstinence. These periods last from a few days to a few years, but all too often, they end with relapse into use and disorder. The most severely affected people experience several episodes of temporary abstinence followed by relapse into use (L.-Y. Chen, Kaufmann, et al., 2013; Dean et al., 2011; Grella & Stein, 2013). They receive treatment and temporarily stabilize their lives, but struggle to maintain the changes they make (McLellan, Lewis, O'Brien, & Kleber, 2000; Mertens, Kline-Simon, Delucchi, Moore, & Weisner, 2012; White, 2009).

Sometimes, periods of less intense use or abstinence are long enough that people achieve remission from drug use disorder (DUD), meaning the absence of drug use-related symptoms (American Psychiatric Association, 2013). Estimates put the lifetime prevalence of experiencing any period of remission from DUD (which could mean just one year) as high as 90% (Heyman, 2013b; Lopez-Quintero et al., 2011). However, the primary study used to draw such conclusions is the National Epidemiologic Study on Alcohol and Related Conditions (NESARC), which had only two waves of data collected approximately 3 years apart (C. M. Chen et al., 2010). More conservative estimates are that around 60% of people with a DUD achieve remission, though these estimates draw from largely clinical samples of more severely affected individuals (Fleury et al., 2016; White, 2012). Regardless of the true rate of remission, many people are not

achieving the quality of life necessary to prevent relapse into disorder (Moos & Finney, 2011; Price, Risk, & Spitznagel, 2001).

The quality of life necessary to prevent relapse is a life defined by recovery and not just remission. Recovery goes beyond the clinical focus in remission on absence of drug use-related symptoms to encompass significant and sustained improvement in multiple areas of functioning: relationships, quality of life, health, and well-being (Ashford et al., 2019; Substance Abuse and Mental Health Services Administration, 2012). In recovery, people sustain the changes they have made, making relapse much less likely. Thus, "sustainable recovery" is redundant; recovery *is* sustainability.

The inability to maintain change is the source of the cynicism in statements about having quit "a thousand times." The challenge is not in quitting, but in staying quit. Yet, it is in these periods of quitting that the potential for recovery exists. To improve outcomes so that more people achieve recovery from addiction, it is important to understand what can nurture that potential into reality – to understand the dynamics that undermine nascent change and contribute to relapse.

Interactions between PWUD and their loved ones are critical to understanding how to promote and sustain recovery. This includes more than the extent of recovery capital or the number of abstinent people in PWUD's social networks (Bohnert, Bradshaw, & Latkin, 2009; Brewer, Catalano, Haggerty, Gainey, & Fleming, 1998; Buchanan & Latkin, 2008). The quality of and interactions in relationships are not exogenous influences on the PWUD but contribute to the causes and consequences of addiction itself. This is posited to occur because how people think addiction recovery works (their "mental models of addiction recovery") creates unintended

consequences that contribute to the difficult transition from quitting to staying quit. Given this assumption, the study asks:

1. What do people who use drugs and their loved ones believe it takes to successfully recover from addiction?

2. Given these beliefs about recovery and the available evidence on remission, relapse, and recovery, what places to intervene and leverage points would support recovery and prevent relapse?

Significance of the Study

This study offers the first known theory based in principles of reinforcing and balancing feedback of how remission and recovery might succeed or falter as the result of the dynamic interplay between those who are addicted and their loved ones. It seeks to change how researchers think about addressing the issues of relapse, remission, and recovery.

The theory provides insight into potential sources of resistance to change, which suggests future directions for research on treatment receipt. The simulation model provides insight into the relative importance of different variables that interact to bring about remission, relapse, or recovery. Given the consistency these insights have with extant literature, these findings suggest leverage points for practice and policy that could help more people to achieve recovery.

Chapter 2: Background

Theoretical Framework

Complex adaptive systems (CAS) theory informs this study conceptually and methodologically. Together with social cognitive theories, CAS provides a conceptual framework for examining psychosocial adaptive responses in addiction. CAS and control theory also form the methodological foundation of the system dynamics method used in this study.

Complex Adaptive Systems (CAS)

Complex adaptive systems (CAS) are systems in which the interrelated components adapt over time to changes in the system (El-Sayed, Scarborough, Seemann, & Galea, 2012; D. A. Marshall, Burgos-Liz, IJzerman, Crown, et al., 2015; J. H. Miller & Page, 2007). Individuals, relationships, and social environments are all examples of CAS, which combine to create a complex system of systems (CSoS) (Apostolopoulos, Lemke, Barry, Hassmiller Lich, & Lich, 2017). In a complex adaptive *social* system, people are the interrelated components.

In CAS, multiple levels interact in ways that are often unpredictable and prone to 'policy resistance,' which is when problems persist despite multiple attempts to fix them (J. Homer & Hirsch, 2006; Sterman, 2006). 'Policy' broadly refers to any rules which guide decisions and that are based on a set of beliefs about how a system will respond to goal-oriented action (Forrester, 1961). Policy resistance with regards to an individual's addiction manifests as continual relapse despite considerable efforts on the part of people with DUDs to maintain remission and achieve recovery.

Relapse is a dynamic process occurring within a CAS. The ability to achieve recovery is undermined when people's well-intentioned actions either unintentionally revert the system

(individuals, as well as their social systems) to its former state through balancing feedback processes which reestablish the status quo, or exacerbate addiction through reinforcing feedback processes that lead to more use or more severe consequences than would have otherwise occurred.

CAS Features

A central feature of CAS is that their components are interdependent. Each person's actions result in different behavior among other people in the system, continually changing the social environment. It is this continual dynamic interdependency that makes the system adaptive (J. H. Miller & Page, 2007). Moreover, this interdependency and adaptation implies that much of the CAS' behavior is endogenous, or arising from within (Richardson, 1999). Thus, a key benefit of using a CAS framework is that it encourages people at all levels of the illicit drug addiction 'ecosystem' to consider how their own actions and behaviors, and not an outside force, are contributing to the problem. The other implication is that boundaries of the system are important to define, because endogeneity occurs within those boundaries; anything outside of those boundaries is exogenous and therefore not amenable to change from within.

A second feature of CAS is emergence. Emergent phenomena result from the interactions of individuals and therefore cannot be explained by isolating individual behavior from its social context (Epstein, 2006). Emergence is important for developing sustainable interventions to address drug addiction because it creates the 'social spaces' in which drug use and recovery occur. Social spaces are the subjective meanings attached to a physical location because of the social interactions that occur there (Cresswell, 2013) and might include, for instance, the social spaces in which PWUD interact with their loved ones as well as with other PWUD.

A third feature of CAS is that they exhibit unanticipated responses to externally-generated change, such as 'top-down' interventions. This is a direct result of their interdependence and emergence. Interventions must contend with the unpredictability of the targeted individuals *and* each of the individuals within their complex adaptive systems (family members, other PWUD, partners, etc.). Thus, when considering how to support sustainable recovery for individuals, intervention designers must consider not only the people they are targeting, but also the people in their lives.

A CAS framework explicates how multiple levels interact: individuals perceive and respond to information about their relationships, social networks, or communities, thus changing the complex adaptive system of which they are a part. A CAS framework, furthermore, requires a shift to operational thinking, i.e., what is "actually happening" among the people that make up the system; it is not enough to merely understand the correlation between variables that describe people (Olaya, 2012). Moreover, a CAS framework highlights the importance of understanding what information people are using, interpreting, and responding to. Their responses to (mis)information affect the larger systems of which they are a part, which is a reminder that the "truth" – i.e., what evidence-based literature suggests – is sometimes not as important for sustainable, effective interventions as what people *perceive* the truth to be.

Mental Models of Dynamic Systems

The internal frameworks that people use to organize information and make decisions are their mental models, or their internalized, dynamic theories about a complex process, which are developed from personal experience, memory, and observation (Doyle & Ford, 1998, 1999). More simply stated, a mental model is how people think things work based on their experiences.

Mental models have been compared to maxims in structuration theory (Lane, 2001) and schemas in social psychology (Levine et al., 2002).

Mental models are available for conscious introspection, so do not include the vast amount of unconscious mental activity that also affects behavior. Because people can only know so much about experiences outside their own (i.e., they have bounded rationality), and are limited in their ability to explain even their own behaviors, mental models are incomplete, fuzzy, biased, and imprecise (Costanza & Ruth, 1998; Doyle & Ford, 1998, 1999, Forrester, 1971, 1992). As a result, mental models are sometimes even internally contradictory, and often conflict within complex adaptive social systems, leading people to work at cross-purposes. To understand a person's mental model is not to understand reality, but to understand their view of reality. Though they are limited and flawed, mental models reflect some degree of truth or accuracy and, more importantly, can be improved.

Feedback Effects and State Space

In control feedback theory, feedback behavior can be negative/balancing/self-regulating (leading to equilibrium and stability) or positive/reinforcing/amplifying (leading to vicious or virtuous cycles as well as instability) (Forrester, 1961; Richardson, 1999; Sterman, 2000). Even simple systems can have multiple feedback loops operating, often simultaneously, though at different rates. Consequently, feedback loops differ in their strength and effects on system behavior because of how quickly changes are amplified or resisted.

People who use drugs (PWUD) occupy different states (addiction, remission, recovery) according to feedback loops that are driven by the interaction between multiple state variables, or attributes, that change over time. Collectively, the value of these state variables represents their

current condition, but at different values they also represent all possible conditions. All the possible states that the system (a PWUD, in this case) can occupy are found within a *state space*. Individuals transition over time through different regions of the state space (Sato, 2016; Siegfried, 2014).

The combination of feedback and continuous change means that the stability of PWUD's addiction trajectories (their state space locations) are variable across people and across time. Some locations in state space are transient; systems quickly move out of these states and into more stable equilibrium points, which are points of least resistance (Stringfellow & Sato, 2016). For PWUD, the dominance of different feedback loops changes depending on the region of the "addiction state space" they are in; if they are severely addicted, then some feedback loops are stronger than if they were less severely addicted, not addicted at all, in remission, or in long-term, sustainable recovery. Thus, despite the seeming instability of their lives, a person who is addicted may be at a more stable equilibrium point than that of a "weekend warrior," a relatively transient state; people are either pulled into drug scenes or are pulled back to more "conventional" lifestyles (Fast, Small, Wood, & Kerr, 2009). A person in long-term recovery is in a more stable equilibrium than a person in short-term recovery. The likelihood that PWUD will shift to one state space or another – become more or less severely addicted, achieve remission or recovery – depends on where they currently are in that state space, as well as their initial conditions, i.e., where they started.

Conceptualizing current and former drug users as existing within a state space of multiple possible states encompasses a wider range of phenomena than compulsive use among people who are addicted, which is at most a few states within the entire state space. Compulsive use states, often seen in addiction, receive disproportionate attention from researchers. While an

addicted, compulsive use state is the most damaging to individuals and their family, a focus on what keeps people addicted leads to comparatively less attention on what keeps drug users in other possible states, such as remission and recovery and, most importantly, what leads drug users who are addicted out of that state.

State space conceptualization allows for questions about what pushes and pulls people to different states, how they move through state space, whether there are unobservable states, the instability of certain state spaces and whether people are at unstable or stable equilibrium points, and what determines which direction people move in from these unstable equilibrium points. These are not purely theoretical questions, though arguably even the shift to such a conceptualization allows for a more fruitful conversation about drug use and addiction.

Substantive Background

The substantive background review is based on the intersection between concepts that had been reviewed in preparation for this study and concepts that arose during interviews and were included in the final theory and models. The grounded theory approach meant that there were no a priori concepts assumed to be important; however, the author was 'sensitized' to certain concepts (Charmaz, 2014), and if these became relevant in the coding of data then they were considered for inclusion.

First, control theory as previously applied to addiction research and how it connects to social cognitive theories of behavioral change will be discussed. Then, a set of 'requisites' for recovery will be posited, which will be compared to the salient concepts that arose in the grounded theory, as there is not a one-to-one relationship.

In the grounded dynamic theory, multiple concepts are referenced, some without a clear corollary in the literature. Thus, only the most salient concepts that have received significant research attention are included in this background. These concepts, if not explicitly included in the model, provide context and nuance to the interpretation of the model results.

Control Theory and Social Cognitive Theories of Behavioral Change

The central process in mental models is a familiar one in social cognitive theories of behavioral change: beliefs inform intentions, motives, or goals, which inform actions (McAlister, Perry, & Parcel, 2008; Orr & Plaut, 2014; Webb, Sniehotta, & Michie, 2010). Whenever someone acts to meet goals, balancing feedback is present or, in behavioral terms, self-regulation. Balancing feedback and a related theory, cybernetic control theory, have been used to highlight where addiction interventions can target different points in the self-regulation process, based on behavior change theories (Webb et al., 2010).

Webb et al. (2010) describe how, in a balancing feedback framework, an individual's 'input function' is the current perception of the rate of behavior change that is compared to the goal ("Am I changing as quickly as I think I should?"). The 'output function' is the behavior, which is changed in proportion to the gap between the goal and the current perceive rate of behavior change. Behavior changes might have the intended impact, in the intended direction, or they might not. Therefore, the person making the changes must continually reassess (or monitor) the rate of behavior change and make further adjustments to the output function (behavior). This process forms a cybernetic control loop driven by negative feedback. Several interventions target the reference value or goal and are based on social cognition models. A central tenet of these models is that beliefs determine intentions to act, and intentions determine behavior (Orr & Plaut, 2014). This suggests that changing goals – and thus behavior – requires changing beliefs.

11

This is consistent with a systems principle that the mindset or paradigm (belief) in which a system operates is the most powerful leverage point because it reorganizes everything else, from goals to actions (Meadows, 1997).

Ewart's (1991, p. 933) social action theory also used cybernetic control loops to understand self-regulation of behaviors in the social context. It builds on the action-outcome control or feedback model, in which the consequences of action (behavior) lead to adjustments and maintenance at a stable set point. Ewart's modification to the action-control loop process was to add mechanisms that recognized the interdependence between individuals' behaviors and how others can support behavior change.

Recovery

Recovery is hypothesized to also be driven by reinforcing feedback processes, in which the rate of change is amplified in the same direction, and not by balancing feedback alone. The Substance Abuse and Mental Health Services Administration defines recovery as: "A process of change through which individuals improve their health and wellness, live a self-directed life, and strive to reach their full potential" and identifies four domains: health, home, purpose, and community (2012). Other definitions similarly converge on healthy relationships, a sense of purpose or meaning, belonging to a community, and stability of resources, with less agreement about whether recovery requires abstinence from all mind-altering substances, including even medications that help treat addiction (Maffina, Deane, Lyons, Crowe, & Kelly, 2013; Neale, Panebianco, et al., 2015). The most recent definition to emerge is "an individualized, intentional, dynamic, and relational process involving sustained efforts to improve wellness" (Ashford et al., 2019).

Study findings differ on how many underlying constructs "recovery" includes. The 50-item Assessment of Recovery Capital and its shortened 10-item version, which measures substance use, health, meaningful activities, and social support, reflects just one underlying factor (Groshkova, Best, & White, 2013; Vilsaint et al., 2017). However, the items on the ARC are of questionable construct validity for recovery. For instance, it is not clear that an affirmative answer to, "I am happy dealing with a range of professional people," (Vilsaint et al., 2017) represents recovery. These items were developed by practitioners and service users alone; whether the service users were currently using drugs is not specified. It is noted here because it is one of only two measures developed specifically for drug addiction recovery.

The other addiction recovery measure is SURE (Substance Use Recovery Evaluator), which involved extensive and iterative testing of items, including with current PWUD (Neale et al., 2016). In its early development, the authors noted that the 27 indicators of recovery identified by a diverse group of stakeholders fell into one of two categories involving either the use of alcohol or drugs, or well-being and quality of life (Neale, Panebianco, et al., 2015). However, a factor analysis of the final measure identified 5 factors: substance use, material resources, outlook on life, self-care, and relationships (Neale et al., 2016).

Many recovery advocates push for the definition of recovery to include abstinence from alcohol, drugs, and non-prescribed medications (Substance Abuse and Mental Health Services Administration, 2012). Such definitions are contested because they exclude people who either continue to use mind-altering substances but no longer experience problems related to their use, or who would prefer to do so (Neale, Nettleton, & Pickering, 2011, 2013). Thus, the recovery debate has inherited the larger debate in the field about abstinence-only approaches versus harm reduction approaches, with 'recovery' often assumed to be more aligned with an abstinence-only

approach. Indeed, even a conversation about measurement of the concept of recovery is suggested as potentially "selling out" (Neale, Panebianco, et al., 2015).

The concepts that arose in the interviews closely aligned with these existing definitions and domains of recovery. Recovery is operationalized in this study as low propensity to use drugs, high social role functioning and expectations for same, and high support received. These final constructs were chosen based on the definitions of recovery just described. The Results will discuss how these are related to each other in feedback loops based on analysis of the interviews.

Propensity to Use

In this study, drug use refers to the consumption by any method (inhaling, swallowing, injecting, snorting) of methamphetamine, cocaine, heroin, or the nonmedical use of prescription opioids. Drug use is best understood as a series of discrete events (as are all behaviors) measured and averaged over a period of days, weeks, months, or years. However, especially in drug addiction, behaviors are not always a good indicator of underlying motivations, desires, or preferences; a PWUD might increasingly prefer not to use because of how drugs have affected their lives but feel compelled to do so anyway due to withdrawal or cravings. These feelings of withdrawal or craving are certainly motivating factors themselves, but in the moment, they might have a stronger effect on the PWUD than long-term motivations, desires, or preferences not to use (W. R. Miller & Rose, 2015). Moreover, each drug use 'event' is affected by external factors; a PWUD might prefer to use but be unable to access drugs, or might be trying to quit using only to 'run into' another PWUD and relapse. Thus, how the underlying motivations, desires, or preferences translate into behavior is dependent on the interaction of these factors, which results in the discrete event of using or not using drugs on any given day.

In this study, a PWUD's 'propensity to use' is the construct used to reflect the underlying – and often competing – motivations, desires, or preferences about drug use. Propensity to use is aligned with how participants talked about drug use; they care not *only* whether someone is using, but whether someone would *prefer* to be using.

Propensity to use is assumed to be a key factor in determining the behavior of drug use, but not the only factor. As a continuous latent construct, it is meant to reflect a PWUD's preferences or inclination more than their behavior. The higher the propensity, the higher the preference or inclination toward use, and thus the higher the likelihood of use. This is similar to the link between attitudes, intentions, and behavior, though 'propensity to use' is not driven by consistent beliefs or attitudes (Fishbein & Ajzen, 1975). Instead, the PWUD's complex relationship with drugs leads to unstable motivations and therefore a weakened ability to predict behavior. Nonetheless, propensity to use and drug use are theorized to move in the same direction. 'Propensity to use' is similar to the concept of ambivalence about drugs or quitting drugs, which will be discussed below.

'Propensity to use' (drugs) is not measured in addiction literature, though it is a measurable construct. Drug use trajectories, episodes, and patterns, however, are frequently measured in addiction research, and as such are useful starting points for understanding the underlying dynamics in addiction. This study uses both 'propensity to use' and drug use behavior as reference modes for building the model and in the model itself; they are used in accordance with how they were discussed in interviews and are addressed in the literature. A summary of research examining trajectories, episodes, and patterns of drug use behavior is below.

Drug Use Behavior

The primary body of research that tracks drug use longitudinally comes from UCLA's CALDAR studies, which followed people who use drugs for between 10 and 33 years (Y.-I. Hser, Huang, Brecht, Li, & Evans, 2008). These studies draw primarily from clinical populations and thus oversample more severely addicted people. Their lifetime use extends for longer periods of time and involves more episodes in and out of use due to treatment and incarceration compared to people in the general population who have less chaotic "addiction careers" (Y.-I. Hser, Longshore, & Anglin, 2007; Kertesz et al., 2012; Lopez-Quintero et al., 2011). Their frequent engagement in treatment makes severely addicted individuals easier to reach than the significant majority of people with a DUD who never receive formal treatment (Grant et al., 2016). This means we have a better understanding of their generalized patterns of drug use (i.e., "addiction careers" of 30 or more years, infrequent voluntary periods of abstinence) than we do for people with less severe drug use disorder.

The CALDAR studies provide among the best sources of longitudinal data on patterns of use for multiple drugs including heroin, methamphetamine, and cocaine. One set of studies (Brecht, Lovinger, Herbeck, & Urada, 2013; Y.-I. Hser, Huang, et al., 2008) has examined trajectories of treatment and use, which is useful for understanding overall patterns of use averaged over years. (e.g., Brecht, Lovinger, Herbeck, & Urada, 2013; Hser, Huang, et al., 2008). Trajectories of use over a 10-year period were: consistently high (30%, more likely heroin), moderate (36%, more likely meth), increasing (14%), decreasing (14%), or low (6%) (Y.-I. Hser, Huang, et al., 2008). In a sample of methamphetamine users only, the trajectories were low (25%), moderate (30%), high (19%), and decreasing (26%) (Brecht et al., 2013). When extended over 30 years, nearly half of heroin users who had been in a methadone treatment

program were deceased; of those who were not deceased, 74.5% of users fell into one of three

decreasing trajectories, which varied based on their speed: rapid (24.6%), moderate (14.7%), and

gradual (35.2%), with the remaining 25.5% showing no decline in use (Grella & Lovinger,

2011). When using the entire baseline sample, including those who are deceased or lost to

follow-up, this and other studies find abstinence rates of about 30% by 10 years (Y. I. Hser,

Evans, Grella, Ling, & Anglin, 2015). No studies were identified following methamphetamine

users for more than 10 years. However, the studies following them for 10 years suggest that they

are more likely to have already decreased their use relative to heroin users.

These studies suggest that among the more severely affected, regardless of drug used,

only a small minority will decrease their use in the first 10 years (the "rapid decrease" group).

However, if they survive – and mortality rates are higher for heroin users than for stimulant users

(Degenhardt & Hall, 2012; Lopez-Quintero et al., 2015) – most will decrease their use by 30

years after initiation. Figure 2.1 extrapolates from three studies to depict the most commonly

described patterns of use over time among more severely addicted PWUD.
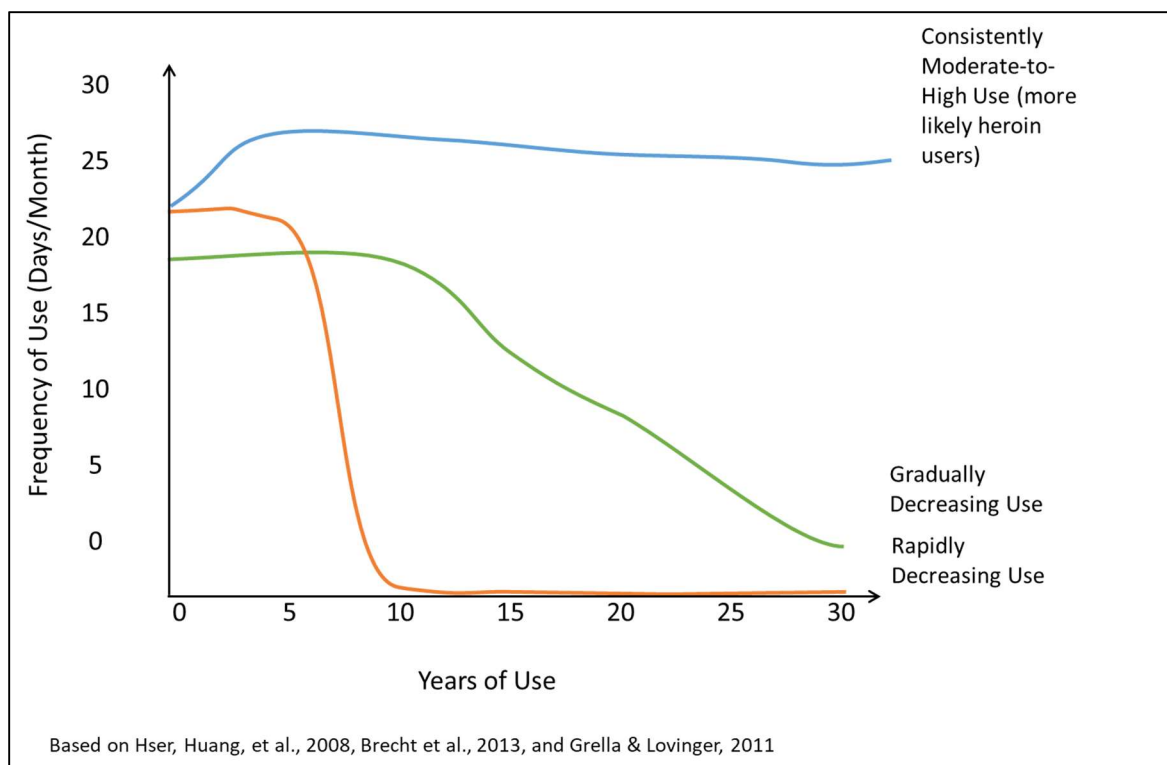
Figure 2.1. Trajectories of Use Over 30 Years as Described in the Literature

Trajectory studies are useful for understanding the direction of use over time but not for understanding the remission-relapse cycle. It is not apparent from these trajectories that many PWUD experience periods of abstinence regardless of their 'final' outcome. Rather, the impression given is that "moderate use" individuals, for instance, used their drug of choice at the same frequency, year after year, with little change. Yet analysis of these same samples reveals this not to be the case. For instance, in one study PWUD experienced multiple 'episodes' over a 10-year period, where an episode indicates a transition between no use, low use, high use, or incarceration; people who used heroin experienced on average 9 episodes while people who used methamphetamine or cocaine averaged 7 episodes. Deceleration, i.e., changing from high use to no or low use, was about half as common among heroin users (39.8%) than methamphetamine users (80.4%) (Y. I. Hser, Evans, Huang, Brecht, & Li, 2008). Heroin users averaged fewer and

shorter episodes of no use compared to methamphetamine users, a similar number and length of low use episodes, and more but shorter episodes of high use. This is likely because high use episodes were more likely to be truncated by incarceration; notably, incarceration generally transitioned back into use, possibly indicating little change in propensity to use. Heroin users' episodes of no, low, or high use tended to be about the same length (12-17 months), while methamphetamine users' episodes varied more (11-23 months).

Another analysis of all 4 CALDAR studies likewise reports that there are significant periods of abstinence among these samples in the 10 years after treatment (Evans, Li, Grella, Brecht, & Hser, 2013). Depending on their age when they entered treatment, the average number of months of use ranged from 21-34.9, meaning that there were more months abstinent. The data do not indicate if these months of abstinence were consecutive, rather than interspersed, but other analyses of these samples would suggest that the heroin users were more likely to have long durations of either abstinence or use, whereas the stimulant users had shorter but more frequent periods of abstinent months.

For instance, Nosyk et al. (2013) examined periods of heroin abstinence over the addiction career for a sample of men whose heroin use started in the 1950s-1960s, finding that 82% had at least one episode of abstinence with a median duration of 15 months. The modal number of episodes of abstinence was one, lasting 2 years and starting 14.6 years after initiation. However, over 60% had more than one abstinence episode, and each subsequent abstinence episode lasted progressively longer. A separate analysis of samples that included both men and women who used heroin, methamphetamine, or cocaine found that over a 12-month time period, there was significant stability in health 'states' (abstinence, non-daily use, daily use, treatment, and incarceration), especially for heroin users (B Nosyk et al., 2014). Nonetheless, across all 3

19

drugs, approximately 30% of PWUD transitioned between states in a given 12-month period. As with other research, methamphetamine users had more and longer episodes of abstinence compared to heroin users. Regardless of drug type, however, episodes of daily use got shorter over time, though there were no discernible patterns in the duration of other health states (B Nosyk et al., 2014). Taken together, these studies show that heroin users tend to have more stable patterns of high frequency use but do experience periods of abstinence even when their general trajectory is persistently high use, while stimulant users have an overall more erratic pattern of use, with more transitions and more variation in frequency.

Other studies point to even more frequent transitions. One study of primarily Black clients in the Chicago area who had a mix of drug use disorders reported 3-4 episodes of care in a 9-year period between first treatment and a full year of abstinence (Dennis, Scott, Funk, & Foss, 2005). In the same sample, 65% transitioned between using, treatment, and "recovery" (defined as not using but not in treatment) as frequently as twice in 3 months (Scott, Dennis, & Foss, 2005). If episodes of care or transitions between using, treatment, and "recovery" reflect actual changes in propensity to use, then we could expect to see at least minor variations in propensity occurring every few months and meaningful shifts every few years. Similarly, methodological papers describing ways of measuring the discontinuity of use over time show that even when comparing similar numbers of transition frequencies and rates, high variability in use patterns is observed (M. Boeri, Tyndall, Whalen, Ballard, & Whalen, 2011; Whalen & Boeri, 2014).

Research on samples of people who have remitted also provide clues to remission-relapse cycles over time. Studies on the probability of any period of remission over the lifetime vary widely, from 35-99%. White's (2012) review of studies indicates a 59% remission rate among

those with lifetime DUD. Lopez-Quintero and other NESARC (general population)-based studies have much higher probabilities, from 80-99%, but these are only 3-year follow-ups and do not include heroin or methamphetamine estimates specifically (Compton, Thomas, Stinson, & Grant, 2007; Grant et al., 2016; Lopez-Quintero et al., 2011). Fleury et al.'s (2016) systematic review of mostly clinical studies estimate that two-thirds achieve at least a 6-month remission on average 14 years after initiating their drug of choice. Over the mean follow-up period of 17 years, 39.7% of the baseline samples, which includes those who are deceased or lost to follow-up, had achieved remission for at least 1 year; only 27.5% of the baseline sample had achieved at least a 5-year remission. The standard rate, which excludes people who are deceased or lost to follow-up, of 5-year remission was much higher, at 52.8%. These studies confirm the trajectory studies showing that, if people survive their addiction, their likelihood of remission will increase over time.

However, remission might occur one year, only to be followed by relapse the next year. Each year, between 15-25% of people dependent on heroin, cocaine, or methamphetamine will remit (Calabria et al., 2010). Given the numerous studies showing that periods of abstinence (and thus presumably remission) can last as long as 12-24 months yet still end in relapse, we can assume that a significant proportion of those who remit, even for a full year, will later relapse – and then later remit again. Indeed, in one sample of privately insured patients receiving outpatient treatment who achieved remission within the first year after treatment, they identified three groups who had different probabilities of remaining in remission over the next 13 years (Kline-Simon, Chi, Mertens, & Weisner, 2017). The early relapse group (36%) had a low probability of remission; they relapsed within the first 5 years after exiting treatment in remission, and their probability of remission never surpassed 20% in the remaining 8 years of the

study. The declining remission group (33%) had a decreasing probability of remission; they were more likely to relapse in the first 5 years, with about 50% remaining in remission at 13 years. The stable remission group (31%) had a stable remission probability, meaning they were unlikely to relapse after treatment. These findings support other studies showing that a minimum of 5 years of remission is necessary before being considered stably remitted (Y.-I. Hser, 2007). For instance, in a sample of methamphetamine users who had been in treatment (Brecht & Herbeck, 2014), 23% maintained abstinence throughout the follow-up period, which averaged 60 months. This means that over three-quarters relapsed, and did so in the first 5 years, indicating again that even the first 5 years after remission remain a high-risk period. However, those with at least 5 years of follow-up data averaged 44 months of abstinence, though these were not necessarily continuous. This would seem to indicate that even though many quickly relapsed after exiting treatment, they also (fairly) quickly returned to abstinence.

To the extent it is possible to summarize trajectory and episode studies into representative patterns, the most clinically significant include the following: 1) a pattern of *erratic use with eventual remission* marked by frequent transitions in and out of use for up to 30 years after initiation, more likely among stimulant users and unlikely among heroin users; 2) a pattern of *persistently moderate or high use with eventual remission,* marked by infrequent abstinence for heroin users, and somewhat more frequent periods of abstinence for stimulant users, for the first 10-15 years, followed by a decline in use at varying rates over the next 15-20 years; 3) a pattern of *persistently moderate or high use until death*, more likely among heroin users, lasting for up to 30 years, with only occasional periods of abstinence or remission. Figure 2.2 depicts these 3 patterns. However, there are other patterns as well, including stable remission within the first 10 years and persistently low use. These could be considered similar to the 'desired pattern' in the

22

figure, which shows use remaining low after the first period of abstinence or remission, rather than a return to use. Of course, this 'desired' pattern assumes that a drug use disorder has developed in the first place.
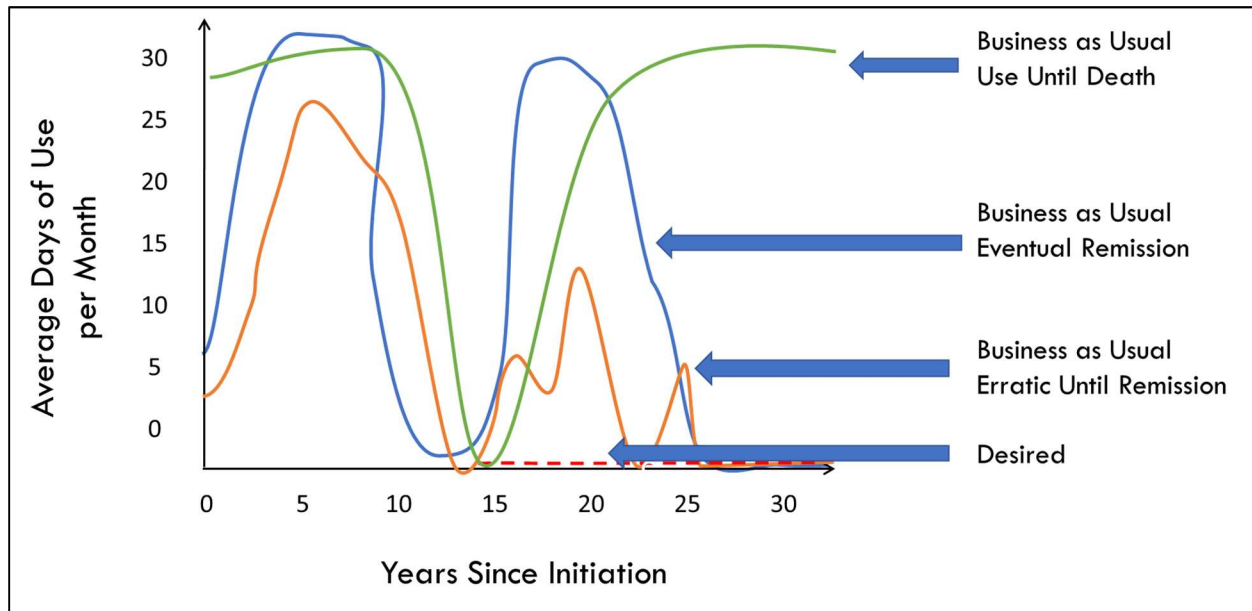
Figure 2.2. Three "Business as Usual" Patterns of Use Over 30 Years and Desired Pattern

'Propensity to use' is theorized to be an underlying *internal* construct that reflects motivations, desires, or preferences toward use. Propensity to use is driven by a multitude of internal factors that simultaneously push and pull people away from drugs. Factors that push people toward drug use and therefore maintain or even increase their propensity to use include those already mentioned, like craving (which can be prompted by being around other PWUD) and withdrawal, as well as negative and positive affective states including shame, stress, and simply a desire to get high. Moreover, part of the learned behavior of addiction include subconscious habitual motivations not immediately accessible to people's consciousness (Koob & Volkow, 2010). At the same time, longer-term social and psychological factors decrease

23

propensity to use and therefore "pull" people away from drug use, namely, awareness of the negative consequences that drug use has had or could have on their lives (Biernacki, 1986; Christo, 1998; Heyman, 2013b).

Thus, propensity to use captures all *internal* factors that influence drug use, while access to drugs is the primary *external* factor that interacts with propensity to influence drug use behavior. (Contact with other PWUD increases access and triggers craving, which is experienced internally.) Therefore, the generalized pattern of declining drug use frequency reflects declining propensity to use.

Behavior is determined by the relative strength of the different 'push' and 'pull' factors (i.e., feedback loops) that affect propensity to use. If a PWUD has persistently moderate or high use, that suggests they have a persistently moderate or high 'propensity to use' that is supported by access. Their persistently high use (and thus 'propensity to use') means that balancing loops are relatively weak for them.

Ambivalence

In addiction, there is a "moment-to-moment balance of motives" when "want" and "ought" compete (West, 2005).This competition between desires or motivations is sometimes referred to as ambivalence, which reflects uncertainty about the relative value of continuing to use versus quitting. Ambivalence is a ubiquitous concept in research and practice on motivational interviewing (MI), a common therapeutic technique in addiction in which the goal is to "resolv[e] ambivalence in the direction of change" (Hettema, Steele, & Miller, 2005). Thus, while propensity to use is not a construct in the addiction literature, ambivalence is a similar construct. The research on ambivalence could therefore provide insight into the theorized relationship between propensity to use and drug use behavior.

24

However, 'ambivalence' is not used in this study due to conceptual problems in the literature. First, definitions of ambivalence are difficult to find in the MI literature. Early descriptions of the concept within the context of MI linked ambivalence to contemplating change and to the act of weighing the pros and cons of using versus not using (W. R. Miller & Tonigan, 1996). In one review article, ambivalence is referenced in statements such as "they want it, and they don't" (Hettema et al., 2005). It has been operationalized as change talk co-occurring with sustain talk, where sustain means continuing to use (Feldstein Ewing, Apodaca, & Gaume, 2016); the two types of talk are seen as independent constructs (W. R. Miller & Rose, 2010). However, this operationalization would only apply if the person is currently using; otherwise, sustain talk (to sustain abstinence, for instance) would be welcomed. Similarly, Miller and Rose (2010) suggest that failure to commit to either abstinence or continued use means higher ambivalence, and they link failure to commit to abstinence to increased use at follow-up. However, by this definition, where failure to commit in either direction is an indicator of ambivalence, ambivalence could be resolved by committing to continued use. Of course, this is not what they intend.

The lack of clarity about what ambivalence is and how to measure it might be the reason that its internal consistency is low compared to factors like recognition of problems and taking action to change (Cronbach's alpha of .60 reported in the original measure versus .83 for taking steps and .85 for recognition) (W. R. Miller & Tonigan, 1996). Lack of clarity about ambivalence could also be why studies do not consistently show that resolving ambivalence is even a necessary mechanism of change (Daeppen, 2016).

Despite the limitations in the definition of ambivalence, 'propensity to use' can be mapped onto ambivalence. In the present study, a lack of commitment to abstinence would mean

no ambivalence is present because the PWUD wants to use; they have a high propensity to use. As propensity falls, ambivalence increases, reaching a high point around an "average" value of propensity; according to the literature's conceptualization of ambivalence, it would begin to fall again as propensity continues to fall. This "U" shape of the ambivalence construct could be at the root of its lack of clarity. Propensity to use, in contrast, has a positive relationship to drug use all along its theorized continuum; all else being equal, when propensity to use is at its lowest, drug use is infrequent or absent and when propensity to use is at its highest, drug use is frequent. In between these extremes (i.e., 'ambivalence') the interaction between 'moment-to-moment' competing factors ranging from craving and withdrawal to awareness of long-term consequences result in drug use or not, depending on which of these is strongest as well as external factors like access.

Expectations for Social Role Functioning and Social Role Functioning

The question, therefore, is how underlying competing motives, desires, or preferences interact and result in behavior change, including reductions in drug use and improvement in social role functioning.

In dynamic theories of drug use such as Heyman's (2009, 2013a) "disorder of choice" theory, competing motives are described as existing in a local versus global framework. In a local choice framework, using will always be chosen over other activities, while in the global choice framework the choice is about lifestyles and social roles. Thus, in the global choice framework the more common choice is to not use drugs because drugs negatively affect the ability to engage in conventional social role behaviors, which is affected by other people who support or discourage engaging in these behaviors. An addicted person living primarily within a

26

local perspective is taking a global perspective during moments of regret for past behavior (Heyman, 2009) or when imagining future, non-drug using selves (Biernacki, 1986). Shifting behavior to align with a different future 'self' (different social roles) is difficult, as it requires maintaining this global perspective through several guaranteed low-value days (i.e., of withdrawal) for the greater, yet uncertain, value of future days. In other words, it is difficult to maintain a low propensity to use, which would be required to achieve and maintain low use or abstinence and shift to a decreasing trajectory of use.

Webb et al. (2010) use control theory to similarly posit two competing motives in drug use. Behavior change is driven by discrepancies or gaps between behaviors and goals, and these gaps spur intentions to change. Goals are believed to be hierarchically arranged such that 'be' goals are considered higher-level than 'do' goals (Webb et al., 2010). That is, who a person wants to *be* is a "higher" goal than the more immediate goal of what someone wants to *do*. Self-regulation is the ability to act in accordance with these higher-level, 'be' goals. 'Be' goals are prioritized in a global choice framework, while 'do' goals are prioritized in a local choice framework. 'Be' goals drive decreasing propensity to use, while 'do' goals drive an increasing propensity. Lowering the propensity to use, then, arises from being able to consistently choose "ought" and "be" goals within a global choice framework, ideally until what one "ought" to do becomes what one wants to do. Such changes in social roles can lead to long-term remission even among people who have had severe heroin addictions (Y.-I. Hser, 2007; Y. I. Hser et al., 2015).

Taken together, prior research suggests that it is not only how well a person is functioning in their social roles, but also how their goals relate to functioning. In this study, these goals are framed more broadly as 'Expectations for Social Role Functioning.' High expectations

for social role functioning suggest that a person is working toward "be" goals, rather than "do" goals, and is using a global choice framework, rather than a local framework (Heyman, 2009; Webb et al., 2010). Expectations reflect what they believe they are capable of and can achieve, and both shape and are shaped by Social Role Functioning itself. However, in contrast to a balancing feedback-only approach, expectations (as goals) do more than support self-regulation; they also directly affect behavior in a reinforcing feedback process.

Expectations for Social Role Functioning belong to the individual (including PWUD), but are shaped by other people's expectations in a continual action-reaction process (Biernacki, 1986; Parsons, 1951).

Social Roles and Reference Groups

In this study, 'social role functioning' denotes how well the PWUD is fulfilling their social roles such as parent, partner, family member, resident, employee, etc. Of especial importance is how well they are functioning as parents, or how well their loved ones perceive they are functioning as parents.

Social roles are closely related to identity. Identity transformation as a fundamental process in recovery has its roots in symbolic interactionism but is echoed throughout the literature on recovery. Biernacki's (1986) study of people who recovered from heroin addiction without treatment is among the most well-known applications of symbolic interactionism to addiction. Biernacki concluded that the conflict between drug-related and conventional identities – that is, the competition between motives, desires, or preferences, i.e., the propensity to use – precipitated the recognition of drug use as problematic. Similar theoretical approaches describe how people in recovery believe their "real" or authentic selves were hidden by drugs; identity work requires distancing oneself not only from the drug-addicted, inauthentic self, but

28

disparaging drug-related identities, especially that of the 'junkie' (M. W. Boeri, 2004; McIntosh & McKeganey, 2000; Radcliffe & Stevens, 2008; Weinberg, 2000).

An important distinction for symbolic interactionism is its explicit incorporation of other people's effect on the PWUD. Social roles are constructed with others, called "reference groups" (Biernacki, 1986; Roy, Nonn, & Haley, 2008). Reference groups make up the different social worlds with which people are involved, and for PWUD include other PWUD, whether family or part of the "scene," as well as non-drug using family, friends, and partners. Social roles of interest in this study are the roles held in relationship to "conventional" reference groups, e.g., friend, partner, child, parent. These social roles come with expectations for behavior and responsibilities (Lemay, 1999), which are shaped in interaction with reference groups.

Social roles exist in the past, present, and future, which means that reference groups can be real or imagined. A desired future social role as a mother, for instance, would include the imagined reference group of children. All people, including PWUD, anticipate how real or imagined reference groups might respond to their behaviors, which influences how they act. How reference groups actually respond to behaviors is also important; their responses shape people's "cumulative biographic image of self," which in turn shapes their behaviors (Biernacki, 1986).

Symbolic interactionists posit that, in recovery, PWUD attempt to draw on their "conventional" social roles. Whether they are able to do so successfully depends on how "spoiled" or stigmatized these social roles have become due to drug use, and how reference groups, such as non-drug-using family members, respond to drug users' behaviors (Waldorf, 1983). Symbolic interactionism further suggests that the anticipated consequences of actions or behaviors, i.e. how reference groups are expected to respond, leads to self-regulation.

29

Thus, while identity construction is often thought of as a deeply personal enterprise, it is also unavoidably social: "shifts in identity practices (what I do to be myself) entail shifts in living practices (what I do with others in order to be myself)" (K. Hughes, 2007, p. 674). However, existential identity crises and reconstructions do not always play a role in addiction recovery; many addicted individuals say the most important reason for quitting was the that "it was time to do other things," (Waldorf, 1983) which may entail a shift to more conventional social role behaviors, but not identity reconstruction.

Empirical data bear out the impact of changing social roles in remission and recovery. Studies spanning three decades (e.g., Goodman, Peterson-Badali, & Henderson, 2011; Waldorf, 1983) have found that motivation to quit is spurred by pressure from spouse, family members, and friends. Heyman (2013b) noted in his review of reasons for quitting drugs that new children, relationships, and a desire to be seen as a good family member are among the most common reasons for quitting drug use. Among emerging adults (ages 16-24) in substance use treatment, feeling a sense of responsibility toward others was the only individual psychosocial predictor of intrinsic motivation to change (Goodman et al., 2015). Social roles continue to predict transitions in and out of drug use disorder well into adulthood (Vergés et al., 2013). Indeed, that people are motivated by the failure to meet their own and others' expectations is consistent with research that shows that role neglect is one of the most severe symptoms of DUD (Saha et al., 2012).

New social roles inform the goals toward which a PWUD is striving, which in turn drives successful behavior changes (Webb et al., 2010). These social roles can even be an important source of self-regulation among people who practice controlled use of addictive substances (Zinberg, 1984), which highlights the importance of the PWUD's ability to meet the goal of fulfilling these social roles, not necessarily the goal of abstinence.

Hope

Hope is a domain in multiple definitions of recovery for both mental illness and addiction (Davidson et al., 2008; Fetzner, McMillan, Sareen, & Asmundson, 2011; Leamy, Bird, Le Boutillier, Williams, & Slade, 2011; Substance Abuse and Mental Health Services Administration, 2012) and is closest to the "outlook on life" factor in the SURE measure (Neale et al., 2016). However, "outlook on life" implies a trait of the individual, whereas hope is conceptualized here as a state. For loved ones, their hope*lessness* is captured in the notion of "putting up with it," (Orford et al., 2005; Orford, Velleman, Copello, Templeton, & Ibanga, 2010).

In the model, the closest corollary to hope is expectations for social role functioning though, as will be explained in the results, these are different in meaningful ways. Instead, hope (and hopelessness) is more accurately captured in one of the loops involving expectations, which will be explained in the Results.

Support Received

'Support received' in the present study is meant to include the social, material, and emotional support that people *receive* (and not just what is theoretically available to them) while they are using *as well as* while they are trying to quit. Thus, it is not just "support for recovery," which is sometimes measured in research.

A PWUD's relationships with other PWUD as well as with people who can provide positive social support are among the most consistent predictors of long-term outcomes (Grella & Stein, 2013; Y.-I. Hser, 2007; Y. I. Hser et al., 2015). Indeed, in one meta-analysis of dozens

of predictors of continued drug use after treatment, "psychosocial variables" were among the few to remain statistically significant and strongly related to outcomes; associations with other PWUD was the strongest predictor of continued use with positive social support predictive of quitting (Brewer et al., 1998). However, the simple presence of abstinent people is an imperfect measure of support. Having abstinent people in one's network is helpful when trying to quit (Costenbader, Astone, & Latkin, 2006) but not protective against risky behaviors while still using drugs (Lovell, 2002). This may be because, once they are trying to quit, PWUD are able to draw upon the abstinent people in their lives for support, but do not necessarily *seek or receive* support from them while they are still using. If they do not have abstinent people in their lives, PWUD might instead build a new network of other people who are abstinent. Indeed, intentionally building an abstinent network while in treatment improved outcomes among people with alcohol use disorder (Litt, Kadden, Tennen, & Kabela-Cormier, 2016).

Theorized Requisites for Remission and Recovery

Based on the prior literature, the following requisites are posited as necessary to achieve remission and recovery. Without any one of these, even if the propensity to use is declining, a person might face significant challenges in quitting:

1. A global choice framework, which supports prioritization of non-drug-related or conventional social roles 'be' goals over 'do' goals

2. Supportive relationships that support social roles, by providing alternative rewards in the form of non-drug activities as well as a fear of losing these rewards and increasing expectations

3. The skills to manage ambivalence about drug use

4. Self-efficacy regarding the skills to manage ambivalence

5. The ability to accurately monitor change, thus sustaining change behaviors

Gaps in Prior Research

Focus on Addiction and Not Recovery

The predominant focus of existing research is on the state of addiction. Addiction is defined as a chronic, relapsing disease (National Institute on Drug Abuse, 2010), meaning that relapse is considered part of the addictive process. However, this only implies what people are relapsing from; indeed, they are relapsing from a period of abstinence, or even remission. Understanding relapse requires understanding what moves people into a state of abstinence, remission, or recovery, and keeps them there. The lack of focus on non-drug using states means there is less research on how or why people quit than how or why they use or escalate their use. As a result, we have a much stronger understanding of the reinforcing loops that drive people toward drug use and much less understanding of what shifts loops in the opposite direction toward recovery, or how these interact with balancing loops that limit use.

Moreover, most research on these factors is quantitative, and little of it is longitudinal over a period of multiple years or decades. Thus, processes that drive change over time such as relationships and support are poorly understood.

Lack of Dynamic Perspective from People Who Use Drugs and their Loved Ones

Mental models of recovery are more than the domains of recovery. They reflect whether people even agree that these are the correct domains, as well as how people believe these domains interact and change over time to support or undermine recovery. Qualitative research

has made modest progress describing how PWUD or who are in recovery believe these domains interact but has not systematically described these interactions to test their underlying logic or they can lead to addiction versus recovery. There has been almost no research on loved ones' perceptions of recovery.

Chapter 3: Methods

3.1 Research Design

The study designed involved several steps. First, in-depth qualitative interviews with people who use drugs and loved ones were conducted, coded, and analyzed using a grounded theory approach. To aid the coding process, qualitative causal loop diagrams (CLDs), based in feedback loops, were constructed based on the emerging theory. The CLDs were iteratively refined as the coding and analysis progressed. Finally, the CLDs were translated into a simulating system dynamics model of integral and algebraic equations. The codes that emerged from the interviews were compared to concepts from the extant literature; where they were similar, existing constructs were used to maintain consistency with prior research (e.g., social role functioning). If the codes did not have a clear corollary from the literature, then the code itself was used. Constructs from the literature were rejected if they did not have a clear link to other constructs in the theory (e.g., ambivalence). The model was used to test the effects of changing key parts of the model on outcomes related to recovery.

Interviews focused on the person who uses drugs and his or her experiences of trying to quit and stay quit, the role of loved ones who do not use in supporting that, and their relationship with those loved ones. Though discussion about other people who use drugs, access, providers and law enforcement, and policies arose, these were not the focus of the interviews or the model. The Results section will present a model boundaries table with constructs included and excluded.

Dynamic Simulation Methods for Complex Adaptive Systems Research

Complex systems of multiple interacting components should be studied using appropriate methods that account for this complexity while also reducing complexity so that the model is

useful for research and policy. System dynamics (SD), used in this study, is a method that uses a combination of causal mapping and computer models built using a system of ordinary differential equations (ODEs) (Forrester, 1961; Sterman, 2000). The goal is to gain insight into how elements within a system interact with each other and to learn how the system is contributing to problematic behavior. Simulation is used to identify changes that are most likely to be effective and sustainable in addressing the problem. Often, these changes are counterintuitive, or the changes that were assumed to be most impactful are not. The results from the model can be used to "work backwards" to understand these counterintuitive insights, and to identify interventions that could have the same effect as the strongest positive changes identified through modeling.

The benefits of dynamic simulation methods in public health research have been discussed extensively in recent years (B. D. L. Marshall & Galea, 2014; D. A. Marshall, Burgos-Liz, IJzerman, Crown, et al., 2015; Roux, 2015). Tools such as SD challenge the utility of analytical frameworks that posit a set of independent, non-correlated variables as 'predictive' of a dependent variable. Sustainable, creative solutions are unlikely to arise from a knowledge of risk factors, without first situating these variables within a dynamic framework that allows for multi-level, nonlinear interactions. SD models nonlinear problems, such as unpredictable fluctuations or small changes that lead to large effects. These effects are driven by the interactions between people, the constructs, states, attributes, or variables (all used interchangeably here) that describe them, and the complex adaptive systems of which they are a part.

System dynamics uses a computer model to simulate the effects of policies and interventions on a dynamic problem. Simulation is useful because people are unable to anticipate

through conceptualization alone the possible consequences of interventions on social systems with multiple inputs and outputs (Forrester, 1961). SD explicitly accounts for mental models as well – specifically, how people use and respond to information about the dynamic system of which they are a part, regardless of whether that information is accurately assessed or appropriately used. At the same time, SD allows the modeler to account for the inherent flaws and limitations of mental models by, for instance, building in the effects of bounded rationality, cognitive biases, delays and inaccuracies in perceptions, etc.

<u>Stocks, Flows, and Information-Feedback Loops</u>

One of the greatest benefits of using SD is to highlight how system structure (information-feedback flows) contributes to behavior over time. In addiction research, this means how people's interpretation and response to information about recovery contributes to the inability to recover.

Stocks and flows are the building blocks of system dynamics models. Stocks represent either information (perceptions, desires, memories) or material (including people) that changes in value or amount over time. The difference between information and material stocks is in whether they are conserved; information is not lost when it is shared, but people moving in and out of a social network or in and out of care are, in essence, "lost" to that network or to care providers (Hovmand, Sato, Kuhlberg, & Chung, 2016). The model presented here includes only the flow of information (where information is meant to include psychological states), and not of material or people.

The value of stocks changes according to their rates of change. The amount or value of stocks is dependent on its current value as well as on the rate of change. The rate of change, in turn, is often affected by the value of other stocks. This creates closed feedback loops, which are

sometimes called information-feedback loops because it is information (perceptions, beliefs, memories) that affects change. Information – about other people, relationships, communities – is constantly flowing through a CAS, and people are continuously interpreting and responding to that information. Their responses (decisions, actions) change the state of the system.

Closed feedback loops mean that behavior is endogenous to the system, where the system is defined by the modeler's boundaries (Richardson, 1999, 2013; Sterman, 2006). It does not mean that the only problems experienced in the system are endogenous to it. Rather, it means that there are almost always things happening within the system that are making the problem worse. Effects that are outside of the system are exogenous. However, expanding the system boundaries could have the effect of making those effects endogenous. For instance, criminal justice policy is relevant but exogenous to an individual-level system because an individual's drug use does not affect criminal justice policy, though criminal justice policy does affect that individual's use. Criminal justice policy would be endogenous in a population-level system when policy-makers respond to population-level changes in drug use by changing criminal justice policy.

An important concept in system dynamics is delays; information delays result when perceptions of reality take time to adjust compared to reality. Often, the time it takes for something to increase may be much shorter or longer than the time it takes to decrease. Delays are often responsible for feedback in a system because people do not have the most current information, and thus they respond to prior information or perceptions, resulting in "errors" in their responses. People act based on their current perception rather than reality, often without accounting for the time it takes for things to change. For instance, it can take a long time to build trust and a much shorter time to lose it, but people may act as if the trust others have in them

changes more slowly than it does, which can lead them to act differently than they would if they had current information. Another implication of delays is that they inhibit the ability to properly understand the relationship between cause and effect (D. A. Marshall, Burgos-Liz, IJzerman, Osgood, et al., 2015; Meadows, 1997; Sterman, 2006).

Visual Heuristics for Causal Mapping in System Dynamics: Causal Loop Diagrams and Stock and Flow Diagrams

SD is utilized in conjunction with a set of heuristic tools that, even without simulation, have proven useful in developing insights (Coyle, 2000; Lane, 2008). Behavior over time graphs, boundary charts, and causal loop diagrams aid in defining the problem and its boundaries and improving logic. These tools can be used, moreover, to develop initial theories.

The most critical heuristic tool used in system dynamics is a visual diagram that maps the relevant parts of the system and how they interconnect. If it is qualitative, it can either be a causal loop diagram or a stock and flow diagram. Causal loop diagrams are used to visually represent reinforcing and balancing feedback loops, and how they interact with each other. A stock and flow diagram is represented with flows, or rates, that increase or decrease the value of the stock, and auxiliary or converter variables that affect the value of flows. A stock and flow diagram is also used for a simulating model.

Figure 3.1 is a causal loop diagram (CLD) showing two very simplified loops relating to drug use and negative and positive memories of drug use. As drug use increases, positive memories of use increase, which increases the propensity to use drugs, and thus drug use itself. However, at the same time, as drug use increases, negative memories associated with use also increase due to negative consequences. These negative memories decrease the propensity to use beyond what it otherwise would be, shown with a '-' sign. Thus, the propensity to use drugs is

affected by these negative and positive memories, and whether someone uses is *in part* due to which of these loops is strongest.
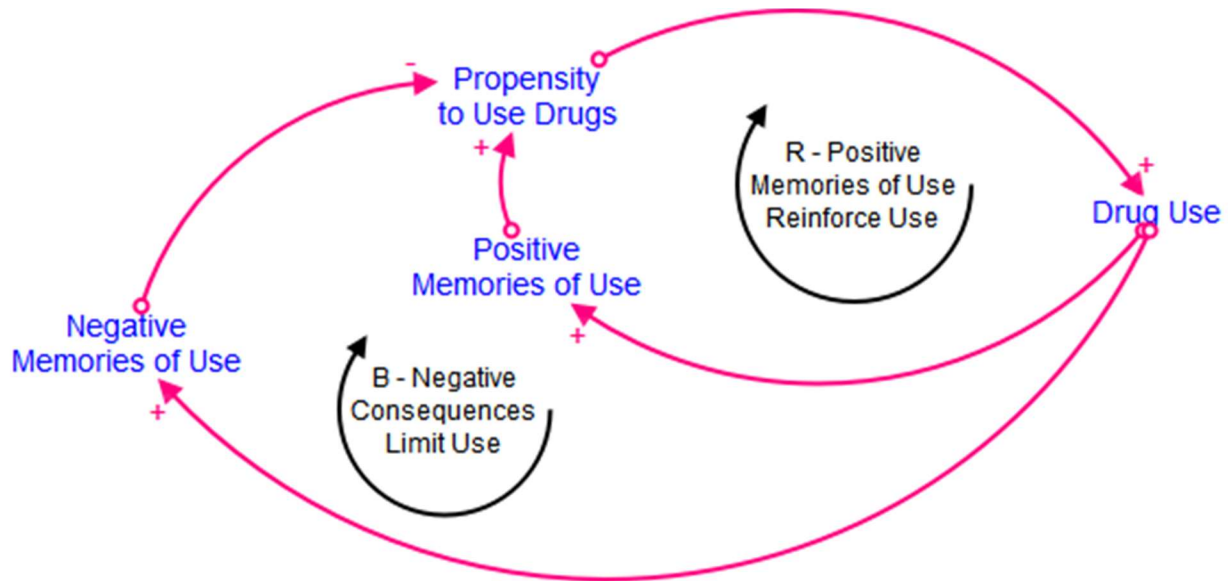
Figure 3.1. Causal Loop Diagram

3.2 Setting

The qualitative data used to inform the model was collected through interviews with people living in Franklin County in the eastern region of Missouri, a county with a population of just over 100,000 (U.S. Census Bureau, 2015b). This county was chosen because the original proposal for this dissertation was focused on the role of social spaces in rural areas. However, as the study progressed, the rural status of the county in which participants resided became less theoretically relevant. Nonetheless, a brief background will be provided discussing federal definitions of rural and how these apply to Franklin County.

Franklin County

Choice of Setting

There are as many as 9 definitions of rural used by the federal government (Economic Research Service, 2007) resulting in estimates of the nation's rural population ranging between 10% and 28% depending on which combination of definitions is used (Hart, Larson, & Lishner, 2005). Franklin County is considered urban and metropolitan, respectively, according to the Census Bureau (United State Census Bureau, n.d.) and Office of Management and Budget (Ingram & Franco, 2012) definitions.

The rural-urban commuting areas (RUCA) are a classification developed by the U.S. Department of Agriculture Economic Research Service (ERS). RUCA codes are based on population density, urbanization, and commuting within or outside of the tract, and are defined at the subcounty or census tract level (United States Department of Agriculture Economic Research Service, 2014). The RUCA scheme is the only one to use the term "small town." The RUCA codes perform well at predicting variables of interest such as population density(National Academies of Sciences Engineering and Medicine, 2016) and are often preferred by researchers because of their flexibility (Hart et al., 2005).

The Federal Office of Rural Health Policy (FORHP) definition, which was the definition used for this study, is a combination of the Census and OMB definitions and the RUCA codes. The FORHP uses the Goldsmith Modification, which is now represented by the RUCA codes. The modification was specifically used to identify small towns and rural areas that are part of geographically large metropolitan counties and that likely lack access to health and mental health services (Goldsmith, Puskin, & Stiles, 1993; Health Resources and Services Administration Office of Rural Health Policy, 2018). Its designations result in 18% of the US population

considered rural (Office of Rural Health Policy, 2010). This definition is meant to overcome the challenges with the U.S. Census Bureau overcounting and the OMB undercounting rural areas. Franklin County is officially designated as a primary care shortage area; it is not considered a mental health shortage area (Rural Health Information Hub, 2016).

Finally, Franklin County also meets the Centers for Medicare and Medicaid Services' definition of rural, which identifies non-urbanized areas (U.S. Department of Health and Human Services, 2014). Non-urbanized areas do not have any census tracts or blocks of at least 50,000 persons. Franklin County has no urbanized areas, only urban clusters of 2,500-50,000 people (U.S. Census Bureau, 2011).

Given the large number of options, decisions about which definition of rural to use should be guided by the research question (Hart et al., 2005). Initially, this study was focused on how rural social spaces impact perceptions and preferences for ways to cut back or quit using drugs. (The study questions shifted, however, as data were collected and analyzed, and social spaces became less important to the theory.) Thus, consideration was given to what it means to be in a "rural social space" and to what interventions are available for people in that space. The FORHP designation accounts for economic and commuting patterns, which were considered most theoretically relevant for understanding social spaces and health service shortage areas. People with greater access to an urbanized area might have different social spaces and different interventions available to them compared to those with less access.

Franklin County represents a choice along the rural-urban continuum that is understudied despite the fact that it likely represents a sizable proportion of the American population. Though it is not quite "suburban" (and, in any case, there is no federal definition of suburban) it is also not as isolated as many rural areas. In rural areas lacking services, perceptions of interventions

would be hypothetical more than meaningful. However, Franklin County has services. There is an adult addiction treatment program, an active drug court, a nationally recognized drug task force, and several 12-step and other self-help groups.

Extant rural drug use studies include populations that meet more definitions of rural than Franklin County, or densely populated downtown areas of the nation's largest metropolitan statistical areas (MSAs), especially in New York City. These large MSAs and Franklin County are categorized in some classification systems as equivalent. Franklin County thus represents a larger proportion of drug users than those found in Mississippi Delta or Appalachia region, the regions covered by previous rural studies, who come from areas representing at most 20% of the population. The counties west and south of Franklin County are more similar to those that have been in previous rural studies, with total populations under 30,000 and designations as nonmetropolitan and outside of urban clusters.

As a nearly all-white race county, Franklin County represents a distinctly different population than its neighbor, St. Louis. Franklin County is 95.3% White non-Hispanic, making it more white than the nation as a whole (U.S. Census Bureau, 2015a, 2015b) and than rural America, which is about 21% non-white, but similar to the rest of rural Missouri (Johnson, 2010). However, while its racial demographics are similar to counties to its south and west, it is more socioeconomically advantaged and has greater access to resources. The median household income is $48,857, which is similar to the state but lower than the median household income in the U.S.; 11.8% are below the poverty level, which is lower than for the state, the country, and rural America (U.S. Census Bureau, 2015a, 2015b). Eighteen percent of persons 25 and older have earned a bachelor's degree or higher, which makes it more similar to rural Americans,

compared to 29% for the country and 27% for the state (United States Department of Agriculture, 2016).

Rural Tracts within Franklin County

Because the definition of rural used in this study is on the tract level, the next decision to make was where to focus recruitment based on tract designation. Eleven of 17 census tracts in Franklin County meet the FORHP definition of rural (Table 3.1) (Office of Rural Health Policy, 2010). Areas that are not rural are primarily on the eastern border near Jefferson and St. Louis Counties; people living in these areas are more likely to have daily commutes to those counties. However, prior research shows that drug use risk is not distributed equally across rural areas; residents of farm areas are at lower risk than residents of small towns (Gamm, Hutchison, Dabney, & Alicia, 2003). Thus, small towns in the central part of the state were targeted more for recruitment than the western part of the county where there is more farmland.

Figure 3.2 is a map of the county with census tracts labeled. The green-shaded region toward the center of the county is Union (pop 10,859, 11.7% poverty rate, 1,114 people per square mile (ppsm)), which in addition to being the county seat is also the location of the only state-funded adult drug addiction treatment provider in the county. The purple region just south of Union is St. Clair (pop 4,711, 10.6% poverty rate, 1,277 ppsm). The yellow-shaded region in the north central part of the county is Washington (pop 14,020, 11.3% poverty rate, 1,497 ppsm), which borders affluent St. Charles County. Finally, Sullivan (pop 7,054, 27.4% poverty rate, 897 ppsm) is the purple region at the southern edge of the county. Sullivan has the greatest proportion of its population below poverty, and the lowest high school graduation rate of the 4 towns (81%). The other yellow-shaded region on the eastern edge of the county, bordering Jefferson County, is Pacific (pop 10,327); it is not considered rural by the FORHP.

Table 3.1. RUCA Code of Census Tracts in Franklin County, Missouri

Area of Franklin County	County Tract FIPS Code	Primary RUCA Code 2010	Description	Population Density (per square mile), 2010
Northeast corner	8001.00	2	Metropolitan area high commuting: primary flow 30% or more to a UA	120.7
Washington	8002.01	4	Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)	1,338.5
South of Washington	8002.02	4	Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)	281.6
West of Washington	8003.00	4	Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)	395.5
Northwest corner	8004.01	10	Rural areas: primary flow to a tract outside a UA or UC	49.4
West border	8004.02	6	Micropolitan low commuting: primary flow 10% to 30% to a large UC	48.1
Southwest corner	8005.00	9	Small town low commuting: primary flow 10% to 30% to a small UC	36.3
Union	8006.01	7	Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)	745.7
Union	8006.02	7	Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)	271.4
Parts of Pacific	8007.01	2	Metropolitan area high commuting: primary flow 30% or more to a UA	352.1
Pacific	8007.02	2	Metropolitan area high commuting: primary flow 30% or more to a UA	367.0
East border	8008.00	2	Metropolitan area high commuting: primary flow 30% or more to a UA	88.9
South of St. Clair	8009.01	9	Small town low commuting: primary flow 10% to 30% to a small UC	131.1
St. Clair	8009.02	3	Metropolitan area low commuting: primary flow 10% to 30% to a UA	253.8
Southeast corner	8010.00	2	Metropolitan area high commuting: primary flow 30% or more to a UA	33.7
Sullivan	8011.01	7	Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)	287.5
Sullivan, Oak Grove	8011.02	7	Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)	129.5
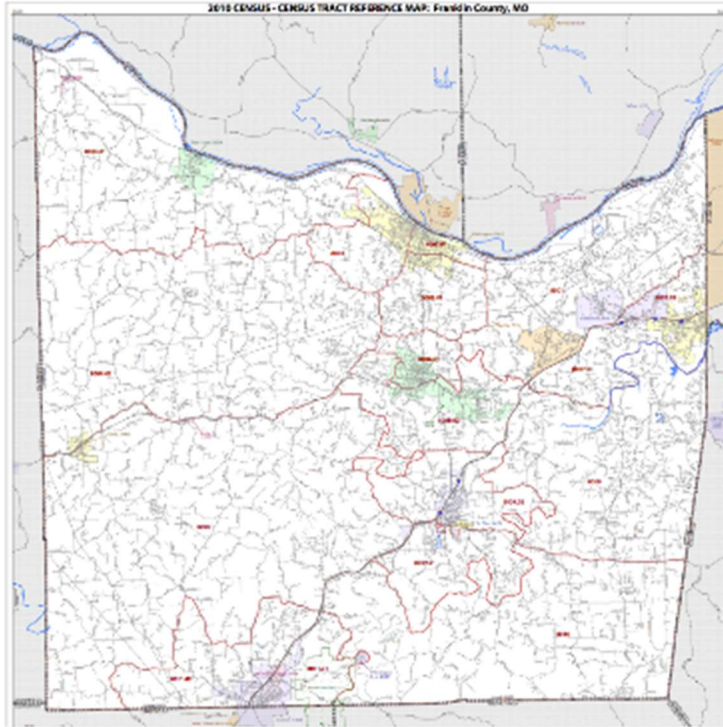
Figure 3.2. Map of 2010 Census Tracts in Franklin County, Missouri

Four communities were targeted for recruitment: Washington, Union, St. Clair, and Sullivan. These four towns are "urban clusters," which have areas of at least 2,500 but fewer than 50,000 people (U.S. Census Bureau, 2011). These roughly correspond to tracts 8002.01, 8002.02, 8003.00, 8006.01, 8009.01, 8009.02, 8006.02, 8011.01, and 8011.02 in Table 3.1. Pacific and the eastern region of the county bordering Jefferson County were not targeted for recruitment because these tracts (8001.00, 8007.01, 8007.02, 8008.00) are all considered metropolitan. However, any participants living in Franklin County were eligible for participation, provided they met the other criteria (explained below).

Regional Drug Trends

Population level data on drug use are not available for Franklin County. However, news reports within the past 5 years have noted the significant problems with methamphetamine (Bella, 2013), heroin (Greenwald, 2015), and prescription opioids (Louis, 2016) in Franklin

46

County. Franklin County is in the Eastern Missouri region, which in the designation used by the Substance Abuse and Mental Health Administration (SAMHSA) includes Franklin, Jefferson, St. Louis, St. Charles, Warren, and Lincoln Counties as well as St. Louis City.

The most recent Eastern region report released by SAMHSA includes data from 2002-2016. However, only heroin and cocaine data are available for that period. This is because changes were made starting in 2015 to questions about prescription drug misuse and methamphetamine that affect those estimates and make them incomparable to prior years (Center for Behavioral Health Statistics and Quality, 2016). Thus, those drugs are also not included in aggregate numbers spanning 2015 onwards. Table 3.2 shows the most recent years for which data are available, as this is the best available data on the substate (Eastern region) level.

Table 3.2. Past Year Use, Eastern Region Excluding St. Louis City and County

Drug	Years	Percent
Methamphetamine	2002-2011	0.4
Cocaine	2002-2016	1.1
Pain Relievers	2002-2011	1.9
Heroin	2002-2016	0.1

Data for 2015-2016 are available for all drugs of interest at the state level. By far the most commonly used illicit drug was misused pain relievers (prescription opioids), used by 4.2% of Missourians who had not also used heroin. Only .3% of the population had used heroin, .6% had used methamphetamine, and 1.1% had used cocaine. However, the proportions of population who had disorder show that the burden *among users* fell most heavily
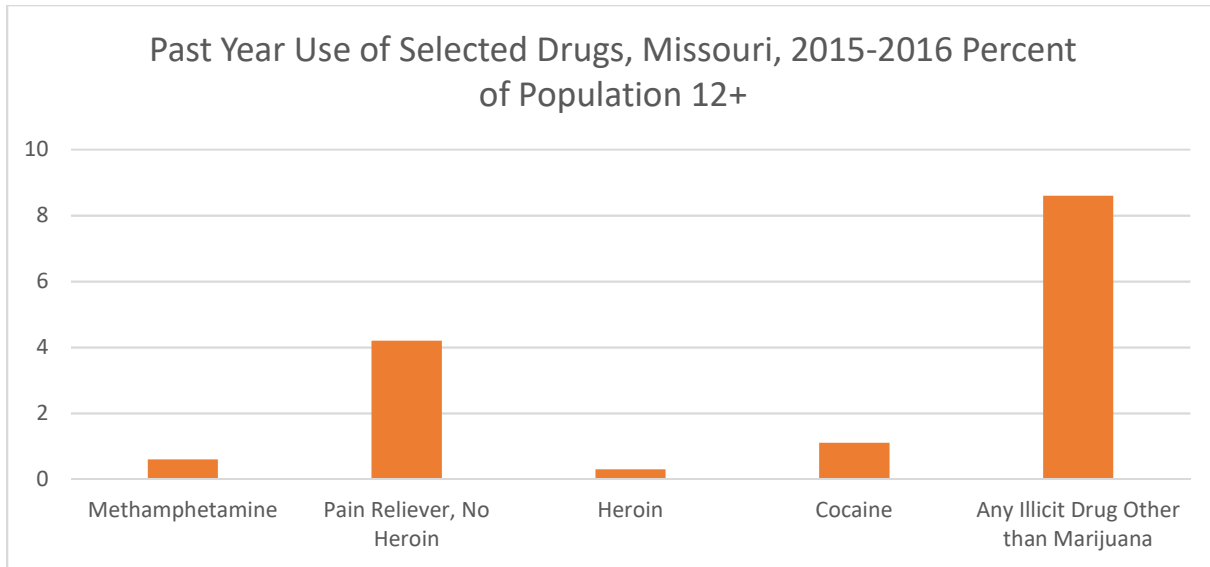
Figure 3.3. Past Year Use of Selected Drugs, Missouri, 2015-2016

among heroin users; nearly all users in the population had a disorder (14,000 users versus 13,000 people with disorder). In contrast, approximately one-half of past year methamphetamine users (.3% of the total population), 20% of pain reliever users (.9% of the total population), and less than .3% of the total population had a use disorder. The exact proportion is not obtainable for cocaine use disorder as the number is too small to be publicly released without risking confidentiality.

Data collection took place as fentanyl was gaining national and local attention for its contribution to increased rates of overdose and overdose mortality among heroin (and, increasingly, cocaine) users (Centers for Disease Control and Prevention, 2018).

General Health Indicators and Outcomes

Franklin County's access to care and overall health is relatively strong. Franklin County is ranked 8th in the state in terms of its access to clinical care, according to *County Health Rankings & Roadmaps.* Since 2016, Franklin County has been ranked #34 or #35 34 in overall

health outcomes, a significant increase from 2015 (#51) and 2014 (#57), out of 115 counties (County Health Rankings & Roadmaps, 2016a). Franklin County's mortality rate due to drug overdose was 30 per 100,000 for the years 2014-2016, the 8th highest in the state (County Health Rankings & Roadmaps, 2016b).

3.3 Sampling and Recruitment

A multimodal approach was used to inform the community about the study. This included targeted sampling, informal conversations, flyering in public locations, three Narcotics Anonymous meetings and one SMART Recovery meeting, and geographically-targeted online advertisements (P. J. Draus, Siegal, Carlson, Falck, & Wang, 2005; Watters & Biernacki, 1989). Specifically, a Facebook page was set up, with occasional paid promotions that targeted all zip codes in Franklin County. In addition, information about the study (including a link to the Facebook page) was provided in the public comment section of local newspaper articles involving drugs.

Participants were given slips of paper with information about the study to share with their friends and family. This "snowball" sampling technique was successful in bringing in several additional participants (P. J. Draus et al., 2005; Guest, 2015). Finally, ethnographic techniques familiarized the author with the area for theory development (Guest, 2015). Attending open mutual aid (Narcotics Anonymous and SMART Recovery) meetings also led to identifying potential participants.

Eligibility criteria for all participants included being at least 18 years of age and living in the study county. People with recent or current use of drugs ("PWUD") and the concerned loved ones of PWUD ("loved ones") were eligible. PWUD must have used methamphetamine, cocaine,

heroin, or prescription opioids at least once in the past year, or regularly in the past five years, which is often the minimum period considered necessary to establish a stable remission with lower likelihood of relapse (Brecht & Herbeck, 2014; Y.-I. Hser, 2007; Kline-Simon et al., 2017), meaning that if people can make it at least five years without relapse, their chances of remaining in remission are much higher. "Regularly" was defined as at least weekly for at least three months (Baker et al., 2005; Darke, Kaye, & Torok, 2012; Perez et al., 2012; Robins, Helzer, Hesselbrock, & Wish, 2010). Concerned loved ones must have been concerned about a loved one's use of one of these substances; it was a deliberate choice not to attach a time frame to their concern or overly define 'concern.' If respondents were eligible and still interested in participating, an interview was scheduled at a time and place convenient for them. Most screening to identify eligible participants occurred on the phone, though on occasion people were screened in person.

As the study progressed, non-probabilistic sampling techniques (purposive and maximum variation sampling) were used to identify people with a diversity of experiences (Bernard, 2011; Guest, 2015; Padgett, 2008). Specifically, purposive sampling, which is used to seek participants based on their expected ability to provide information to answer the research question (Padgett, 2008), guided a change in Facebook advertising to target people who were no longer using, and participants were told to give the study information slips to friends who had not used in the past year. Maximum variation sampling was used to saturate relevant dimensions (Bernard & Gravlee, 2015). After about half of the interviews had been completed, recruitment shifted toward concerned loved ones, as it became clear that variation in their experiences was more significant than that of the people who had used drugs, and that there was less extant research on this population to inform theory development. Interviews proceeded until theoretical saturation

was reached (Charmaz, 2014). In this study, that meant no new theoretical linkages were discovered in participants' mental models of addiction recovery. Theoretical saturation was assessed separately for PWUD and loved ones. This study was approved by the Washington University in St. Louis Institutional Review Board.

3.4 Data Collection

Interviews took place in private areas of public locations (namely, meeting rooms at Burger King) or in participants' homes or workplaces; all but one interview took place in the study county. Interviews lasted between 1 and 4 hours and were recorded on a digital recording device (SD card) with the participant's consent. Consent was obtained verbally for participation, recording, and follow-up, and recorded via a simple checkmark by Ms. Stringfellow. At the end of the interview, participants were compensated $20 in cash. Ms. Stringfellow conducted all interviews.

Qualitative Interviews

The interviews were in-depth and semi-structured. Initial interviews focused on eliciting a broad narrative from participants, with questions such as, "How did you get to where you are today?", "How would you describe this place to people not from around here?" (in order to understand the social spaces in which people lived and used drugs (P. Draus & Carlson, 2009), "What do you think it takes to recover from addiction?", and, finally, "What is not available in this area that you think could help people to cut back or quit?" (Notably, this sometimes became only "help people to quit," as many participants made it clear early in the interview that they did not believe "cutting back" was an option.) Because complex adaptive social systems served as the guiding theoretical principle, there was an emphasis on their perception of whether and how other people influence recovery. As theory development progressed, interview questioning

51

shifted to clarify patterns emerging from the data and how participants believed they related to addiction recovery. These questions are meant to elicit mental models of how recovery from addiction "works." The goal was to elicit operational data that informs about how people believe things work, how things change over time, and how different variables or constructs fit together. Thus, it naturally guards against content and thematic analysis, which is not useful for building a model or grounded theory (Glaser, 2002), because the analyst has to be able to craft a dynamic explanation for what is going on.

Standardized Data

Social Network Measure

Participants also completed the NIDA-recommended PhenX toolkit (Hamilton et al., 2011) social network measure in order to elicit information about people they turned to for health and important matters (Perry & Pescosolido, 2010). Several questions ask about the nature of each relationship, related to both important matters and health, and a matrix is used to record the closeness between network members. In addition, participants were asked to indicate which network members, to their knowledge, had ever used illicit drugs including marijuana; this was recorded as a simple yes or no with no text indicating the nature of the question.

Most participants completed the network measure at the beginning of the interview, as it proved useful for priming participants to think about their relationships, and as a reference for the interviewer to ask about specific people during the interview.

Sociodemographic Data

Sociodemographic variables collected from all participants included: age; gender; ethnicity; race; marital status; number of children; highest grade completed; employment status;

health insurance coverage; and annual family income. For most of these measures, language from the PhenX toolkit was used. However, some parts were simplified. For race and ethnicity, there were no follow-up questions about ancestry listed in the PhenX protocol as this could make the person identifiable due to the small population of non-White persons in Franklin County.

Past 30-day alcohol use, smoking status, lifetime illicit drug use, and screen for DUD

The interviewer administered past 30-day alcohol and smoking status questions, while participants self-administered questions about lifetime illicit drug use. The final measure, self-administered by PWUD, was the DAST-10, a short questionnaire to screen for drug use disorder (Bohn, Babor, & Kranzler, 1991).

3.5 Data Coding and Analysis

Interviews were transcribed verbatim, first by Ms. Stringfellow and research assistants from the Social System Design Lab, and then using an online professional service. They were imported into MaxQDA v12 for coding. Coding proceeded in two stages, initial and focused, following constructivist grounded theory principles, in which there are no a priori codes (Charmaz, 2014). Initial coding is a line-by-line analysis of the data, which breaks up the story told by participants and ensures that as many concepts and ideas can emerge as possible. The goal is not to describe participants' stories but to find latent patterns across events, occurrences, or interactions described by participants through constant comparison. Thus, the stories as conceived by participants cannot be taken in whole; they are "fractured," and the resulting codes are later reconstructed through theoretical coding.

The goal of open coding is to identify the core code or codes, which are the problems central to resolving the participants' main concerns and thus relate to most other categories. They

should recur frequently in the data, represent stable patterns, and account for most variation in behavior. Once the core code was identified, focused coding began, with the goal of making theoretical connections across codes (Charmaz, 2014). Patterns and connections in the data were identified through constant comparison, abductive reasoning (M. Agar, 2006; Bendassolli, 2013; Bryant, 2009; Charmaz, 2014; Haig, 1995; Nathaniel, 2011; Timmermans & Tavory, 2012), and memo-writing. Constant comparative analysis facilitates rising codes above specific people and incidents to identify patterns and generate concepts, i.e., conceptualization or naming the emerging pattern (Glaser, 2002). These strategies are standard best practices for qualitative coding and analysis techniques in constructivist (Charmaz, 2014) and classic (Glaser, 1998; Glaser & Strauss, 1967) grounded theory, as well as ethnographic research (M. Agar, 2013; M. H. Agar, 1996).

Consistent with these techniques, Ms. Stringfellow was the sole coder (M. Agar, 2013; Glaser, 1978, 1998). However, to ensure that no major codes were missed at the initial stages of open coding, a second coder, trained in qualitative analysis, coded three interview transcripts independently for major codes and connections across codes. Overall, Ms. Stringfellow identified more codes, and the second coder did not identify any codes that Ms. Stringfellow had missed. Codes that Ms. Stringfellow had identified that the second coder had not were discussed and the second coder agreed these were present. The differences were primarily in emphasis. Ms. Stringfellow completed all subsequent coding, consistent with grounded theory technique.

As noted, this study used a feedback-based approach within the framework of complex adaptive systems. Thus, principles from control theory were used as theoretical codes. Control theory makes explicit that people have goals, which they compare to their current perceived state. The difference between these goals and current states are the gaps that spur people to

action, though their actions do not always have the intended consequences. In addition to goals and gaps, the principle of self-reinforcing behavior also guided theoretical coding.

Once the basic theory was developed, the core concepts emerging from the theory were further refined by consulting extant literature. Previous research helped to differentiate and operationalize concepts as well as clarify the nature of mechanisms that had emerged from the grounded theory.

To aid in theory development, tools and visual heuristics from the field of system dynamics were used during coding and in later interviews. Two main heuristics were used: behavior over time graphs (BOTGs) to reflect how people talk about change over time, and causal loop diagrams (CLDs) to reflect relationships between concepts. CLDs are the visual representation of people's mental models. A single CLD was built that synthesized the multiple perspectives of participants into a collective mental model. The goal was to create a causal loop diagram that was parsimonious. Thus, variables and the links between them were chosen based on their ability to reflect a wide a range of experiences. Building the CLD proceeded iteratively with a simplified simulating model. Together, the qualitative CLD and simulating model were used to identify feedback processes that may be contributing to relapse.

The reinforcing and balancing feedback loops identified and refined for this study are based on explicit participant narratives, inference when connecting participants' narratives together, and narratives that were incomplete but similar to those found in extant research on addiction remission, recovery, and relapse. Results, therefore, are different from traditional results in that they inherently relate the concepts of the present study to those of previous studies. This triangulation of data sources is a key strength of grounded theory (Glaser & Strauss, 1967) and systems science modeling (Roux, 2015).

Triangulation of multiple sources of data and perspectives form as holistic a view as possible. This is especially true for theorizing the role of loved ones, given that loved ones who participate in studies are different from those who do not. Thus, in order to theorize the role of loved ones, sources of data included: how the participant loved ones talked about the person with addiction in their lives; how the participants who had used drugs talked about their loved ones; how the participants who had used drugs talked about others who were addicted; prior qualitative research on family members; and correlational studies indicating a link between social support and outcomes.

The most difficult perspectives to represent are that of non-supportive family members as described by the person with addiction. Participants who had been addicted described their most non-supportive loved ones as the most abusive, leaving little reason to doubt that their support for recovery was nonexistent. Even if these family members would claim they were supportive of recovery, the experience of abuse is enough to negate such support. Regarding loved ones, none claimed to be fully supportive without reservation; all had at least purported lines that their addicted loved ones should not cross. Moreover, the descriptions of the support they provided were consistent with descriptions of support by the participants who had been addicted.

3.6 Simulation Model Development

Reference Modes and Stylized Facts

The simulating model is an etiological, or theoretical, model to understand basic mechanisms and processes that undermine or support recovery. These types of models are built

to reproduce prototypical patterns of behavior, rather than the patterns of specific individuals, and are qualitatively validated (Gilbert, 2008; Hoffer, 2013).

In system dynamics, these patterns over time are called reference modes. Reference modes are represented in abstracted graphs over time, rather than time series data, that highlight shifts in behavior modes over time (Sterman, 2000). Behavior modes are common patterns of behavior found in social systems such as exponential growth and decay, goal-seeking behavior, and oscillatory behavior (Sterman, 2000). Identifying these behavior modes is important because it can point to possible underlying feedback loops (Sato, 2016).

In system dynamics, reference modes are framed not just in terms of how they have changed over time, but also what they are expected to look like in the future without any changes to the system ("business as usual" or "feared"), and what their desired pattern would be in the future ("desired"). The focus is not just on the nature of the problem currently, but in understanding how it has evolved and what it would take to create desirable change. Reference modes can represent just one variable over time, or a set of variables. When a set of variables is the focus, that means not only that each variable should change over time as expected based on prototypical patterns, but also that the relationships between variables should change in expected ways.

A similar concept is 'stylized facts,' which are "broad, but not necessarily universal generalizations of empirical observations and describe essential characteristics of a phenomenon that call for an explanation" (Railsback & Grimm, 2012, p. 228). For example, we would expect that as a person who is addicted to drugs increases their drug use, functioning decreases. Use and functioning may not change at the same rate, and declining functioning may differ in severity

across individuals, but in no circumstances would we expect improvement in functioning the more that an addicted person uses drugs.

This study used a set of reference modes, all related to the operationalized definition of recovery. The goal was for the model to reproduce patterns in which the variables of social role functioning, expectations for same, support received, and propensity to use drugs changed over time, and together over time, in expected ways based on generalizations of empirical observations, i.e., stylized facts. These reference modes were defined based on a combination of extant literature and the interviews, and thus will be discussed in the Results.

Interview Excerpts to Codes to Causal Links to Equations

To build a parsimonious model able to replicate the reference modes, it was critical to gain clarity about how variables are connected. Most of the conceptual work lay in determining how recovery concepts were connected in participants' minds, i.e., their mental models. Decisions about causal links were made based on codes from the qualitative data and prior research, mostly qualitative, that had been conducted to highlight the perspective of PWUD and loved ones.

Figure 3.4 depicts the iterative process of moving from interview excerpts to a code, a causal link, and finally an equation, before returning to the data or collecting additional data. Simulating the model is not shown as a step, but it also occurs continuously throughout the model building process. Simulating the model informs coding by clarifying the logic that underlies participants' experiences; it informs the causal links by identifying redundant links and creating a more parsimonious model; it informs the equations by highlighting what changes in

58

formulation could better approximate the reference modes; it informs returning to the data by clarifying what data could be helpful to produce a more useful simulation.
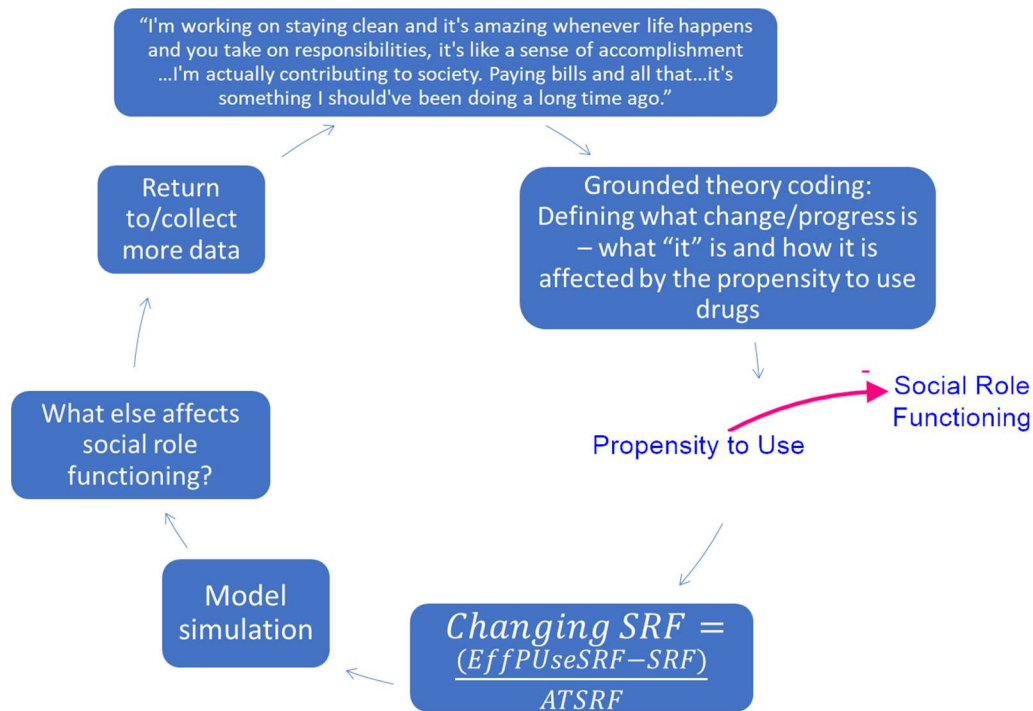
Figure 3.4. Iterative Translation between Interviews, Coding, and Model

However, the figure also highlights the inevitable loss of nuance and complexity when translating text into a code, and a code into an equation that can be used in a simulation. Initially, there were many more concepts connecting propensity to use and social role functioning, but they all showed the same patterns when simulated. Moreover, many different construct names were used to capture what is now called "social role functioning." These variations were either in vivo language from interviews or attempts to capture concepts directly from coding. However, in the end it became clear that what people were describing was their functioning – a ubiquitous concept in addiction literature – and, more specifically, their functioning in social roles (compared to, for instance, their health or mental health functioning).

Model Calibration Based on Reference Modes and Stylized Facts

Each parameter in the model (the variables and causal links between them) requires a corresponding value or set of values for the model to simulate. Identifying the "correct" value is different for an individual-level model because of variation across individuals, such as how long it takes to change perceptions. A population-level model might take the average across people for a given variable, but at an individual-level it is more accurate to think of it as the most typical value for a given individual. Thus, any combination of parameters could theoretically represent a single individual or, more likely, a typology representing PWUD with similar underlying motivations, experiences, and behaviors. However, some combinations produce more plausible model results than others.

Calibration was used to identify values that produced plausible results in the simulation consistent with the reference modes. When these values are changed independently, the model is highly sensitive to those changes. However, when one or more parameters are changed together so that they keep their relative ratios, the model is less sensitive. Thus, the relative difference between parameters, especially delays, were the focus of calibration. Often, values were chosen based on the qualitative data. For instance, words like "eventually" suggest delays of months or years, while in other instances – especially when talking about changing patterns of use – participants would reference changes that typically last a few days to a few months at most.

Causal links also affect the model results. To test the sensitivity of these links, modular testing was used. In modular testing, parts of the model are systematically turned off to test their effects. If turning off parts of the model does not change the model results, this suggests that part of the model could be eliminated to achieve greater parsimony; however, the decision is also

dependent on its theoretical value. The goal is to identify the simplest structure with the least uncertainty that can still produce realistic results.

The final model was one whose structure (i.e., the causal links) could reproduce the reference modes and whose behavior responded as expected to changes in parameters. All models built for this study were built in Stella Architect version 1.8.1.

Model Experimentation

After the baseline model was able to reproduce the reference modes, experimentation with the model was used to identify potential ways to intervene to create sustainable and positive change. The changes, or "experiments," that were tested on the model were based on participant interviews and extant research, treatment interventions, and policy.

The goal in an etiological model is to understand the basic mechanisms that could be contributing to a problematic or interesting behavior pattern. The goal in experimentation with this type of model is to identify a "difference that makes a difference," meaning a qualitative and sustainable shift of the overall trends in the model in a different direction (M. Agar, 2003; Yang & Gilbert, 2008). This contrasts with numeric differences that do not change the overall trajectory or shape of the curve (Figure 3.5*)*. However, there may be exceptions where a slight numeric improvement could translate to a meaningful difference for a PWUD.
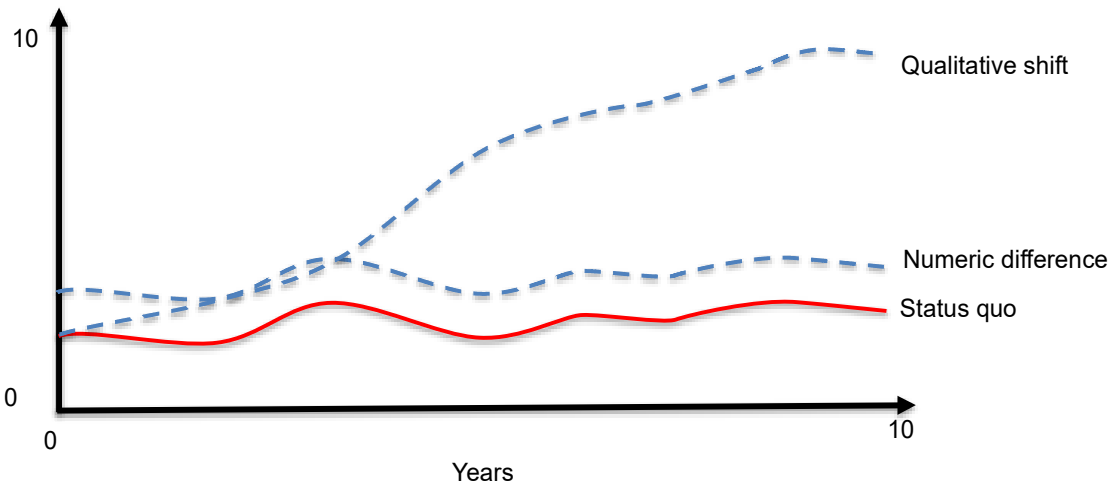
Figure 3.5. Difference Between a Qualitative Shift and a Numeric Difference in Trends

Mechanisms that qualitatively and sustainably shift trends are called leverage points, or small changes that have a disproportionate impact on outcomes (Epstein, 2008; Lich, Ginexi, Osgood, & Mabry, 2013; D. A. Marshall, Burgos-Liz, IJzerman, Osgood, et al., 2015). The impact of leverage points is ideally positive, though it could be negative. "Small changes" and "disproportionate impact" are emphasized because sometimes the effort that would be required to make large positive changes is proportionately large. Whether the effort is worth it would need to be considered carefully. Furthermore, a small change in the model might not translate into a small change in people's lives or policy.

The goal was to identify what combination of experiments could produce recovery, operationalized as sustained low propensity to use, high social role functioning and expectations for functioning, and high support received. For it to be recovery, these patterns must be sustained for an extended period of time in the model. Once leverage points were identified, the next step was to "work backwards" to understand what *specific* types of policy interventions, if any, could

produce those kinds of changes (Hovmand, 2014; Moss, 2008). Implications for interventions are addressed in the Discussion.

Results for the qualitative, theoretical causal loop diagrams and the simulating model will be presented sequentially. The first chapter will discuss the Results based on the theory arising from the analysis of qualitative data. The theory was developed while using causal loop diagrams as heuristic tools to clarify possible causal links and variables. However, many of these were complex causal loop diagrams that are not part of the simulation and so are not shown here. The most important loops are those that were carried forward into the simulation.

Chapter 4: Grounded Theory Results

Sample

A total of 24 participants were interviewed for the study, including 14 people who use(d) drugs

(PWUD) and 10 "loved ones." Table 4.1 describes the sample.

Table 4.1. Sample

	People Who Use(d) Drugs (n = 14)	Loved Ones (n = 10)
Age (Mean)	31.5	46.7
Sex (% Male)	43%	20%
Race (% White, Non-Hispanic)	93%	100%
Drug of Choice		
Methamphetamine	43%	10%
Heroin	57%	80%
Cocaine	7%	10%
Average (SD) [Range] DAST-10*	8 (2) [1-10]	N/A
Education (% with more than high school or GED)	64%	100%
Median [Range] Household Income**	$25,000 [$7,000-109,000]	$65,000 [$10,000-125,000]

*among those who had used DOC in past year
**excludes one DU participant who reported his parents' income and no personal income

Participants were nearly all white, consistent with the demographics of the study county;

one male identified as Native American. PWUD were 31.5 years on average and loved ones 46.7

years. The most common drugs of concern for people who use were heroin and

methamphetamine; for loved ones, their concern was overwhelmingly heroin. One participant

stated he had had two drugs of choice: methamphetamine and cocaine. All but 3 loved ones were

parents, and all but one parent was a mother. Compared to Franklin County's median income of $53,849 (2013-2017), PWUD's income was less than half, while loved ones' was higher (U.S. Census Bureau, n.d.).

Most PWUD would likely have met the criteria for an opioid or methamphetamine use disorder (American Psychiatric Association, 2013). The average DAST-10 score among those who had used their drug of choice in the past year was an 8, indicating severe risk for DUD (Skinner, 1982). Among PWUD who had not used in the past year, they described having experienced homelessness because of their use, perceiving a need for or receiving treatment, and suicidality, indicating that they had likely had a disorder. Participants described varying levels of treatment and mutual aid experience (Table 4.2). However, they were not always asked about their treatment experiences, though they often arose spontaneously; thus, it is possible some treatment experiences were not mentioned.

Table 4.2. Most Intensive Level of Treatment by Drug of Choice (n = 14)

	Addiction-Specific Treatment	Intensive Mental Health Treatment Only	Intensive Mutual Aid Involvement Only	No Treatment or Intensive Mutual Aid Involvement
Methamphetamine	1	3	0	2
Heroin	4	1	1	2

Most PWUD mentioned having attended at least 1 Alcoholics or Narcotics Anonymous meeting. Of the 4 heroin users who reported having received addiction treatment, 1 was on methadone, 1 was hoping to be prescribed Vivitrol after being unsuccessful with Suboxone, and 1 had been involved in drug court treatment. Of the 4 with no treatment or intensive mutual aid involvement, 1 heroin user was planning to check himself into a detoxification facility that day and another

heroin user had a brief period of counseling that he did not find useful. Thus, only 2 people (both former methamphetamine users) reported no addiction or intensive mental health treatment, no plans to receive treatment, and no extensive involvement in mutual aid groups. Neither perceived themselves to have been severely addicted, and one, a man who had manufactured and dealt methamphetamine, quit primarily because of concerns about being arrested and not because of any perceived personal problems. All the loved ones reported that the person with addiction in their lives had received some form of outside help.

Factors Driving the Propensity to Use

There are several reinforcing feedback loops that operate on a brief time scale (hours or days at most) that affect the propensity to use and thus drug use itself. They will be described briefly, but they are not the primary focus of the theory or of the model. They are represented collectively in a simple reinforcing feedback loop involving only Propensity to Use. The stock and flow structure with just this reinforcing loop is shown below. As this does not involve any other variables, it will not be shown in subsequent diagrams.
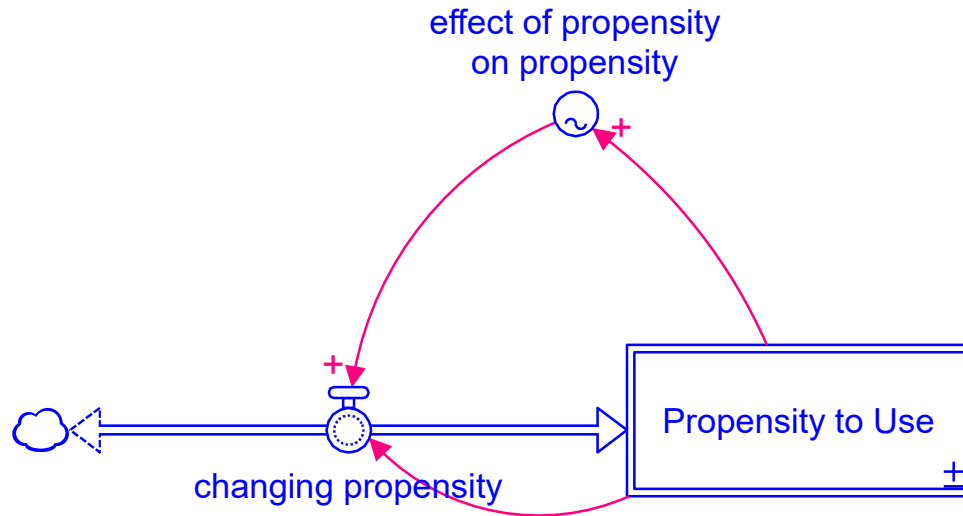
Figure 4.1. Propensity Reinforcing Loop

These loops include drug use as an automatic process (not described by participants but present in the literature) and as a coping mechanism for stress and shame, brief scares that limit use (the only effect not captured in the simplified reinforcing feedback loop), withdrawal, craving, and short-term effects of "people, places, and things" (as a trigger of craving and source of access). The ability to manage these short-acting reinforcing dynamics is dependent on the social psychological variables that *are* the focus of the model (i.e., the ability to consciously inhibit craving is thought to occur due to altering the emotional value of a drug-related stimuli (Volkow et al., 2010) or while consciously thinking about non-drug rewards (Kirschner et al., 2018)). If the model purpose were instead to replicate drug use patterns over a period of days and weeks, these loops and their variables would be explicated in detail.

Automatic Processes

The inability to control one's drug use in the moment is largely attributed to underlying automatic processes that occur after habitual drug use, which are difficult though not impossible

to control (Volkow et al., 2010). In the present theory, these processes are assumed to be constant in their effect and to operate on a timeline of seconds and minutes, and thus are excluded because the present theory's relevant dynamics occur over a period of months, years, and decades. Instead, the assumption is that whether these automatic processes can be brought under control and even reversed is dependent on the interactions between longer-term loops at the social psychological and behavioral level.

Drug Use as a Coping Mechanism

Just before they quit, participants' report that their lives had been spiraling out of control: smaller negative consequences become bigger ones, resulting in a cascade of negative events and increasing chaos such as homelessness and joblessness, which increase shame and stress. Often, drugs are used to cope with these feelings, further increasing the chaos that contributes to declining social role functioning and creating a reinforcing feedback loop.

Brief Scares

Sometimes, the spiraling downward is temporarily halted by a balancing loop in the form of a brief scare – "something real happens" or they "saw where I was headed" – that temporarily decreases the propensity to use. Often, these scares occur while high and are the result of witnessing someone else experience a negative consequence of use, such as an overdose. However, there was skepticism about the long-term impact of "something real happening," if there is an effect at all:

> ***Male, late 20s, quit heroin within the past 3 months:*** *"It [my friend's overdose] scared me. Not enough to where I decided to quit fully. But it scared me for a period of time where I didn't want to do it…It was just a repetitive cycle of, something real would happen...*
>
> ***I:*** *Did you completely stop heroin after that or just cut back?*

P: I just cut – I stopped probably for a few days."

Female, early 20s, quit methamphetamine 1 year prior: "*She had gotten a bad shot and was just super, super sick. Two people brought her to the door and dropped her off.*

At this point, I was still pretty new to my addiction and to that whole world, so I had no idea what to do… That was one of the first times like, "I don't want to end up like that." That was one thing that didn't really necessarily make me want to quit but it made me want to use less."

Withdrawal

Withdrawal includes not only physiological withdrawal from opioids (referred to as being "sick," with flu-like symptoms including nausea, chills, vomiting, and fatigue), but also psychological withdrawal from stimulants and opioids. Psychological withdrawal means having to face whatever reality they experience without drugs: "A lot of people just don't want to deal with not being high." To ease the symptoms of withdrawal, or to avoid experiencing them in the first place, drug use is increased. These balancing feedback loop effects operate quickly, within hours, days, or weeks depending on the frequency of use and the drug's physiological profile.

Craving

A PWUD who is addicted and/or who has a high propensity to use, even if they have not used for months or even years, can experience craving when they are exposed to drug use cues (Koob & Volkow, 2010). Craving typically involves obsessively thinking about use, and can lead a PWUD, even someone in remission, to compulsively seek drugs. This forms a balancing loop wherein drug -using relieves the feeling of craving, albeit only for as long as the drug has its effect. This dynamic takes place in a matter of hours. Craving is distinct from propensity to use because it does not reflect how someone "feels" about drugs or the effect of drugs on their support or social role functioning, which impacts the overall propensity to use. Rather, in many

participant descriptions, craving is an acutely physical experience: "Your cells scream for that substance," with uncomfortable feelings "in the pit of the stomach," and a great deal of anxiety.

People, Places, and Things

Cues that can trigger craving include people around other PWUD, who activate memories of drug use and increase, in the short term, the propensity to use. Use itself will increase if the PWUD with whom they are spending time are actively using. Participants described multiple measures they took, and believed others should take, to reduce the ability to act on the temptation to use. These measures include getting away from the "scene," deleting phone numbers of their dealers (though several people noted that there were some numbers they would never forget), and spending any spare cash "so I couldn't do anything stupid."

Shame

Both loved ones and PWUD described a dynamic wherein social role functioning declines due to drug use (among other causes), resulting in an exacerbation of existing shame. Drugs are used to "hide" from this shame, which only further strengthens the multiple reinforcing loops feeding addictive behavior. This is in addition to shame due to abusive childhoods and relationships.

The remainder of this section will describe the grounded theory developed from analysis of the qualitative interviews.

"You Have to Want It"

Participants believe that a sustained recovery from addiction only happens if someone "wants it" enough. If someone does not "want it," then recovery will not occur:

> *Male, late-20s, quit heroin < 3 months:* *"You've got to want it…It's not court-ordered. It's not, I had a near-death experience so I'm going to start shit. You have to find it in yourself that you want to change something bad enough to where you're going to stop all the BS and start living life for what it is. Be responsible for your actions."*

> *Female, mid-30s, quit methamphetamine almost 4 years prior:* *"I've found that unless they actually want to help themselves, there's nothing you can do to help them."*

They must want not only to quit using drugs, but also to change the Self and become someone who is different, new, or even better – or return to who they were before, who they truly are. Such changes entail a transformation from an unrecognizable and inauthentic person whose rationality and even morality are compromised by drugs, to a "good," functioning person whose actions make sense. 'It' is having a "normal" life with "normal" stressors:

> *Female, mid-20s, quit heroin within past month:* *"I want to have nice things. I just want to have a normal life. My kids deserve so much better than that. I'm tired of giving them a shitty life."*

The impetus for these changes often arises from a fear of their future self. Not only are they unhappy with who they are currently, but they have imagined a future self that is even worse, and their desire to change is sparked by that fear. However, if the change is not sustained and the addiction deepens, the next feared future self is more troubling than the previous one. Too often, the addiction is deepened by hopelessness arising through this same process of falling expectations combined with falling social role functioning.

To the last, the participants who had used drugs expressed that they wanted it more this time than they wanted it last time, which was greater still than the time before that. This was true regardless of their current use status. "Wanting it," viewed retrospectively, is forever an uphill march toward eventual yet elusive salvation. There must be something missing within them, or

71

they would have already succeeded at staying abstinent. If they had recently relapsed, they must not have wanted it enough, perhaps because they had not experienced enough negative consequences.

This creates a dynamic wherein another promise is always made and another promise is broken. Hence, loved ones increasingly look for evidence that the addicted person "wants it" to determine how to move forward with the relationship. The seeming inability to respond to negative consequences – the very essence of addiction – challenges all their expectations of rational behavior. Evidence that the addicted person wants it is a return to expected rational behavior, and thus trustworthiness.

There are many ways that loved ones monitor for evidence of wanting it. Drug use itself is closely monitored, but so is how well they are functioning in their social roles. More crucially, the person with addiction must have chosen actions that *intentionally* decreased their use or improved their functioning. Actions that are coerced or actions that only inadvertently lead to positive change fail to constitute evidence of wanting it. Thus, coerced treatment and the use of medications undermine the perception that someone wants it. With coerced treatment, they did not choose to quit or otherwise change of their own volition. With medications, they did not have to wrestle with their ambivalence; it was removed for them. The belief is that if they do not "want it," then they are more likely to relapse when the outside force is removed.

Eventually, PWUD get "sick and tired of being sick and tired." Fatigue with drug use and the associated lifestyle sets in, and this contributes to longer periods of abstinence than the fear of future Self alone. Time itself offers a salve, though not a true cure; as people age it becomes harder to overcome and overlook their fatigue. However, fatigue is not a guarantee against relapse, especially when hopelessness and social isolation are present.

The tendency to prove and seek evidence of sincerely 'wanting it' is so strong that it permeated the interviews. The interviewer found herself in the same dynamic with participants as they described with their loved ones. PWUD narratives were, in large part, an extension of their attempts to convince the people in their lives of their sincerity. At the same time, without realizing it at first, the interviewer was attempting to discern the sincerity of their latest quit attempt. The second coder and research assistants did the same when reviewing transcripts.

The remainder of the Results will discuss how the belief in sincerely "wanting it" is created and maintained, and how it leads to unintended consequences. The impact that this mental model has on addiction recovery dynamics will be described in terms of feedback loops, which either amplify (reinforcing loops) or regulate (balancing loops) change.

The Feedback Dynamics of Quitting and Addiction Recovery

Fear of Future Self

Against the backdrop of the multiple factors that drive the propensity to use are feedback loop dynamics that operate on a longer time scale and involve notions of the Self: how the person who is addicted and their loved ones perceive who they are, who they should be, and who they can be.

The implication in "wanting it" – to be a different, better person – is that there is an expectation that is not currently being met; there is a gap between (social role) functioning and expectations (Figure 4.2). This gap raises the specter of the 'feared self,' (Paternoster & Shawn, 2009) or the person to avoid becoming, and decreases the propensity to use. The 'feared self' looms large in people's narratives about how they came to "want it." In the periods leading up to abstinence, they have found a point – at the time, at least – beyond which they will not go:

73

Female, mid 30s, had quit heroin just over 1 year prior: *"People that I used with were liars, cheaters, thieves – honestly, they were sketchy…They were very selfish…Before, they might have been okay, but at some point or another, they always got to that point… I didn't want to become sketchy. I didn't want to become a horrible person. That was my bottom."*

Male, late 20s, had quit heroin within past 3 months: *"Where I was going was nothing good…: Do you want to be a father? Do you want to die? Do you want to be in jail? I had three options there."*

While behaviors are inextricably linked to the 'self,' the self is more than what a person does. The expectations are not simply about the behaviors in which one engages but also are about the core of who someone is and who they could become – a person who is proud of what they do, versus a person who is ashamed, because what they do is a reflection of who they are.
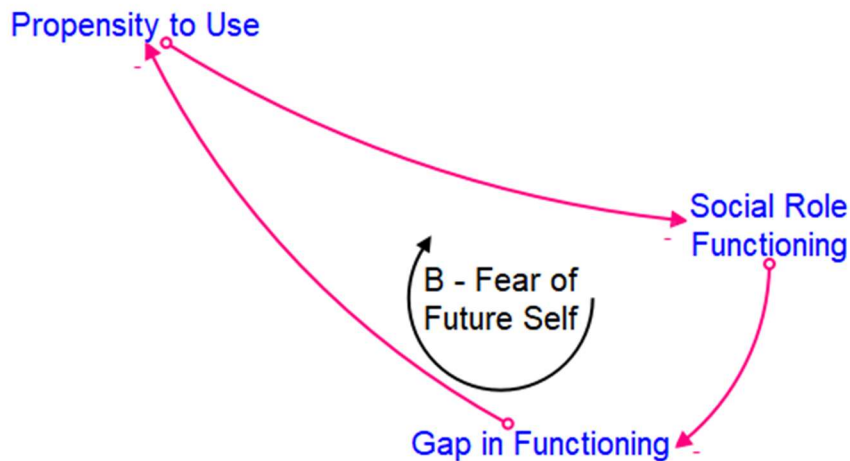
Figure 4.2. Fear of Future Self

As social role functioning declines, the gap between expectations and functioning rises, and the fear of who one might become decreases the propensity to use. As propensity to use declines, functioning starts to improve. This reduces the gap between expectations and functioning, thus increasing the propensity to use and potentially precipitating a relapse.

Adjusting Expectations

Expectations for social role functioning create the gap that drives the fear of future self. Expectations rise or fall due to an assessment of current social role functioning, such as holding a job, taking care of children, etc. Current functioning is the accumulation of all past functioning and therefore all past experiences. The gap with expectations grows as social role functioning falls. There are two ways to close this gap: improve functioning or reduce expectations. Because functional improvement is difficult during addiction, many PWUD instead lower their expectations. Only in retrospect do they recognize how low their expectations had fallen:

> **Male, late 20s, had quit heroin within past 3 months:** *"I was to the point where I'd rather sleep outside instead of my house because of how dirty it was…It was bad. Now I've accepted that that's not a good way to be, that's not where I want to be."*

Loved ones similarly recognize how the person who is addicted gets "used to" increasingly lower functioning:

> **Male, uncle addicted to methamphetamine:** *"My grandma and grandfather were pretty well off. They had a really nice house and then he [uncle] went to a trailer and he was like, "This is junk. I don't want to stay here." Then he got used to it. Then he got worse."*

Expectations track the history of the self while at the same time forming the basis of the ideal future self (Biernacki, 1986). Thus, a gap between who they are now and who they want to be in the future can also lead people with addiction to adjust their expectations upwards:

> **Female, early 20s, quit methamphetamine 1 year prior:** *"I didn't want that life anymore, I didn't want to live like that. Because I've always wanted to be a mom at some point. I thought about how I was raised with my biological parents when they were always high and drunk. That's not how I want my kids to be raised. It*

wasn't like a big lightbulb moment; it was just sitting there after I left my ex, just like, 'It has to change. The only time I can change it is right now.'"
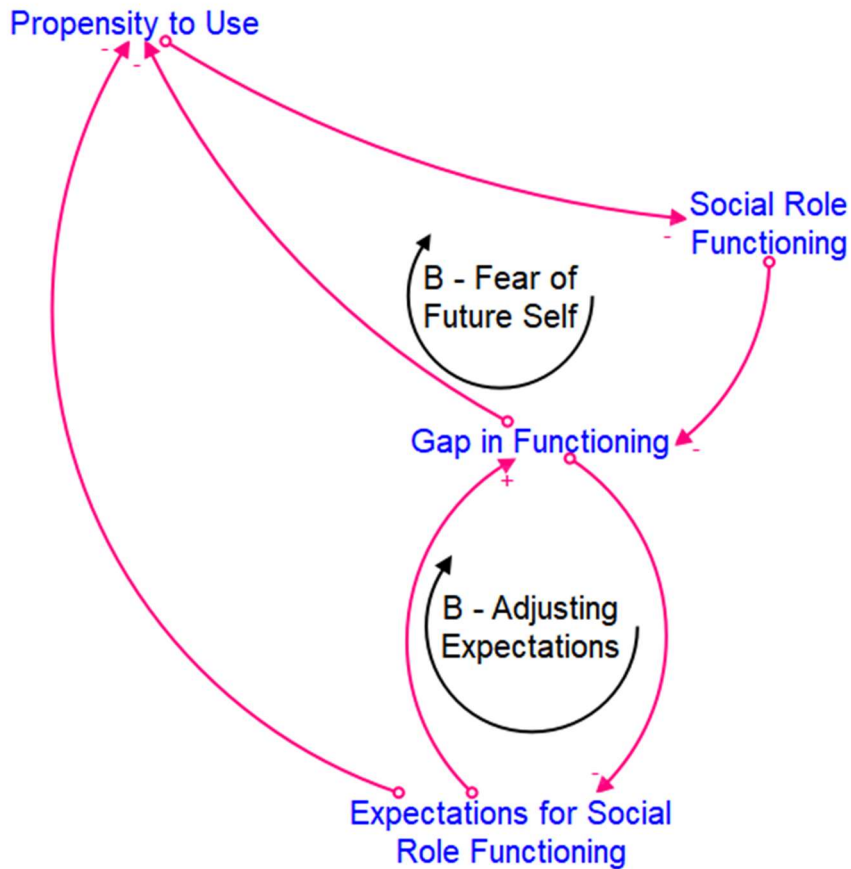
Figure 4.3. Adjusting Expectations

Nothing to Live For and Nothing to Lose

As functioning and expectations continue to fall, hopelessness sets in; there is "nothing to live for and nothing to lose." They have little hope for who they can be in the future, thus providing neither a reason to quit nor a reason not to use (Hänninen & Koski-Jännes, 1999):

> **Female, mid-40s, actively using methamphetamine:** *"I fell off. Got real bad. I used a lot, whenever I finally signed off on my kids. 'Cause I didn't care anymore, you know?"*

During active addiction, these low expectations narrow the PWUD's 'future orientation' to the next several hours, days, or weeks at most, increasing the propensity to use and exacerbating the addictive cycle (Lewis, 2015). However, even once someone has quit using, low expectations increase the risk of relapse, especially if meaningful functional improvement seems impossible:

> ***Female, mid-40s, quit methamphetamine one year prior:*** *"They give up [on recovery]. My son's having this problem. He's like, "I made so many mistakes. Everybody knows." You're so young, but in his mind he's already destroyed his life at 23. You carry that, especially in a small town you get labeled as a druggie. There's a lot of people that have overcome addiction. But who's going to give them a job? Who's going to let them live there? What do you do? People will only fight so long before they give up. When every door you hit closes in your face, that's humiliating. People just need a chance sometimes."*

Expectations are not only shaped by past functioning, but also by other people's expectations. This includes an amorphous "everybody" as well as loved ones, who expect less and less of the addicted person. Where once they might have hoped for college and a career, now they just hope their child can stay out of jail:

> ***Mother, daughter addicted to heroin****: "Right now, I just want her to be a normal person in society who can work and not break the law, to stay out of jail, that's what I want right now. That's my expectations. Other than that, I don't have any expectations for her for right now because I don't know which way she's going to go."*

However, some loved ones attempt to increase the expectations of the person with addiction by reminding PWUD that there is something to live for:

> ***Father, 40s, son addicted to heroin, currently incarcerated:*** *"Every time I'm talking to him, I'm reminding him of that. I'm pushing that. "See, this is happening. You're doing it. This is what the world is like without drugs and you've survived it another day and you sound happy. I'm talking to you on the phone. Its eight o'clock at night and you're happy." Another thing that I keep*

pushing for him is to realize that it is possible. There is a world without drugs that he did not realize before."

People in recovery have successfully increased their expectations, transforming the reinforcing loop to "Something to Live For and Everything to Lose. Hope has increased and there is now a reason to stay quit and benefits to not using:

> ***Female, mid-40s, quit methamphetamine within past year:*** *"I consider myself to be pretty darn strong to be able to say no. I'm like, ''I don't need that in my life.' But sure, it would be easy to say yes, but I've got too much to lose and it would push me that much further back."*

Figure 4.4 shows how falling expectations increase the propensity to use, which decreases social role functioning. The gap between expectations and grows, triggering the adjusting expectations loop and resulting in even lower expectations. The gap can also trigger the balancing loop, "Fear of future self," which, all else being equal, decreases the propensity to use. However, if the hopelessness loop ("Nothing to live for and nothing to lose") is dominant, then it is more powerful than the fear of future self, meaning that all else is *not* equal.
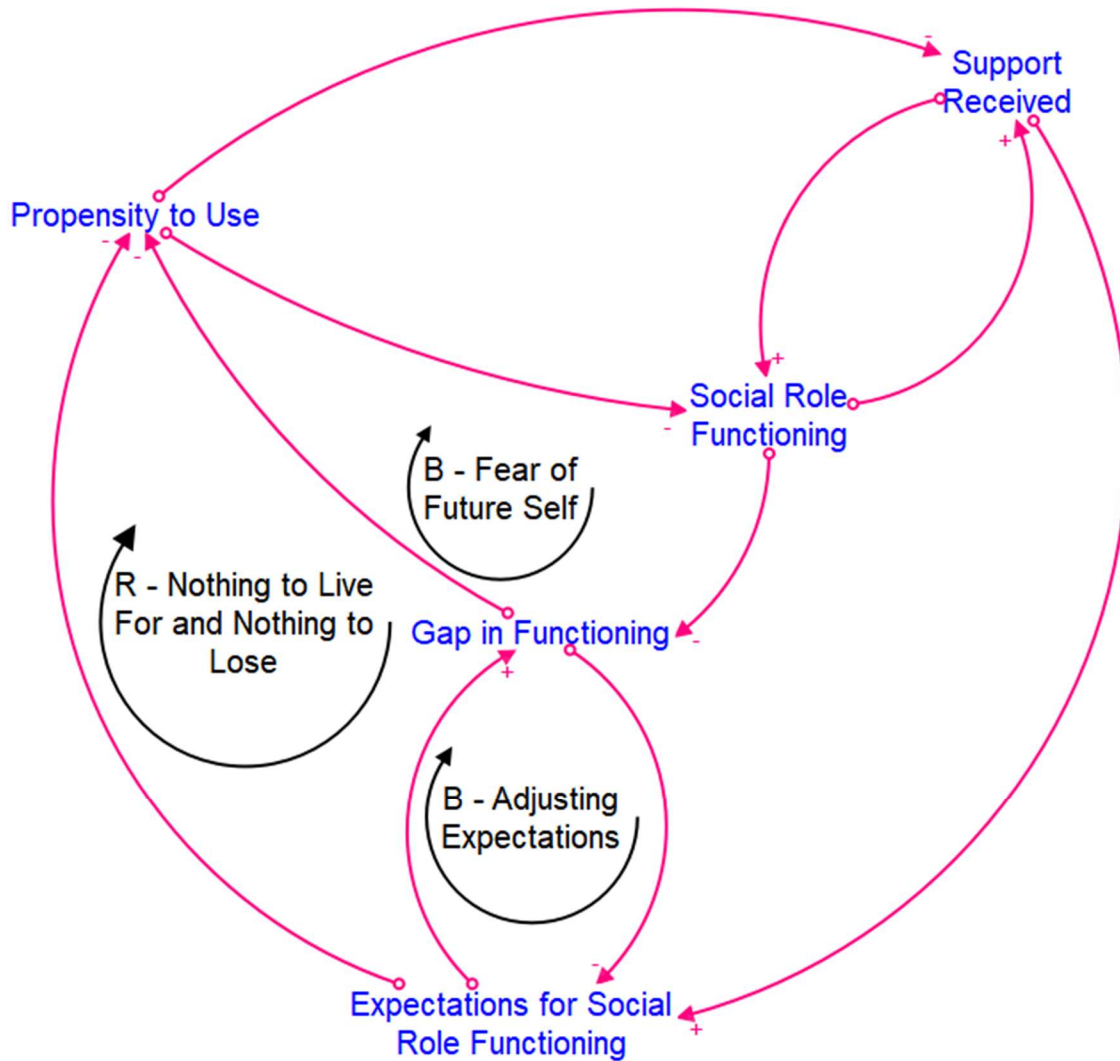
Figure 4.4. Nothing to Live For and Nothing to Lose

Sometimes this increase in expectations arises not from increasing functioning, but instead from hope. Hope is awareness that there is a way out, and that there are alternatives to their current situation. However, the initial spark of hope often comes from other people rather than from within, because they have never known a different way to live:

> **Male, late 20s, quit methamphetamine and cocaine 2 years prior:** *"Those people that aren't like that [addicted] anymore that lived through it need to be coming and talking to gymnasiums full of kids. These schools should want that.*
>
> **I:** *Why is that important?*

P: Because it helps show them that they're not stuck in their situation or it doesn't define who they're going to be in life...I know how it feels to be stuck and to think this is it and this is all life is ever going to be. And there's no way to change it, so why try...when you're there, you feel like you're stuck. It's the only option. It's so hard to realize it's not the only option and that you can do something different."

Female, late 20s, quit heroin 2 years prior: *"Then you see people that are clean and how good they are doing, you want to obtain that. That's really what happened with me, hearing somebody at the second [Narcotics Anonymous] meeting...Hearing her almost identical story: childhood, using -- Pretty much identical. She didn't know my name, I didn't even know her name, but I related to her and she was celebrating 18 months clean that night. That's something that I will never ever forget. I will never forget that night, down to where I sat."*

Ambivalence About Quitting and Support-Seeking

In their state of hopelessness, reaching out for help feels almost impossible for people who are addicted to drugs. Even when they know that they "want it," there is something holding them back from making the attempt to quit or asking for help to do so:

Female, mid 30s, quit methamphetamine 4 years prior: *"And he [roommate using heroin] wants to get clean, he says he does. Which I do believe him. To a point. 'Cause I've been there, too. 'Cause at one point I did want to get clean, but I didn't want to get clean at the same time. I was right there on the teeter totter right there at the end but not quite done. I knew I needed to be done but mentally I wasn't ready."*

This reluctance to make the next step arises from a combination of hopelessness itself (nothing will help), shame (a construct considered for inclusion in the model and discussed briefly above), and ambivalence about quitting (a part of them still wants to use).

In the context of the mental model that "you have to want it," ambivalence about quitting is interpreted by both PWUD and their loved ones as a sign of not genuinely wanting it, thus creating delays in seeking and receiving help. Ambivalence about quitting reduces support received, even if support is available. Increased propensity to use decreases support sought,

which decreases support received for two reasons: first, because the person is not seeking

support that might be available and, second, because loved ones look for support seeking as

evidence that the PWUD "wants it," and thus they are more likely to provide support when

someone is seeking it. (Both of these effects are captured in the link from 'support sought' to

'support received.' The second effect will be discussed in more detail below.) Less support from

loved ones means lowered expectations for social role functioning. With decreased expectations,

propensity to use starts to increase again.
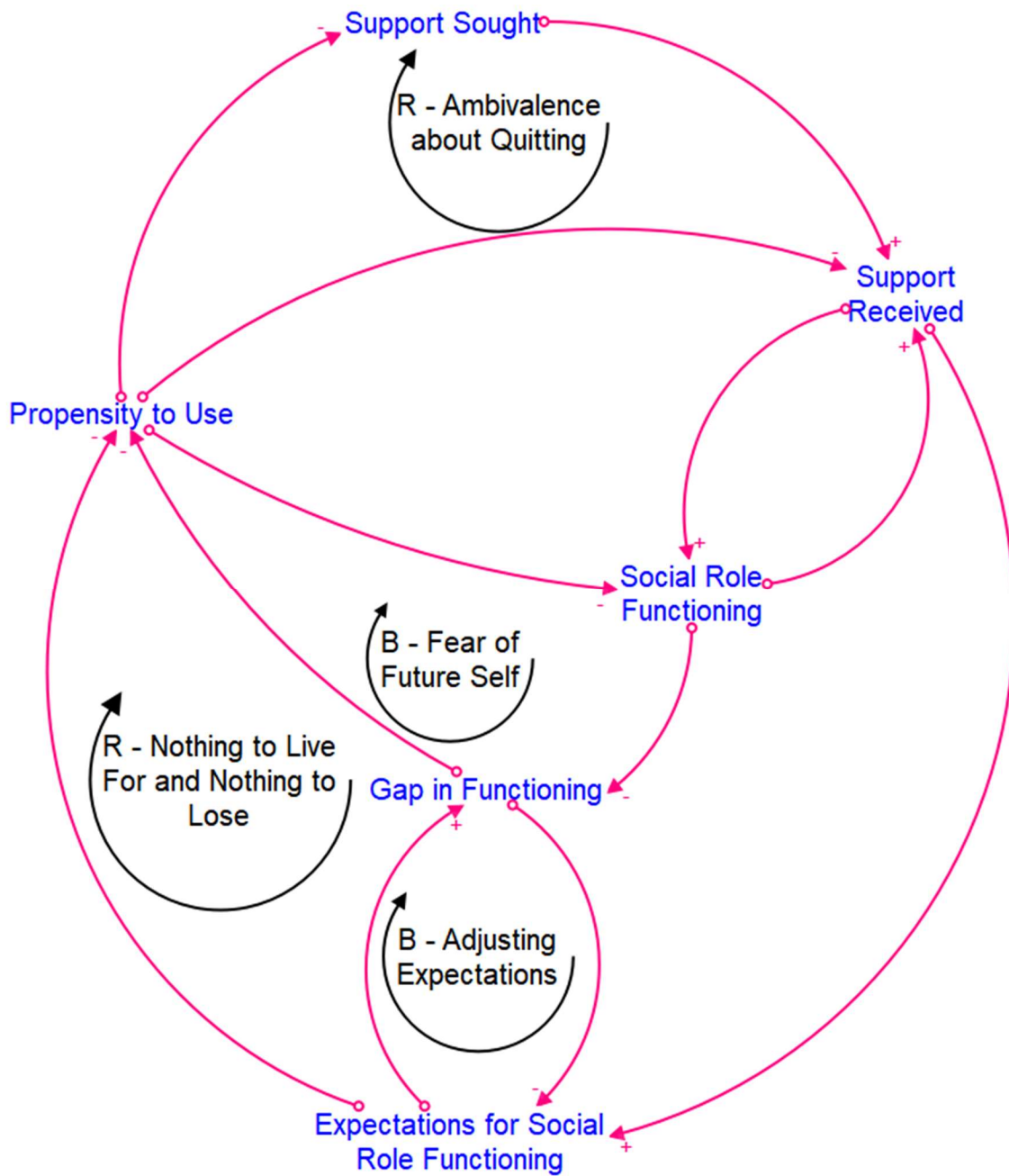
Figure 4.5. Ambivalence about Quitting Reinforces Use

Viewed retrospectively, participants who had used drugs believed they could only be truly "ready" to quite once they had eliminated their ambivalence about quitting. Participants might have believed they needed to account for past behavior, such as failing to quit sooner

(McIntosh & McKeganey, 2000). However, epidemiological surveys suggest that these

statements could be taken at face value; consistently, 40% of people surveyed who think they

might have needed help to quit using drugs did not seek help because they were not ready to quit

(Bose, Hedden, Lipari, Park-Lee, & Tice, 2018b; Substance Abuse and Mental Health Services

Administration, 2014).

Ambivalence about use leads participants to believe that there are right and wrong

reasons to quit; if it is "forced" by outside factors, a lower propensity to use is perceived as less

real or sincere. They have not managed their ambivalence and thus do not "really" want it:

> ***Female, early 20s, quit methamphetamine 1 year prior:*** *I would say I did have an increase for the desire to quit just because I knew that's what I would have to do to keep our relationship. So, I did have an increase, it was kind of a forced increase, but it was still there.*
>
> ***I:*** *That's another thing that comes up, is this idea that there is something that can force people. How is that different from it just coming up on its own?*
>
> ***P:*** *When it's forced it's not as meaningful and it doesn't have as big of an impact as when it comes up on its own. It's your own feelings.*

> ***I:*** *Is there anything different about this time he quit versus the last time he quit versus the time before?*
>
> ***Male, uncle addicted to methamphetamine:*** *Honestly from what I've noticed, this is the first real time he's wanted to. There's been times where I feel like grandpa keeps giving him money or something. He's cutting him off now unless he gets help. Then he'll go give the illusion of getting help. Or the court makes him go or this happens or that happens. I feel like this is the first time he's actually wanted to get his own help. Asking for it and really wanting to go get it."*

Quitting in response to threat, i.e., responding rationally to the threat of negative

consequences, does little to convince others, or even oneself, that someone truly "wants it." Too

often, they have seen someone relapse after the threat was lifted. For a brief period – even up to

2 years – and with the right amount of external force, anyone can go to work, pay their bills, and provide for their children (i.e., improve their functioning). They only "really" want it if they continue to do these things, and avoid relapse, when all forms of outside force have been removed. Drug court is viewed especially skeptically as people doubt its long-term impact:

> ***Mother, mid-50s, son addicted to heroin:*** *"I've known a lot of people that's had to go through the drug courts. It's not done them any good. They've got to want to."*

> ***Male, mid-30s, currently using heroin but planning to seek treatment that day:*** *"I know a few people that's went because I think that the law told them to and they always end up getting kicked out or leaving…Everybody I've known that's went to the drug court has used as soon as they got out. That's not the answer."*

These outside factors do not force people to wrestle with their ambivalence about quitting. Thus, abstinence and other behavior change achieved due to lack of access also counts less: "They only quit because they couldn't get drugs," "I was only clean because I didn't have the choice to use." Incarceration makes it difficult to gauge whether someone sincerely wants it, because any abstinence is assumed to be due entirely to reduced access:

> ***Father, mid-40s, son addicted to heroin:*** *"We are at a crossroads right now where he is almost a year sober, and it's all because he's been incarcerated. That's the only reason he's been a year sober. He's different now that he is sober, but we are looking at the future where he will be released from prison and he will have access to drugs, and it's the big question of what will happen then? Big question."*

> ***Female, mid-30s, quit methamphetamine 4 years prior:*** *"When you got somebody that's forced in there, that's not ready for the help, they may act like they're gonna do it. But as soon as you let them back out into the free world, they're back to the way they were.*

As relapses and negative consequences increase, people with addiction find it less and less likely that others will be there for them, even as they are increasingly aware that they need others. They ask, "Will my family take me seriously? Will they be there for me even though I've

relapsed before?" Mutual distrust has built over time, as the person who is addicted is never quite sure if their loved ones will abandon them if a relapse were to occur. One woman, after stating her boyfriend and father of her young child will "stay by my side" if she were to relapse to heroin use, went on to say, "But we'll see."

People who are addicted also ask themselves, "Can I do it this time?" For them, too, a relapse is evidence that they must not have wanted it *enough* the last time. If they had wanted it enough, then they would have done things differently: they would have been more careful about who they spent time with; they would have been more accountable; they would have been more on guard; they would not have let themselves become stressed, or depressed, or too comfortable. Or, perhaps, they had not experienced enough negative consequences last time, but *this time* they have, and those consequences are enough to make it last. Their shame and lingering doubts about whether others will be there for them can lead to an unwillingness to ask for support. They do not want to burden others:

> ***Female, early 20s, currently withdrawing from heroin:*** *"I mentioned it [treatment], because my step-sister has an uncle who owns a rehab in Florida. I thought about talking to her or something, but I guess I'm trying to do it on my own first. Don't really want to go to my family for help. I feel like that's having them try to fix my problems and I want to fix them on my own first, because it's my fault."*

Monitoring for Evidence of Wanting It and Willingness to Give Support

Repeated relapses lead to a 'cautious pessimism' about whether to trust someone's latest quit attempt: "You hold your breath," "History does repeat itself," "We helped him a lot more on the first time than we did the millionth time." For loved ones who are constantly asking, "Do they *really* want it this time? Will they ever change?", evidence of such would provide a clear

'yes' or 'no' to these questions. With such evidence, they are more willing to spend time with the person claiming to have quit, rather than avoid them. They might be willing to assist them financially, rather than cut them off. And, most important, they might be willing to trust them and be vulnerable again, rather than put up emotional boundaries. If they could only learn whether someone really "wants it," then they could, perhaps, exhale.

Because knowing whether someone "wants it" is important for the future of the relationship, it becomes essential to monitor for evidence that their addicted loved one has changed and has begun to function as a rational person. To ascertain whether rationality is present, whether they have reason to hope for the future, loved ones look for evidence that drugs have lost their power. They monitor closely, even obsessively, the behaviors they believe to be proxies of "wanting it." Monitoring extends beyond, "Did they use today?" or "Are they high right now?" though these are important questions as well. Rather, loved ones seek to understand whether the person in early recovery is making choices that evince a sincere desire to be a different person, not only by quitting drugs, but by "doing the right thing." Both former PWUD and loved ones engage in this monitoring, not to mention drug, family, and criminal courts and treatment providers.

Desires are not directly observable by others, and a hoped-for future self is even less so. Yet participants expressed that such shifts (e.g., in the propensity to use and in expectations for social role functioning) should nonetheless result in visible evidence that they "really" want it this time. There are certain things a rational person who wants to be "normal" and functioning would do to achieve this goal: not use drugs, do everything in their power to prevent use (namely, asking for help and avoiding other users), and take responsibility for themselves

(improved social role functioning). Moreover, they would do these things of their own free will, not because they were "forced" to.

In Figure 4.6, the label, "Monitoring for evidence of wanting it," encompasses two separate loops: 1) as social role functioning decreases, support received decreases, which reduces expectations, increases the propensity to use, and reduces social role functioning; 2) as propensity to use increases, support received decreases, which reduces expectations and increases the propensity to use. Moreover, this loop comprises the same variable as the "Ambivalence about Quitting loop," but from a different perspective. As support sought decreases, support received decreases, which decreases expectations and increases the propensity to use, which decreases support sought. However, in this instance, support received decreases because, from the loved ones' perspective, failing to seek support is evidence that the person does not really "want it," and thus they reduce the support they are willing to provide.
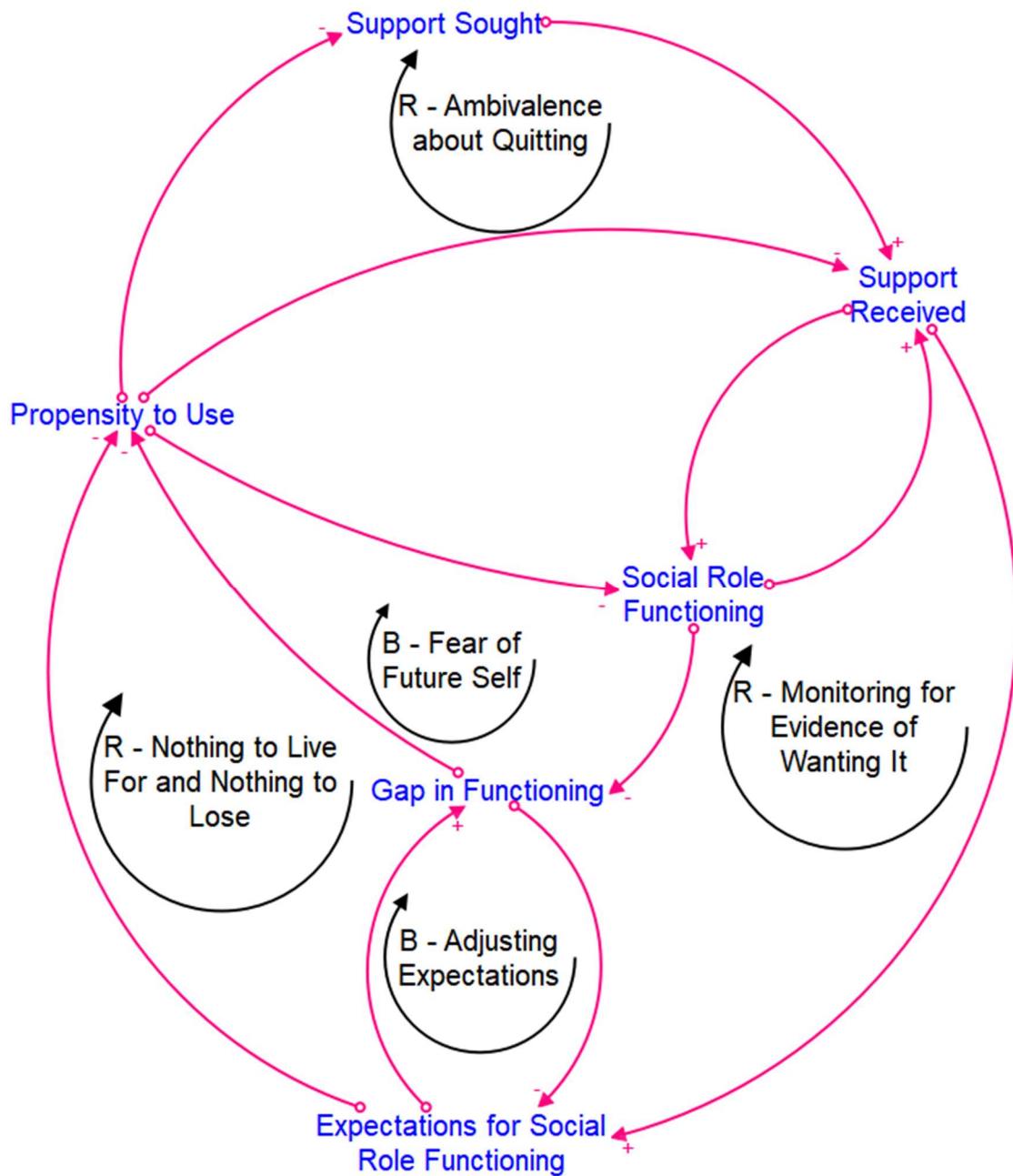
Figure 4.6. Monitoring for Evidence of Wanting It

The most direct target of monitoring is drug use itself, which is done "just by looking at a person": pinpoint or dilated pupils, picked-up arms, "the tweaker dance," positive drug tests, weight changes, bad teeth, time spent in the bathroom, needle marks, skin clarity, sweating,

whether they answer the phone or not, how much or how little they sleep, the sound of their voice, the speed at which they talk. However, some of these "cues and clues" could easily be misinterpreted in the context of a distrustful relationship; some people could be perceived as actively using when they were not. Alternatively, some people might not display any of these signs despite using frequently. Unless present for the use itself, no one else can ever really know whether a person is using drugs, or how much or how often.

Moreover, as discussed, abstinence alone is insufficient evidence of "wanting it" if it is believed to result from coercion. Therefore, loved ones also monitor with whom the PWUD is spending time as additional evidence of "wanting it." They ask about the friends their loved one is spending time with to learn whether those people are also PWUD. If someone is believed to be spending time with drug users, this is interpreted as, at best, evidence that they are knowingly putting themselves at risk of relapse, which suggests they do not really "want it," or, at worst, that they already have relapsed. Participants who had used drugs similarly felt that a key way of proving that you want it is by changing with whom you spend time.

In addition to use itself, there are myriad other signals that someone truly "wants it." Primarily, they should "do the right thing," i.e., improve their social role functioning. This means no longer doing all the things they have been doing – lying, stealing, fighting, neglecting their children – and starting to do the things they have not been doing, like holding down a job, paying bills, and living independently. However, as with drug use, a loved one can only ever *perceive* how well a person who is addicted or in recovery is functioning, and there is significant potential for errors and delays of perception and misattributions of cause. For instance, they could perceive a change in functioning that reflects the actual direction of change (either improved or worsened), but attribute this wrongly to a change in drug use. Moreover, participates noted and

research has found that PWUD intentionally hide their use from others by "keeping it together" (Mateu-Gelabert et al., 2005), i.e., by functioning, which suggests that it is not as easy as believed to discern whether someone is using drugs based on their functioning.

Finally, as noted, another key piece of evidence for loved ones is whether the person with addiction is willing to ask for support. They look for signs such as seeking treatment, going to groups, taking active measures to prevent relapse, working to improve health, and reaching out to abstinent friends and family for help.

> ***Mother, son in recovery from heroin addiction, daughter still actively using heroin:*** *"And when you want to help, you know how to get it. because they're all aware of how to get the help. They've been through it already enough. And when you want the help, you'll get the help…They just don't want to stop using. And until they're really ready they're not going to stop using. My own children, other people's children. Until they're really ready or they're forced by locking them up, they're not gonna get help. Unless they really, really want it. You know some people get tired of being sick and tired. And when they do, they finally change. they change their whole life. They can quit using...I cut myself off until she called me and basically was ready to do something."*

In turn, people who are in early recovery expect that showing such willingness, especially in the face of a lapse or relapse to drug use, should help to convince their loved ones of their sincerity:

> ***Female, early 20s, quit methamphetamine 1 year prior:*** *"I wanted her to know that even though I did screw up that I was still trying.*
>
> *I: What do you get out of demonstrating that you're trying to others?*
>
> *It strengthens your relationship with others. You lose trust for awhile. No one will trust you but the more you show that you're trying to stay clean and you're working on it, you're going to get more trust and people are going to actually want to be around you a little more. You'll build stronger relationships."*

It is not enough that such shifts in functioning, drug use, and seeking support are taking place; these changes must persist. Thus, loved ones and people in recovery track behavioral and mood changes, attempt to interpret Facebook posts and photographs, or a sudden lack thereof, and look for signs of social isolation. All signal an impending relapse, casting doubt that they "wanted it" as much as they had thought.

Loved Ones Withdrawing Support

Loved ones' support is contingent on finding evidence that change is sincere this time. Disappointment in who the person with addiction has become (their perceived low social role functioning) leads to withdrawing support (Orford et al., 2005). Thus, a reinforcing loop is created: the lack of support decreases social role functioning, which decreases support received. However, this simple two-variable loop masks a great deal of nuance and complexity, especially involving the role of hope (and hopelessness), which is important for understanding the decision to withdraw support. This nuance will be explored in more detail below.
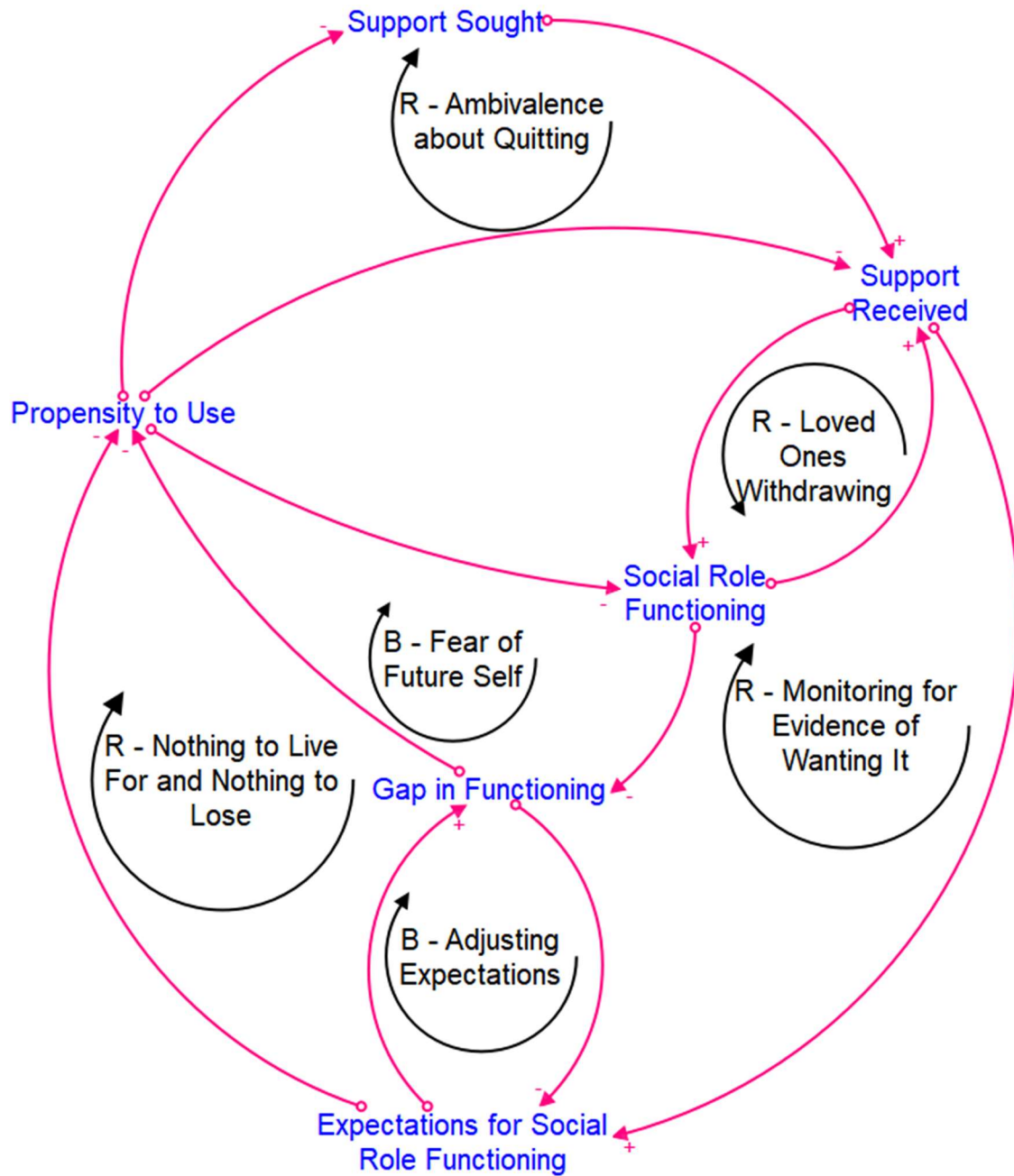
Figure 4.7. Loved Ones Withdrawing

Hope and Hopelessness

        With declining hope – there never seems to be a complete loss – that a loved one can

recover from their addiction, there is a deep sense of what has been lost (Orford et al., 2005,

2010). This loss of what could have been contributes significantly to t loved ones' levels of stress. This loss is in addition to the stress resulting from all the potential and actual consequences of addiction: incarceration, financial strains, taking custody of grandchildren, overdose, death. Parents experience profound pain, as shown in this exchange between a woman, whose son was addicted to heroin, and her friend:

> **P:** *They [friends] worry because they think [my son] stresses me out.*
>
> **Friend:** *That is absolute truth.*
>
> **P:** *They just offer their support…But when you have somebody like [my son] there's really not anything anybody can do… I tell him all the time I despise him. And that just that breaks my heart, but I tell him right straight to his face, "I despise you. How can you just continue to think that everything you do is OK? How can you know the way that I feel about you and take it with a grain of salt?" He is my pain.*
>
> **Friend**: *But she loves him. [laughs]*
>
> **P:** *Yes, I do. I love him dearly.*

Parents of adult children addicted to heroin have had especially to prepare themselves as much as is possible for their child's death: *"Her rock bottom is not going to be a rock bottom, it's going to be death…Her obituary is already written."* She had written it after her daughter's most recent overdose, which her 4-year-old grandson witnessed.

Loved ones can only witness, with an increasing sense of powerlessness, the consequences of use and the lack of change despite these consequences. Compulsively engaging in a behavior in the face of negative consequences – a form of irrationality – is the very definition of addiction. That does not make it any easier to understand or cope with, especially when the solutions they had hoped would work (treatment, social coercion) or they believe

93

should have a made a difference (incarceration, legal coercion) have not. It feels personal: "How could he do this to me?" Unable to understand this frame of mind, loved ones conclude that only drugs could cause such irrationality. Drugs change you, make you dumb, cloud your judgment, compromise your moral boundaries, cause you to lose yourself, and lead you to neglect your children. Notably, many participants who had used drugs voiced similar thoughts. The more that the consequences associated with use accumulate while drug use persists, the more the person with addiction is perceived to not "want it."

Providing support to a person with addiction inevitably causes stress, which can be mitigated in very few ways.. In fact, the only time that loved ones of heroin users experienced less stress or worry was while the PWUD was incarcerated, which is preferable to "kicking rocks at a headstone." But, notwithstanding the fact that some loved ones facilitated PWUD's arrests or refused to bail them out of jail, incarceration is outside of their control.

The situation is untenable, unsustainable: something must change, and often the one thing they have control over is how they relate to the person with addiction. Consistent with other studies (Orford et al., 2005), withdrawing support to protect oneself, home, and family sometimes feels like it is the only option available:

> ***Mother, son in recovery from heroin addiction, daughter still actively using heroin:*** *"I don't have a problem having a relationship with them when they're clean. But if they're not clean I have to cut them out. I have to not enable them because if I enable them, they'll just continue to use until they die. Or go to jail or prison again…I have to turn my motherly heart off and have basically, no - you're not living in my home. You're not going to do drugs in my home. You're not going to have drugs in my home. I'm not going to be around you if you continue to do this to your own children and that type of thing and to this family. I'm not going to have contact with you. You're not going to see me."*

Loved ones do not always make a conscious decision to build emotional walls without a second thought. Rather, they seek to find that place where they still "answer the phone" for the person who is addicted, but without causing "undue stress" for themselves:

> **Father, son with heroin addiction:** *"There is no guarantee at all...I don't know what's in my son's future and that's the hard part because his future is tied to the whole family's future, not just mine, but the whole family...I can't isolate myself from him and I don't see how my family could isolate ourselves from him. It's impossible.*
>
> *I: If he does get out [of prison] and starts using again, what are you going to do?*
>
> *P: What am I going to do? I'm going to do my best to cope with it in how it affects me, which is on an emotional level. I'm not going to put undue stress upon myself to save him from this anymore. I'm not...There is definitely going to be a change. There has to be. I cannot continue to -- I don't want to say bail him out of his problems, because I don't think I have ever bailed him out of his problems....I would still be his dad. When it comes to his drug addiction it's to the point where he has got to do it on his own. He has to, because I realize now there is nothing I can do when it comes to the drug addiction. There is nothing I can do. I can provide, I can be his dad but that's about it. I can't be his lawyer, I can't be his financier, I can't be his insurer, I can't do any of that anymore.*
>
> *I: What does it mean to be his dad?*
>
> *P: To answer the phone when he calls, that would be number one. Talk to him. That's the main thing...you still have to have the door open. To me that's what being a dad is.*
>
> *I: What would it look like if the door were closed? How would you act differently?*
>
> *P: If the door would be closed, I wouldn't answer the calls. I could say and do very little, and it would affect him enough that it would run him out of my life, but I have no intention of doing that. I don't want to hurt him like that. No intention."*

As addiction progresses, loved ones conclude that if their own love and support, their begging and pleading, multiple episodes of treatment, incarceration or a felony record, loss of relationships and children, overdose, and the very real possibility of death cannot overcome the

power of drugs and make them "want it" enough to change, then there must be, *has to be*, something else – as yet unseen – that can. If loved ones cannot coerce the person with addiction, and if the addicted person cannot respond rationally to negative consequences, then they must not be able to do much at all. Whereas social coercion is used to "make them want it," now they conclude that "you can't make someone want it." Indeed, that conclusion is implicit in the mental model that "you have to want it."

This is the space in which hope dies and is reborn, in the sense that loved ones are reluctant to give up entirely. There is *expecting* someone to "do the right thing," and then there is *hope* that they will: "It could be false hope, but it's what we got." Hope becomes their only source of fortitude moving forward. Somehow, some way, some day the person with addiction will "have to find it within themselves" to overcome the power of drugs. However, by maintaining hope, loved ones believe that this will ensure support is available should the PWUD find this inner strength. But this is not easy to do given that any realistic assessment of the past would suggest no reason to hope. With hope there is continuing vulnerability, which can feel very risky:

> ***Mother, mid-40s, daughter addicted to heroin:*** *"I always have hope it will happen, but I have to stay over here, too, just a little bit, that it may not ever happen. Because I don't want to be devastated again. That's my biggest fear. I don't want my grandson to have to go through it again."*

This sentiment – "staying over here," or holding back emotionally because past experiences suggest that the future will be no different – was quite common among all participants, including PWUD when discussing others about whom they were concerned. This is another way that loved ones withdraw their support, even if subtly and reluctantly.

96

More complex models were developed that included constructs involving loved ones' hopelessness, stress, and powerlessness without providing additional meaningful insight. Ultimately, the effect is to lower support, which has implications for the PWUD who is addicted, which affects the support loved ones offer.

<u>The Effect of Lost Support on Social Role Functioning and Expectations</u>

The effect of loved ones withdrawing is to exacerbate an already-bad situation (contributing to the sense of "spiraling out of control" so often described in participant narratives). Many people with addiction experience a complete severing of important relationships. Several loved ones, for instance, noted they were all the person had left. By the time that people with addiction reach out for help, loved ones have already begun to withdraw their support, either consciously or not.

The effect of lost support received is to lower expectations for social role functioning and social role functioning itself, which reinforces the vicious cycle of lost support. The loss of material support might mean being kicked out and becoming homeless, which is a direct effect on functioning. That this could be interpreted as evidence that they are addicted (they are continuing to use despite negative consequences) it is more often interpreted as more evidence that they do not "want it." The loss of support also indirectly increases the propensity to use, first through emotional boundaries (the loss of emotional support), which means the reference groups for whom the PWUD might want to "get clean" are disappearing and thus self-expectations are decreasing (the "nothing to live for and nothing to lose" loop is strengthened). Finally, lower support decreases expectations, which decreases the gap between expectations and functioning (the "fear of future self" loop is weakened) and thus increases the propensity to use.

The quality of the relationship continues to decline as functioning declines and the perceived or actual propensity to use increases. Loved ones lose faith, and the trust and acceptance they might have once had that allowed them to still have hope, or to generously interpret the person with addiction's functioning or other behaviors, starts to fade as well. In its most extreme form, when people lose all social support and functioning declines precipitously while drug use increases, the result can be what one mother called, quoting her daughter, "tough loving someone to death."

Together, the loved one and the person with addiction create a dynamic of mutual hopelessness for the future. This can happen even when there are periods of abstinence. Drug use or functioning could change, but a delay in perceiving these changes might lead a loved one to assume that the person is still using or has not improved their functioning and base their actions on these flawed perceptions. By the time their perceptions "catch up" to the previous reality, the damage might already be done.

Participants highlighted the importance of receiving support in achieving recovery, though "wanting it" had to come first: "he won't be able to do it on his own, but we can't help him unless he wants to help himself." But reaching out to others for support does not mean that support is found. Moreover, some PWUD expressed sympathy with their family members' need to protect themselves or their home. They felt that they deserved, to a certain extent, others' distrust and suspicion:

> ***Female, 20s, started methadone maintenance treatment for heroin addiction within past month:*** *"Me and my sister have always had a rocky relationship cause we're two completely different people...as soon as I got pregnant with my daughter, she started calling me every day and checking on me and like, we started to have a better relationship. But as soon as she realized I was using that's when our relationship went right back to what it was like before. And then like, I don't know how long ago, but when I was using, I stole some stuff from*

her house and she really was upset about that and she still is. And I understand.
I've said sorry but sorry doesn't really help sometimes. And that's why I'm not
allowed to stay at her house, which I understand that completely." [laughs]

Thus, even when they do recognize support, they might be unwilling to ask for it. It is usually

only when they feel they have no other options that they reach out to others, despite their shame

and fear of being rejected:

> ***Male, mid-30s, planning to enter treatment that day for heroin addiction***: *"It*
> *took for me to lose that job for me to realize OK, wow, this is getting way out of*
> *control. What am I going to do? How am I gonna break it to my family? I can't*
> *break it to my family. I'm scared what's going to happen. To now I'm to the point*
> *where I don't care what they think or say. I got to get help; I don't care what*
> *they think about me. [My family] or anybody. The town itself. I don't care what*
> *they think. I got to get help to be totally done."*

Initial Conditions: Quality of Relationships

A key source of variability was participants' quality of relationships as children and

adolescents, prior to developing their addiction. The most toxic relationships were described by

the participants who had used methamphetamine, and these were all described as toxic prior to

the participant using drugs, typically starting in childhood. This contrasted with participants who

used heroin whose relationships had deteriorated once they started using.

Though the sample size is too small to draw statistical inferences, participants who had

used methamphetamine (meth) (n = 6) had on average 1.4 fewer people in their overall network

(including people they spoke to about important matters and about health problems), 1.8 fewer

people in their important matters network, and 20% more kin in their overall network, compared

to participants who had used heroin (n = 8). Thus, not only did people who had used meth have

smaller networks made up of more family members, but those family members were described as

toxic and abusive, and they had few alternative sources to turn to regarding their health and addiction. No studies were identified that compared the social networks of methamphetamine and heroin users within the same community. The sample size is too small to generalize, but the income of participants who had used meth ($28,650) was on average $20,000 less than those who had used heroin ($48,250). These socioeconomic differences could affect their ability to find new, healthier relationships outside of their toxic kinship networks.

Regardless of the drug used, participants who were addicted experienced profound pain due to the perception that others had no hope for them. Their most faithless loved ones were sometimes also the most abusive. These unseen loved ones were considered partly responsible for the addiction itself, but their perspective of the relationship is not directly accessible. Loved ones who have toxic relationships with the PWUD in their lives are unlikely to respond to advertisements for a study.

The impact of abusive relationships on the person with addiction goes beyond the shame that such abuse creates. Abuse not only affects the entire prism through which people with addiction view themselves, but also how the abuser views the person with addiction. Thus, just as a fundamentally strong relationship provides a certain degree of leniency in how loved ones look for hope and perceive functioning, abusive relationships leave no room for error. From the perspective of the person with addiction, to be abused is to be perceived as perpetually flawed. Any support they provide is guilt-laden, inconsistent, and contingent on their ability to stay off drugs, if it is there at all. They have been rejected throughout their lives by these same loved ones who now neglect to support them:

> *Female, 40s, current methamphetamine user: "I've gotten clean from all of it at times and had a lot of clean time. But it seems like there's always something that makes you go back. Like my mom was a horrible, she used to always assume*

100

that I was doing stuff that I wasn't. And just the way she would go about, the way she'd do things, I would always fall back. Cause she would never believe me. [crying] And if you don't have somebody believing you, you're pretty much screwed anyway."

Several participants who reported toxic relationships described a feeling of relief and a lifting of a tremendous burden when they severed ties with abusive family members, or even when these family members passed away.

Relationship quality does not only affect initial conditions that set the stage for addiction. Adults who experience abuse as children often continue to experience it as adults, and from the same perpetrators. Even if they can protect themselves physically, they cannot protect themselves emotionally. It pervades all interactions between them. Thus, when abusive loved ones engage in the same monitoring behaviors as participant loved ones themselves described, its meaning and intent are interpreted oppositely. One person engaging in such a behavior is described as "looking out" and "caring," whereas another is distrustful and looking for reasons to doubt. Compare these excerpts from the same woman, who had quit methamphetamine 4 years prior to the interview, in talking about her family, especially her mother, versus her husband:

Regarding mother and family:

"Whenever I was needing help, I didn't have anybody around me that was sober that would help me. My friend and her old man, they were getting high with me. They were right there beside me doing it, so they were no help to me. My mom, like I said, had her problem with her pills, so she wasn't no help to me. And when I would try and say something to her all she wanted to do was belittle me. Down me and talk bad to me. Go behind my back and talk to people bad about me. That didn't help me none. That's not a way to help somebody. Not at all...

They all looked down at me. People didn't want anything to do with me. Anytime I'd come around all I'd hear was whispers. You know, I'm trying to – meanwhile I'm trying to, you know, I'm sober right now. I mean even when I was getting high I still had my sober days. I had days when I wasn't on it. And I would try and go to family stuff, like Christmas, Thanksgiving. They'd invite me, you know,

'cause I was family. But then when I'd get there nobody would talk to me. Everybody would be all hushy-hushy around me. Let's not let [participant] hear this, you know. And that didn't help me none at all."

Regarding Husband:

"Usually when I went to work, I went straight to work. Get out of work and came straight back home. I didn't stop anywhere, didn't do anything else. He [husband] knew when I was leaving and he knew when exactly when I would get back. If I was gonna be late I'd get a hold of him. If I was later than what I normally was, yeah, he'd question. "Where you been? What have you been doing? You weren't out getting high, were you?" You know, he was asking questions.

I: How did that make you feel?

It was a little aggravating at first. 'Cause I...I didn't know if he trusted me. Which, he did. He did trust me. He just asked 'cause he cared. Even now if he asks me, "Where you been?" "Oh, I been here and there, you know." It don't bother me."

Ostensibly, these behaviors are similar to each other and to those described by participant loved ones, who mentioned monitoring for signs of use and of really "wanting it," and who would sometimes doubt recovery was possible. However, despite these surface similarities, the gestalt emotion differs markedly. Participants who had used drugs described how these monitoring behaviors permeated their relationships, with an acute sense of the pain that had been inflicted on them; participants who described engaging in monitoring did so with an acute sense of pain that addiction had caused in their loved ones.

This acute pain was especially noticeable with parents, who were the majority of participant loved ones. They would describe what their child was like when young – good, sweet, hyperactive, sensitive, smart, etc. – usually in the context of describing how much drugs had changed them. There was recognition – anger at "the system," even – that some consequences of addiction, such as incarceration and homelessness, can make it difficult if not impossible to fully

regain functioning, which made it hard to have hope. There was also a sense that addictive behavior lent itself to hopelessness. However, at base, the addicted person in their lives is a victim of the power of drugs, not fundamentally flawed, and for this reason the participants loved ones, for the most part, retained some hope.

In only one instance did a loved one express hopelessness that appeared to be grounded in fatalism about who the person with addiction fundamentally *is*. In this exchange with her youngest daughter, they describe how the participant's oldest daughter "does not want to quit, period." Throughout the interview, they had described her as having "always" been manipulative and a "bad mother," even before being addicted to heroin:

> **Mother, 50s:** *That's the thing with [my daughter] - there is nothing in her mentality, whatsoever in her anywhere, does she think, "I've hit rock bottom. This is not the life that I want to live – lost my kids." None of that even sparks in her brain. She likes the way she lives. She likes the drugs, she likes not knowing, living place to place…There is nothing in her saying, "Yes, I want to get off the drugs, but I can't." None of that ever crosses her mind whatsoever…*

> *There was another time where [my daughter's husband] said, "You either go out and stay at your mom or your dad's down in the country or I'm done with you. I'm not going to have anything to do with you anymore if you don't go and get off the drugs."…I've written her letters, I have tried catching her after she's gotten out of jail, and been clean for a while, and nothing.*

> **I:** *As far as you can tell she doesn't want to quit?*

> **P:** *She does not want to quit, period.*

> **Daughter/Sister:** *No, if already losing one kid and then being pregnant and everything that-- how could you be pregnant and go-- everything that I'm doing is ruining my baby, but I'm not willing to stop."*

A perception that someone is fundamentally flawed can lead to a distort interpretation of their behaviors. They perceive a certain willfulness to the irrationality of addiction, as if the person with addiction prefers living a life with poor functioning and low expectations. The

103

irrationality of the addiction engenders considerable anger, even when the drug use does not

involve the "drug of choice":

> ***Female, mid-40s, male partner and father of child currently (in her estimation) using cocaine:*** *"He'll swear to me; he'll look me in the eyes and say I love you so much. I would never choose that. I would never want to lose you. And literally less than 24 hours, there was pot in his car. Are you kidding me? You just told me how much you love me; I mean the world to you, and you would never choose drugs over me. You know you'll lose our family. And you're doing it, and you don't care. And then he wants to twist it and turn it around on me, which is a typical addict. It was disgusting."*

The person with the addiction has become a "typical addict"; there is no individuality, only the

addiction which, this same woman had elsewhere stated in the interview, was a reflection of who

he "really" was.

In contrast, the loved ones who spoke most confidently or hopefully about the person

with addiction's ability to eventually recover seemed to express the most confidence in the

relationship. The quality of the relationship itself helped them to sustain hope, to give the person

with addiction the benefit of the doubt, and to generously interpret evidence of change. One

mother even went dumpster diving with her daughter in the middle of the night, as she saw it as a

welcome alternative to heroin use.

Sick and Tired

With functioning, expectations, and support declining, and sometimes never high to begin

with, the "fear of future self" loop begins to resemble an individual race to the bottom or

crossing of the Rubicon (MacDonald & Marsh, 2002). If these were the only dynamics

operating, then the modal outcome for people with a methamphetamine or heroin use disorder

would be to continue using until death; while this does occur for some individuals, conservative

104

estimates are that 60% of people with a drug use disorder achieve a stable remission (Fleury et al., 2016; White, 2012). However, one reason this remission might not transition to recovery, with meaningful improvement in quality of life, functioning, and relationships, is because the dynamic driving the remission is avoidance of further negative outcomes rather than striving for positive outcomes. The final loop in the cyclical pattern in addiction is "Sick and tired," as seen in Figure 4.8. As fatigue with drug use and the associated lifestyle increases, the propensity to use decreases. However, this is a balancing loop, so as propensity to use decreases and social role functioning starts to increase ever so slightly, fatigue starts to slowly decline.
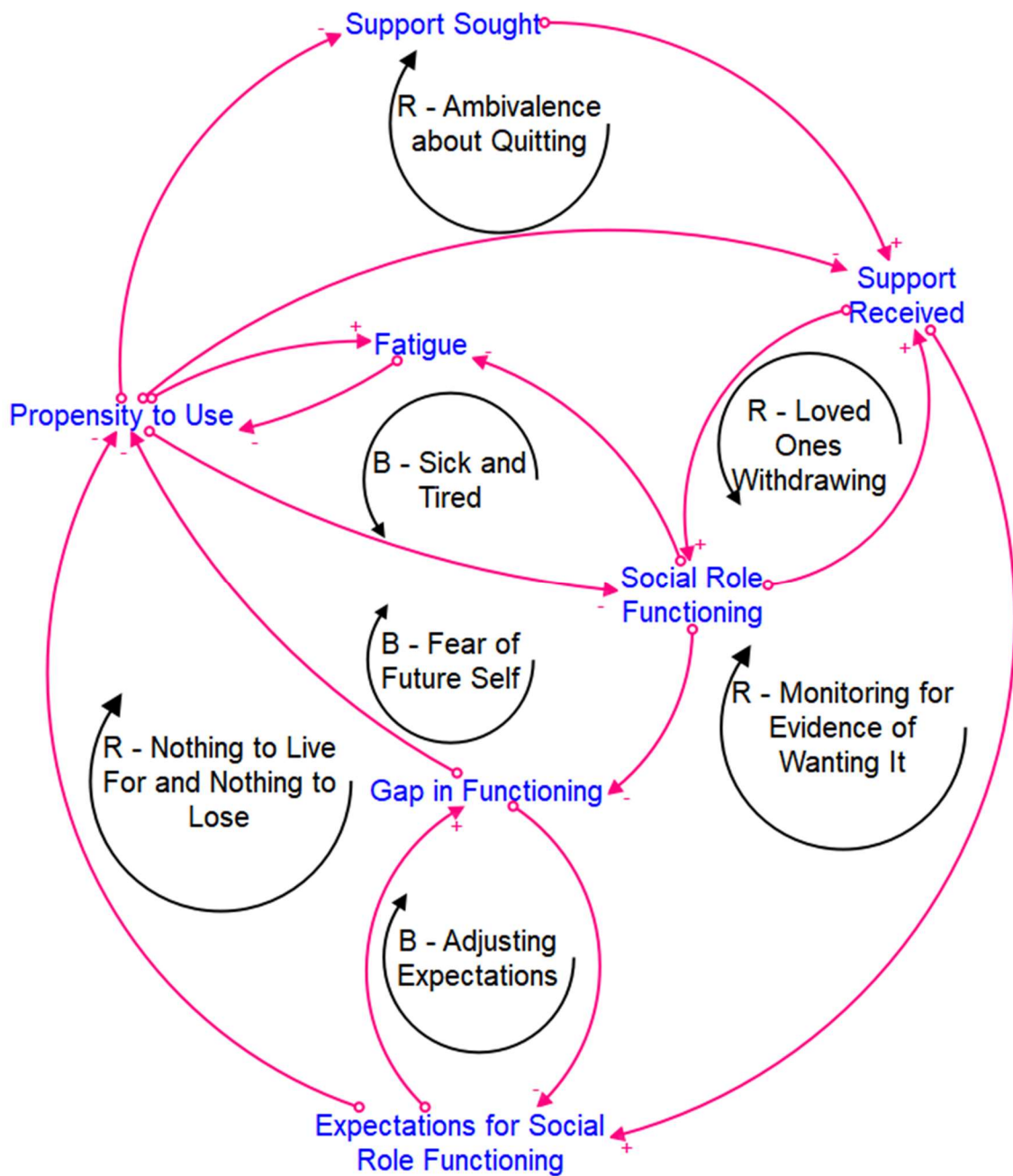
Figure 4.8. Sick and Tired Balancing Loop (Final Diagram)

In interviews it was sometimes difficult to distinguish between fears and fatigue. However, language involving fear, which necessarily involves the future, was more often about

fears for who they could become (representing the "fear of future self" balancing loop), whereas feelings associated with the drug-using lifestyle were about various forms of emotional and physical that they were *currently* experiencing due directly to their drug use, e.g., "tired of being sick," "I can't do this no more" (Laudet, B, & White, 2009). Indeed, there were few, if any, fears expressed about long-term health effects of drug use that had not yet materialized.

Fatigue from the lifestyles associated with heroin use versus methamphetamine use manifests differently. For opioid users who have developed a physical dependence, their fatigue associated with the lifestyle results from wearying of withdrawal:

> ***Female, late 20s, quit heroin two years prior:*** *"I wanted to quit because I was tired of having to do the same thing every day. I was tired of being sick if I did not have that drug. That made me want to have a desire to quit. My willpower to deal with the sickness was not strong enough. It goes to desire to use more, to keep that sickness away…the getting off of the drugs is miserable…Those drugs make us feel good. We don't want to face reality. You continue to use more and more. Most of us do have a desire to quit, but our will isn't strong enough for us to quit."*

For people who use methamphetamine, the fatigue is associated with the lifestyle as well, except it is more likely to be "drama" that is fatiguing:

> *I: And what put you over the edge?*
>
> ***Female, mid 30s, quit methamphetamine 4 years prior:*** *I think all the drama and stupid crap I was dealing with. I mean, people around me…I can only handle so much drama, so much BS for so long. Before I'm finally like, 'Alright. I'm done. No more. I can't do this no more.'*

Fatigue does not necessarily lead to quitting, but the overall pattern appears to be that this fatigue grows over time and eventually reaches a threshold that is physically and mentally unsustainable; they are "done with it" or "sick and tired of being sick and tired." They finally quit for good – or

at least for longer than they have before. Later, when they experience cravings or are thinking

about returning to use, they remind themselves of this fatigue as a way to quell the urge to use:

> ***Male, late 20s, had quit methamphetamine and cocaine in past 2 years:*** *I can want to get high and then I get that craving and then I literally have conversations with myself and start reminding myself all the things that happen when I'm high. And it's never a good outcome.*

The grounded theory and therefore the simulating model that will be described next are

bounded by the concepts just described. However, it is important to note that these two processes

proceeded iteratively; the original causal loop diagram and simulating model was much more

complex, and as the simulating model became simpler so, too, did the causal loop diagrams used

to represent the grounded theory. The goal in doing so was to satisfy the boundary-adequacy

(structure) test, which is meant to ensure that only the structure needed to reproduce the behavior

is included, and no more. Structure that produced no meaningful difference in model behavior

was removed if it theoretically could be captured in the remaining variables. Moreover, some

aspects relevant to drug use behavior – namely, access – were periodically added to re-assess

their effect. However, adding access never produced significantly different model outcomes,

even when it was endogenous to the model (i.e., access would reduce dramatically if social role

functioning reached a critical low, meant to represent, for instance, incarceration). The overall

pattern of propensity to use did not change. Theoretically, this makes sense, as access is

important insofar as it supports an underlying high propensity to use. Note that many of the

excluded concepts will be important to explore in future work.

Table 4.3 shows the included concepts that are endogenous to the model (i.e., part of

feedback loops), the included concepts that are exogenous, meaning they are not part of feedback

loops, and the excluded concepts that were considered for inclusion but ultimately deemed

outside of the current model's boundaries.

Table 4.3. Model Boundaries

Endogenous	Exogenous	Excluded
Propensity to Use	All delays	Access
Reinforcing Effect of Propensity*		Stress
Social Role Functioning		Shame
Expectations for Social Role Functioning		Other PWUD
Support Received		
Support Sought		
Fatigue		

*implicitly includes withdrawal and craving

The next chapter will first define the reference modes that the simulation model was built

to replicate and then discuss the process through which the preceding theory was translated into a

simulation model. This will be followed by model equations, discussions of confidence-building

tests, a presentation of the baseline model results and, finally, results of model experimentation.

Chapter 5: Model Simulation Results

The previous discussion presented a grounded theory of addiction relapse and recovery using two types of feedback loops – reinforcing and balancing – to explain the cyclical dynamics of addiction relapse, remission, and recovery. This chapter translates that theory into a system dynamics model.

There are a number of tests to build confidence in the validity of system dynamics models (Forrester & Senge, 1979). The extent to which these tests are 'passed' for this model will be referenced throughout this chapter. The first test is the structure verification test, meaning that the variables (stocks) and the feedback loops between them are a faithful representation of the actual system, allowing for simplifications made as necessary for parsimony. The concepts included in the final model and the interactions between them are derived from the interviews, which were highly consistent with extant literature. Preliminary versions of the model, in causal loop diagram form, were shared with participants, with modifications made as necessary. The structure verification test is considered strongly passed for this particular sample, and moderately passed for similar samples from other studies. However, additional verification would be done with a more diverse sample of PWUD and their loved ones as well as with addiction experts to fully satisfy this test on generalizable theoretical grounds.

Reference Modes

References modes were defined for several of the major variables in the model: propensity to use, social role functioning, support received, and fatigue. The reference mode for propensity to use will first be shown independently, and then it will be shown in a graph along

with social role functioning, support received, and fatigue, to indicate how they are hypothesized to change together over time.

Propensity to Use

Propensity to use captures the competing motivations, desires, and preferences as described by participants. Thus, the reference mode used will be for 'propensity to use,' rather than drug use behaviors, because the assumption is that the threshold at which propensity translates into frequent use, occasional use, or abstinence differs across individuals, across time, and across drug types (i.e., stimulants versus opioids). The distinction was important in participants' mental models because abstinence that results from truly decreased propensity "counts" more than "forced abstinence." However, as described in the preceding section, others can only perceive the behavior of drug use, which they infer, often inaccurately, to reflect the underlying propensity.

The research reviewed previously indicates three primary patterns of use that are of most interest clinically and for public health: erratic with remission, persistent with remission, and persistent until death. The 'desired' pattern is the least commonly observed pattern among clinical samples, which is either stable remission within the first 10 years of initiation, or persistently low use. Figure 2.1 depicting these four patterns is reproduced below as Figure 5.1.

111
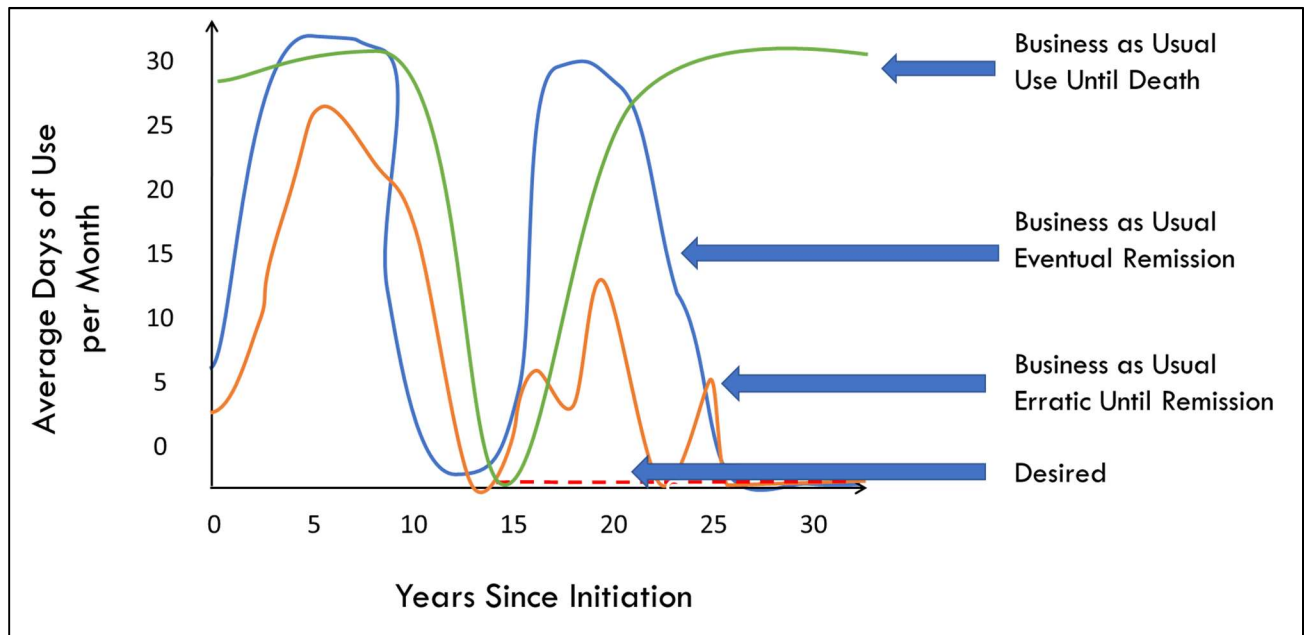
Figure 5.1. Three "Business as Usual" Patterns of Use Over 30 Years and Desired Pattern

However, that research was based on primarily clinical samples of people who started using drugs between the 1950s and 1980s. In contrast, the oldest participants in the present study, who were methamphetamine users, started using methamphetamine in the 1980 and 90s; moreover, most participants, regardless of drug used, had not received addiction treatment. While the participants who had used methamphetamine did describe erratic patterns of use spanning decades, the participants who had used heroin described having experienced episodes of abstinence within the first 10 years of their use, if not sooner. Thus, they appeared to have experienced more time abstinent than people in prior studies who used heroin, perhaps indicating stronger balancing loops. The study's reference modes, therefore, will draw on the extant research as well as participants' descriptions of their or their loved one's use.

Overall, participants described their propensity to use (though that word was not used) as declining over time. Initially, propensity to use is high. As physical and psychological

112

dependence develops, drug use becomes less appealing and is perceived to turn into a coping mechanism for dealing with "reality," and no longer just a way to get "fucked up." Moreover, use brings greater and greater consequences, just as it becomes harder and harder to quit and remain abstinent. The relationship with drugs becomes more complex (i.e., there is ambivalence about quitting versus continuing to use). As a result, there are periodic episodes of decreased propensity (i.e., "I'm done with it") due to the "fear of future self" or short-lived (a few weeks at most) fears about death or illness. Thus, there are short-lived periods during which the rate of decline increases and drug use stops. However, eventually, "there's always something to make you go back," which suggests a weakening of the balancing loops, and the shame, stress, or other negative affect states the PWUD is experiencing causes the propensity to use to increase again, with use itself soon to follow. Thus, we would expect to see a pattern that shows not just an overall gradual decline in propensity to use, but also these oscillations due to balancing loops. This pattern suggests a reference mode with oscillations around a declining average.

Figure 5.2 shows the reference mode for propensity to use that reflects a prototypical or modal pattern for propensity to use, drawing on a combination of the extant literature and participant interviews. This reference mode is meant to represent both opioid and stimulant users. Although methamphetamine use is more erratic than heroin use, they share similar propensity narratives. One explanation is that the lack of physical dependency among methamphetamine and other stimulant users makes it easier to respond to declines in propensity. Put another way, propensity to use might need to reach a lower value for people who use heroin or other opioids, compared to people who use stimulants, before it influences behavior. In Figure 5.2, even though there are two reductions in propensity before quitting occurs around a value of 40 around year 12, it is followed by a relapse as propensity to use rises again before falling and

staying below 40 starting at around year 15. The subsequent increases in propensity to use

remain below the threshold for quitting, indicating continued abstinence, even when there are

increases at approximately years 17, 22, and 28 in propensity. This is the Feared or 'Business as

usual' pattern, though we can imagine worst case scenarios in which remission never occurs..

The 'desired' pattern is that the first time there is a reduction in propensity, it falls much lower,

well below the threshold for quitting. However, another way to think of this is that the threshold

for quitting could be raised, which might mean that the PWUD has more resources to support

translating their propensity into behavior change.
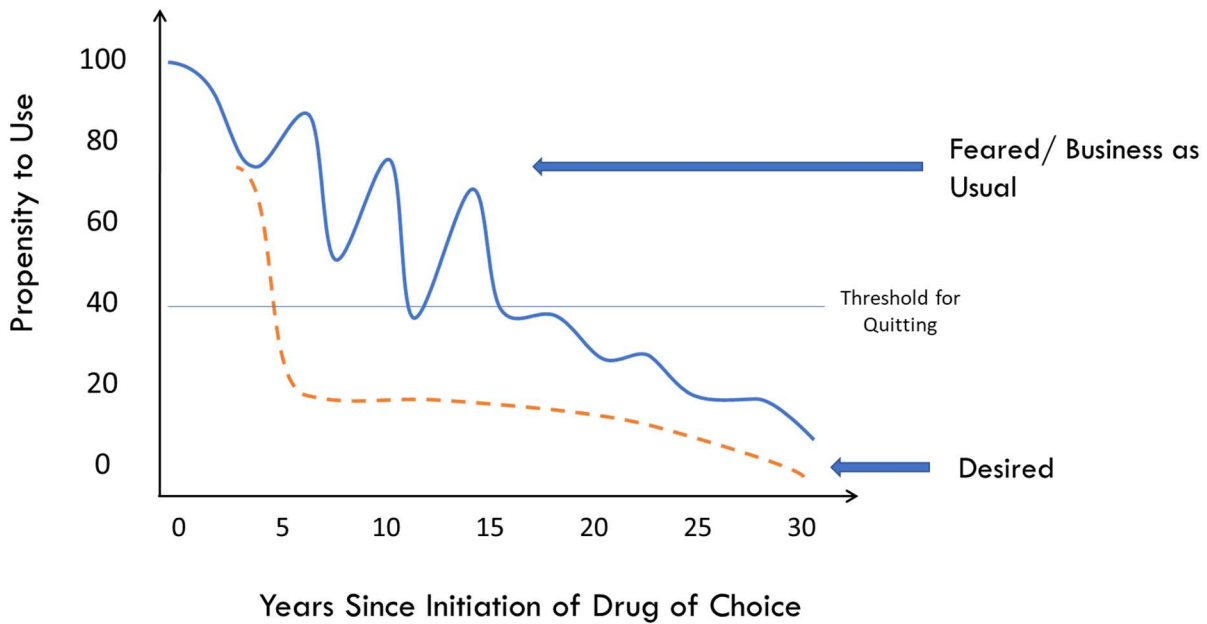
Figure 5.2. Reference Mode for Propensity to Use

The time horizon of the reference mode reflects that of the model (30 years) and of the

longer follow-up periods in longitudinal studies. This allows for various 'types' of users to be

modeled, by creating models that produce remission or recovery within 10, 15, 20, etc. years, or

never. Thirty years also gives the model enough time to 'relapse,' which prior research suggests

can occur, albeit rarely, as many as 15 years after remission. However, it is important to note that the interviews were only conducted with people who had quit within the past 5 years, and some much more recently, and most had not been using their drug of choice for more than 10 years. Thus, the dynamics they describe might differ significantly from those that occur later in addiction careers or recovery. However, the assumption is that the same dynamics continue to operate in these later years, and that whether remission is sustained or recovery occurs is dependent on these dynamics sustaining themselves, and not on new loops introduced later.

The reference mode depicts a moderate case of addiction in which sustained remission occurs around 15 years after initiation. For another person, however, the threshold for propensity to translate into behavior change could be higher or lower, which could shorten or extend the addiction career and create more, or less, erratic use patterns. Model development focused on producing patterns of behavior that reproduced stylized facts for all patterns of propensity to use; the reference mode presented here is just one pattern among many.

The remainder of the reference modes will now be described as they relate to an outcome in which remission is achieved within 15 years after initiation, followed by recovery. Developmental timing matters, and the earlier a PWUD successfully quits the better for long-term outcomes, even if they later relapse (Evans et al., 2013). In worst case scenarios, where remission never occurs, we would expect a stable state of poor social role functioning, expectations for same, and low support received, regardless of propensity to use. In cases where remission does occur until 20 or more years after initiation, we might expect that social role functioning and support received increase slightly after remission, but that expectations might not follow, because the long-term consequences of addiction are much harder to overcome at this point. However, when remission occurs earlier, such as around year 15, the possible outcomes

115

vary more widely dependent on initial conditions and exogenous factors. Therefore, though a full, sustainable recovery is not currently the most common outcome achieved for people with addiction, the reference mode reflects what we should expect in recovery. Model building focused on reproducing multiple patterns, including no remission, remission without recovery, and remission with recovery, where recovery was operationalized as low propensity to use and high or increasing social role functioning, expectations for social role functioning, and support received.

Social Role Functioning

Social role functioning is hypothesized to generally decline over time, with sharp declines during periods of drug use, and a stabilization or even small increases during periods of reduced use or abstinence. These small increases in functioning were included based on comments in interviews such as, "She quit using a few weeks ago and is doing really good," "Now I'm actually contributing to society. Paying bills and all that stuff," which they described after just a few months of abstinence.

The effect of sustained remission on social role functioning (as opposed to recovery, which is defined here as increasing social role functioning) is unclear based on the interviews. Most PWUD did not describe having experienced remission longer than a year or two, and most loved ones had not witnessed the PWUD in their lives experience sustained remissions, either. Thus, to construct the reference mode for expected social role functioning after sustained negative levels of propensity, Kelly et al.'s (2018) findings were used. This study was a probability-based survey of the US adult population that examined changes in recovery indices

by comparing responses of those who had started their recovery within the last 5 years versus within the last 40 years. People were considered in recovery if they affirmatively answered that they "used to have a problem with drugs or alcohol, but no longer do" (Kelly et al., 2018), which is broader definition than is used for this study.

Overall, Kelly et al.'s findings suggest that we should expect rapid improvement in *quality of life and recovery capital (i.e., not necessarily social role functioning)* in the first 6-11 years after recovery, followed by continual improvement but at a slower rate, with an 'average' quality of life not being reached until at least 15 years after recovery (Kelly et al., 2018).

Quality of life and recovery capital are not completely analogous to 'social role functioning.' Quality of life, which was measured using the EUROHIS-QOL 8 (Rocha, Power, Bushnell, & Fleck, 2012), includes questions about health, energy, personal relationships, living conditions, and money, making it similar to but broader than 'social role functioning,' which is how well the PWUD in recovery is performing in their social roles as parent, partner, family member, resident, employee, etc., and captures an element of perceived Self and identity. It is possible that improvements could be made in many of the domains in quality of life without concomitant improvements in social role functioning. For instance, interview participants described more rapid increases in energy, living conditions, and money after quitting, than they did in health or personal relationships. Social role functioning, therefore, might not increase as quickly as 'quality of life' increases would suggest (or it could increase more quickly, though that is less likely given that social role functioning requires a reference group with whom the social roles are formed, and these reference groups are often hesitant to trust the latest quit attempt). Thus, when examining model behavior, the potential for different rates of change among these constructs was considered.

117

Expectations for Social Role Functioning

'Expectations for social role functioning' is also without a clear analogue in the recovery literature, the closest being broader, less-defined concepts like hope and optimism. To be sure, the choice to focus on 'expectations' largely derives from the symbolic interactionist literature (Biernacki, 1986) and not from the more recent recovery literature. Thus, the reference mode was generated from the interviews, in which the general pattern was that expectations and social role functioning change in the same direction, with functional changes preceding expectations changes, and more quickly. Thus, expectations were hypothesized to not necessarily rise in early recovery, even if functioning does. However, none of the participants had been in recovery for longer than 5 years. Thus, the relationship of expectations to functioning might change once remission is achieved and maintained for more than 5 years. The reference mode therefore reflects the assumption that, in recovery, expectations eventually surpass functioning, meant to indicate the maintenance of a gap that helps to sustain recovery by keeping the person striving toward new goals.

Support Received

The reference mode for support received is based on the interviews and the large body of literature indicating that social support, typically from abstinent social network members, is associated with better long-term outcomes (Bohnert et al., 2009; Brewer et al., 1998; Y.-I. Hser et al., 2007). Specifically, we should expect that support received is inversely related to propensity. However, no studies were identified that track how support among a stable network (such as one's family members) changes as drug use changes, which would be a closer representation of the intended reference mode. This is important because the history of the

relationship matters, and we can imagine people successfully quitting and even achieving remission without any change in support, though achieving recovery would require support.

Thus, the pattern in the reference mode during the years of addiction (up to year 15) is based largely on the interviews and other qualitative research (Orford et al., 2010). Support received is hypothesized to decline over time, with increases in support during the first decline in propensity to use. However, with each subsequent relapse, the decline in support received is even greater. In a model with even more erratic patterns, with each quit attempt, the increases in support are smaller, if there are any at all. This is consistent with participants (both loved ones and PWUD) who described decreasing trust over time in the PWUDs in their lives, leading to the withdrawal of support to protect themselves.

In the reference mode, which depicts recovery rather than remission only, support received increases after a delay. In a remission that never transitions to a recovery, it is just as plausible that there is no increase in support received. If support received does increase, it could do so a couple of different ways: the PWUD seeks support and gets it from loved ones who believe that they really "want it" this time, or, more likely, the PWUD develops new relationships (Bohnert et al., 2009; Christo, 1998; Y.-I. Hser, 2007; Vergés et al., 2013). The baseline model mechanisms more fully capture the former dynamic, rather than the latter, the implications of which will be discussed later.

'Support sought' is not included in the reference mode because its patterns were least apparent and most variable in the interviews, without a strong relationship to actual support received (though they are assumed to be positively correlated). The hypothesized relationship to propensity to use is also underdeveloped compared to other relationships. As will be discussed

later, its effects on the model are negligible, but it is included because it distinguishes the "Ambivalence about quitting" loop from other loops that involve Support Received.

Fatigue

The reference mode for fatigue is based on interviews and on the general 'stylized fact' that fatigue with the lifestyle grows over time ("sick and tired of being sick and tired"). For instance, in a 33-year study of people addicted to heroin, nearly 90% of those who had remitted said they quit either because they were tired of addiction or of the lifestyle (Y.-I. Hser, 2007). In the interviews, PWUD rarely describe this fatigue as decreasing, though its growth might slow. However, based on the hypothesized mechanism, it is theoretically possible that fatigue could decline over time once a long enough period of decreased propensity and increased social role functioning has occurred (these are the two variables hypothesized to affect fatigue with the lifestyle). Figure 5.3 depicts each of the aforementioned patterns of behavior as they are hypothesized to interact together over time when recovery is the outcome.
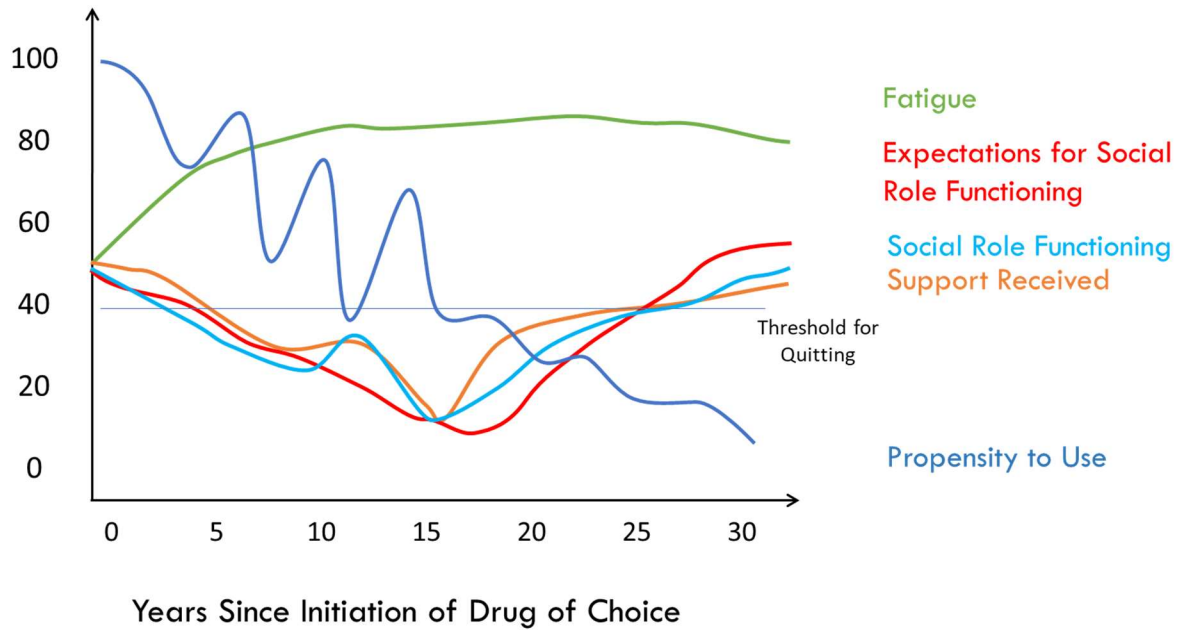
Figure 5.3. Reference Modes for Recovery Starting 15 Years After Initiation

Model-Building Steps

Time Parameters

In this study, the time boundaries start at initiation of the drug of choice. In such a state space, social role functioning, expectations, and support received are unlikely to have significantly begun to decline. This choice of time horizon resulted from a boundary adequacy test. The baseline model was initially built over 15 years, but when extended to 30 years unexpected behavior emerged, and thus the choice was made to have the baseline model run over 30 years (360 months). This allows for smoothing of day-to-day and week-to-week variations but still captures what are often highly dynamic patterns over time.

Simulating the model over 30 years ensures that when experiments are applied, any indicators of recovery in the simulation that occur are sustained for the rest of the model

simulation. This long time horizon also ensures that a return to use does not occur several years later, which can occur but is rare after a stable remission of at least five years (Brecht & Herbeck, 2014; Y.-I. Hser, 2007; Kline-Simon et al., 2017).

The delta time (DT) is set at .25, meaning calculations are performed every half month. This value was chosen based on the generally accepted rule that the DT should be at least 4 times as small as the shortest delay in the model (Sterman, 2000), which is two months in the baseline model and one month in the experiments. Shorter time steps were tested with no change in model dynamics; increasing it to .5 did not result in significantly different dynamics, but was rejected due to the ability of delays in model experiments to be set at under one month. The integration method used is the fourth-order Runge-Kutta (RK4) method. This was chosen because oscillations are hypothesized to be a defining feature of the propensity to use over time, and this method is required to prevent the model from erroneously producing expanding oscillations (Chichakly, 2010; Forrester & Celeste Chung, 1994). Indeed, in the basic structure of the model, which includes only balancing loops, Euler's method did erroneously create expanding oscillations.

Addiction: Damped Oscillations Combined with Reinforcing Feedback Loops

A key insight that arose from model-building is that the experience of addiction and recovery as driven by the mental model that "You have to want it" is likely to be a system of damped oscillations in which propensity falls as functioning reaches a lower equilibrium over time. That is, it is not just that propensity to use falls over time, but that functioning does as well. Damped oscillating systems are a modification of sustained oscillating systems, in which there is a single negative feedback loop involving two stocks (variables) that are pushing each other in

the opposite direction with equal magnitude (Kamin, Martin, Stange, Samaranayake, & Choge, 2002). These oscillations are caused by relative delays in the balancing loops.

In addiction, however, there are also reinforcing loops involving propensity to use (drugs): first, via the myriad effects noted in the section on 'factors driving the propensity to use' that were not explicitly part of the theory, and which are represented by a simple reinforcing loop, and second, via declining expectations, which is a more complex reinforcing feedback loop. Without the first loop, as functioning declines, propensity equally declines , which would imply that the person with addiction is able to adjust their propensity exactly in proportion to what is needed to improve functioning, which is clearly not what occurs in addiction. This means that while the person with addiction can still decrease their propensity to use in response to changes in functioning, support, and expectations, the reinforcing feedback loop makes this more difficult to do.

The final model structure was built starting with the fundamental oscillating structure, and then additional structure was introduced from there. This means that some modeling choices were inevitably driven by the order in which loops were added.

Sustained Oscillations: Fear of Future Self

The first structure built was a sustained oscillating system that includes only the "fear of future self" balancing loop. As propensity increases, functioning declines and the gap between expectations and functioning increases. As the gap increases above 0 (functioning is below expectations), propensity decreases as well. The PWUD perceives that they are using more than they should if they want to meet expectations. However, as the gap falls below 0 (functioning exceeds expectations), the "fear of future self" wanes. The PWUD perceives that they could use

more and still meet expectations, thus increasing their propensity to use. This captures the sentiment expressed by participants and other qualitative research (Neale, Tompkins, et al., 2015) that PWUD in recovery cannot let their guard down or get overconfident, lest they slip up.

If the balancing (negative) feedback loop "Fear of future self" were the only loop involved in the dynamic patterns of addiction relapse and recovery, we would see sustained oscillations involving propensity to use and social role functioning, driven by the gap in functioning. This implies that behavior changes consistently in response to a gap in functioning, which makes several assumptions that do not reflect how addiction works. First, as noted above, it assumes that the person with addiction immediately adjusts their (propensity to) use in proportion to what is needed to improve functioning. Second, it assumes that expectations do not change with changes in functioning. Third, because it is the only loop, the built-in assumption is that this pattern continues indefinitely, with the oscillations neither dampening and reaching equilibrium nor expanding toward increasing chaos. All these assumptions are inconsistent with what is known about addiction.

Note that because the effects of a gap in functioning on propensity can be a negative value and are additive, this means that propensity to use can also take on negative values. Thus, while the reference mode for propensity to use was constructed around a declining average that ranged from 0 to 100, instead propensity oscillates around 0, with values below 0 corresponding behaviorally to abstinence, and values above 0 corresponding to use of increasing levels of intensity or frequency. Moreover, this means that whereas the reference mode posited an arbitrary value of '40' as the threshold below which propensity to use shifts to behavioral abstinence, and that this value is different across time and individuals, the shift to an average value of 0 instead means that each person's '0' is unique. A further implication of this is that, in

124

the model, -50 propensity to use is treated mathematically similar to +50. While a negative propensity to use does vary, i.e., a PWUD might only be slightly disinclined to use, could no longer desire to use drugs, or could have an aversion to drug use, there is likely a higher floor than there is a ceiling on positive values of propensity. Rather than speculate on what the floor and ceiling are, the model instead limits the effects that propensity can have on functioning to the range of -50 to 50. However, once other effects are added, this modeling choice has little impact on the overall behavior of the model.

Addiction Loop: Reinforcing Propensity

The next loop added was a simple 'addiction loop' in which propensity reinforces itself. The reinforcing loop was modeled as having an additive effect, so that regardless of other effects, such as the "fear of future self," this reinforcing loop will always have an impact on propensity. A positive propensity to use has twice the effect on increasing propensity than a negative propensity to use has on decreasing propensity, meaning that the rewarding effects of drugs inherently reinforce themselves more than abstinence does. The size of the effects was calibrated to keep the range of propensity within reasonable limits.

The effect of the reinforcing loop is to shift the system from sustained oscillations to expanding oscillations. Because these unrealistic patterns reflect an incomplete model, no changes were made to any parameters.

Damped Oscillations Driven by Social Role Functioning

The next step was to create an additional balancing feedback loop that leads to damped oscillations, all else being equal. In systems with damped oscillations the balancing feedback loop that creates oscillations (in this case, the gap between expectations and functioning),

125

interacts with a second balancing feedback loop that pushes the system toward an equilibrium by increasing the rate of change toward an equilibrium value (Kamin et al., 2002). In this model, that additional balancing loop – which was not originally hypothesized – is between the stock of Social Role Functioning and its rate of change. As Social Role Functioning decreases, the rate of change decreases; this slowed rate of change implicitly increases Social Role Functioning, because it is larger than what it otherwise would be.

The effect of this additional balancing loop is to dampen the oscillations that previously were expanding. In a pure system of damped oscillations, behavior responds as desired in response to a gap, and the goal of system improvement is to reduce the amount of time it takes to get to equilibrium. Ideally, then, propensity to use would respond such that the gap between the goal and functioning reduces over time, and propensity settles in at whatever equilibrium is required to maintain propensity to use at or below zero. Of course, this is not what happens in addiction. Nor is a pure damped oscillation the behavior mode corresponding to the reference mode. In the reference mode for propensity to use, the oscillations are occurring around a declining average, while at the same time expectations are falling.

Adjusting Expectations Loop

Interviews suggest that gaps between expectations and functioning are a major driver of quit attempts, but that expectations nonetheless decline over time. Thus, the next step was to make expectations responsive to changes in functioning, which corresponds to the "Adjusting Expectations" balancing loop. Expectations adjust to the gap between functioning and expectations. A positive gap that is too large leads to a reduction in expectations as PWUD begin to doubt that they can ever improve. A gap that is becoming increasingly negative (where functioning exceeds expectations) leads to increasing expectations as PWUD realize that they

can function better than they realized. Expectations for social role functioning reflect what PWUD believe they are capable of in their social roles, though often they are discussed in terms of "shoulds."

The model is sensitive to the addition of the stock 'Expectations for Social Role Functioning,' in particular its two delays: the first delay is how far back (how many months) the model averages the gap in functioning before adjusting expectations, and the second delay is the time it takes for expectations to change. The model is sensitive to the length of these delays as well as their length relative to how quickly functioning changes.

Nothing to Live for and Nothing to Lose Loop

The next step was to add the "Nothing to Live For and Nothing to Lose" reinforcing loop, in which expectations affect propensity. Before this, the only effect on Propensity was itself, in a reinforcing loop, and the functioning gap, in the balancing loop "Fear of Future Self."

The effect of expectations on propensity to use is modeled as a nonlinear first-order information delay. It has an additive effect, meaning expectations affect propensity even if the propensity reinforcing loop or "fear of future self" balancing loop are inactive, i.e., their effect is 0. Likewise, if the effect of expectations is 0, propensity can still reinforce itself or the "fear of future self" can still limit propensity. As an example of how these interact together, if the functioning gap is driving down the propensity to use by -30, the propensity reinforcing loop is increasing it by 20, and the expectations gap is increasing it by 7, because the functioning gap is having the largest effect, propensity to use still decreases (by -3), but not as much as it would

have without the effect of propensity reinforcing itself or low expectations reinforcing propensity.

Monitoring for Evidence of Wanting It and Ambivalence About Quitting Reinforcing Loops

The next step was to add support received and support sought, which creates three new reinforcing loops: "Ambivalence about quitting", "Monitoring for evidence of wanting it," and "Loved ones withdrawing," the last of which will be described in the next section.

Both the "Ambivalence about Quitting" and "Monitoring for Evidence" comprise multiple loops, since support affects functioning, which changes expectations, but also affects expectations directly (see Figure 4.6). The loop involving 'support sought' could be viewed from the perspective of the PWUD or loved ones. It is named here from the perspective of the PWUD (their ambivalence), since it operates through the effect of propensity to use on support sought.

Monitoring for Evidence of Wanting It

Three variables influence support received: propensity to use, social role functioning, and support sought. The effect of propensity to use on support received is a key link in the "monitoring for evidence of wanting it" loop. Loved ones look to (propensity) to use drugs to ascertain if the person is "serious" about wanting it. In the model, this effect is represented as a second-order information delay, which is the exponential smooth of propensity to use divided by the level of propensity needed before support increases. The exponential averaging time reflects the time it takes to learn of the PWUD's prior use and the amount of time in the past the loved ones take into consideration when deciding how much to change their support for the PWUD, with more recent use having more weight in this averaging. In the context of this model, wherein

early values of propensity are above 0, longer delays mean less support (i.e., the loved one holds previous use "against" the PWUD even if it was years ago).

The effect of social role functioning on support received is a nonlinear first-order information delay that captures loved ones looking for indications that the PWUD is improving in their social roles before being willing to take risks and be vulnerable. From the perspective of the participants who had used drugs, functioning had more of an effect on support received when relationships were low quality (i.e., low support received); support was more unreliable and contingent on whether they were doing well. This means that the threshold at which support changes is higher for low support relationships. The adjustment time for this effect reflects how far loved ones look back when considering whether functioning is sufficient to proceed with the relationship.

The effect of support sought on support received is the final primary indicator that loved ones look for as a sign that someone really "wants it." This is a first-order information delay that reflects how far back the loved one considers the support that has been sought in the past before deciding whether to provide support in the present.

The effect of support received on expectations closes the loop on "Monitoring for Evidence," since expectations in turn affect propensity and social role functioning. It is a nonlinear first-order information delay of support received divided by the minimum amount of support needed to maintain expectations. The exponential averaging time reflects how far into the past the PWUD considers the support they have received when adjusting their expectations for social role functioning. The support needed to maintain functioning is an absolute value meant to indicate that, regardless of the PWUD's relationship history or expectations of the past, there is a minimum level of support needed before expectations increase. Theoretically speaking,

that level is hypothesized to be equivalent across individuals. The effect of support interacts with the effect of the gap in functioning to change expectations.

Ambivalence about Quitting

Finally, the effect of propensity to use on support sought is a nonlinear first-order information delay that closes the loop on "Ambivalence about quitting." The effect is modeled as propensity to use divided by the propensity needed to seek support (a negative value), which can be thought of as the level propensity must reach before a PWUD considers seeking support. The exponential averaging time reflects how far back the PWUD considers their propensity when deciding whether to seek help. This effect changes the rate of support sought, which is delayed by the adjustment time in support sought.

With the addition of support sought and support received, there is little impact on the overall behavior of the model. (Note that not all loops in 'Monitoring for Evidence of Wanting It' are included yet, as the link from support received to social role functioning has not yet been made.) The magnitude of oscillations in Propensity increases slightly.

Loved Ones Withdrawing Reinforcing Loop

Adding Support Received and linking it with functioning introduces the "Loved Ones Withdrawing" reinforcing loop and closes the final loop in "Monitoring for Evidence of Wanting It." The effect of support received on functioning is added to the effect that propensity has on functioning. The formulation also assumes that even low support has a positive impact on functioning; an alternative formulation could be that low levels of support received decreases functioning rather than just slows its growth. Its effect is calibrated to the effect that propensity

130

to use has on functioning; in the model, this means that it ends up being stronger, but it is an empirical question whether this is true, and for whom.

Sick and Tired Loop

The final addition to the model was the stock of Fatigue, which is increased by decreasing Social Role Functioning and by increasing Propensity to use, which form the "Sick and Tired" balancing loop. This is, in fact, two loops: one directly between Propensity and Fatigue, and the other in which Propensity changes Functioning, which changes Fatigue, which changes Propensity and thus Functioning. The two effects are multiplicative, meaning either functioning can improve or propensity can decline and the effect of Fatigue on decreasing propensity will start to "wear off."

The effect of propensity to use on fatigue is a nonlinear first-order information delay that captures how fatigue grows in response to increasing propensity, relative to a minimum level of propensity required to increase fatigue. The exponential averaging time reflects the amount of time that propensity to use needs to be above this minimum level before affecting fatigue.

The effect of social role functioning on fatigue is also a nonlinear first-order information delay capturing how fatigue increases once functional declines fall below social role functioning's initial value. If functioning rises above initial functioning, then fatigue declines.

The effect of fatigue on propensity to use is the primary driver of the "sick and tired" balancing loop. Becoming "sick and tired" leads many people to finally quit and stay quit but this only happens after an extended period of years if not decades (words like "finally" and "eventually" are used). Fatigue increases relative to a maximum level of fatigue tolerated before it affects propensity. The model is built so that it takes a long time for this fatigue to build and

thus it is slow to fade. Overall, the effect of adding this balancing loop is to lower Propensity to Use over time.

Model Equations

All model equations and parameters can be found in Table 1 of the Appendix. The stock and flow equations are described below. All stocks (state variables), except for propensity to use, are hypothesized to range along a continuum from 0 to 100, meaning that the complete absence of that state would be 0. However, to test extreme conditions, stocks are not constrained to positive values or a max value of 100, meaning that some stocks – primarily social role functioning – do occasionally decline below 0 depending on model parameters. This is to ensure that the parameters in the model can produce extreme outcomes and still respond as expected by reaching constraints from other model variables. For instance, even when propensity to use rises extremely high, fatigue also increases and ultimately slows the growth of propensity to use before decreasing it, which is the expected behavior.

All stocks are information stocks, meaning they do not conserve their quantities and are thus modeled with biflows (the inflow and outflow are the same structure). Changing the rate at which information is communicated does not change the amount of information in the system – rather, its meaning or interpretation is changed.

Propensity to Use

The level of the stock Propensity to Use ($PUse$) is equal to its initial value of 100 at t_0 plus the integral of the net changes in $PUse$ from t_0 to t:

$$PUse(t) = \int_0^t PUse(u) * du + PUse(0); PUse(0) = 100$$

Changing propensity to use reflects how quickly the inclination, tendency, or preference toward using changes. The rate of change in Propensity to Use (*changing PUse*) is affected by three discrepancies in propensity to use arising from the gap between expectations for social role functioning and social role functioning (*PUseDiscGap*), expectations for social role functioning (*PUseDiscExp*), and fatigue (*PUseDiscFat*), plus the reinforcing effect of propensity on itself (*EffPUPU*), divided by the time it takes for the propensity to use to change (*ATPUse*), which is set at 5 months in the baseline model:

$$Changing\ PUse = \frac{(EffPUPU + PUseDiscGap + PUseDiscExp + PUseDiscFat)}{ATPUse}$$

Social Role Functioning

The value of the stock Social Role Functioning (*SRF*) at time t is equal to the initial *SRF* at t_0 plus the integral of net changes to *SRF* from t_0 to t, where *SRF*(0) is equal to 50:

$$SRF(t) = \int_0^t SRF(u) * du + SRF(0); SRF(0) = 50$$

The rate of change in social role functioning (*Changing SRF*) is a function of the effect of propensity to use (*EffPUseSRF*) plus the effect of support received (*EffSRSRF*), subtracted from itself (creating the balancing loop that moves it toward equilibrium), all divided by the time it takes for social role functioning to change (*ATSRF*), which is set at 28 months. The effect of propensity on social role functioning is constrained by the range -50 to 50.

$$Changing\ SRF = \frac{(EffPUseSRF + EffSRSRF - SRF)}{ATSRF}$$

133

Expectations for Social Role Functioning

The value of Expectations for Social Role Functioning (*ExpSRF*) at *t* is equal to the initial value of expectations at t_0 plus the integral of net changes from t_0 to *t:*

$$ExpSRF(t) = \int_0^t ExpSRF(u) * du + ExpSRF(0); ExpSRF(0) = 50$$

The rate of changing expectations for social role functioning (*changing expSRF)* is a function of the effect of the gap between expectations and social role functioning (*EffGapExp)* multiplied by the effect of support received (*EffSRExp),* divided by the time it takes to adjust expectations, which is 40 months:

$$changing\ ExpSRF = \frac{(ExpSRF * EffGapExp * EffSRExp - ExpSRF)}{ATExpSRF}$$

With expectations for social role functioning and social role functioning both defined, we can now define the gap between them as:

$$GapFunc = ExpSRF - SRF$$

Support Sought

Support sought (*SS*) is a stock whose value at time *t* is equal to the initial amount of support sought at t_0 plus the integral of net changes to support sought from t_0 to *t*:

$$SS(t) = \int_0^t SS(u) * du + SS(0); SS(0) = 25$$

The net changes to support sought at each time step are modified by a rate of change (*changing SS*) that increases or decreases based on the effect of propensity to use (*EffPUseSS*),

which is a constant, linear effect, divided by the time it takes to change support, which is set at 60 months.

$$Changing\ SS = \frac{(Max\ SS - SS) * EffPUseSS}{ATSS}$$

A limit of 100 is imposed on how high support sought can rise.

Support Received

Support received (*SR*) is a stock whose value at time *t* is equal to the initial amount of support received at t_0 plus the integral of net changes to support received from t_0 to *t*. When the initial value of support is set to 50, that can be thought of as an "average" relationship:

$$SR(t) = \int_0^t SR(u) * du + SR(0); SR(0) = 25, 50, 75$$

The net changes to support received at each time step are modified by a rate of change (*changing SR*) that increases or decreases based on the multiplied effects of the propensity to use (*EffPUSR*), social role functioning (*EffSRFSR*), and support sought (EffSSSR), divided by the time it takes to change support received, which is set at 120 months.

$$Changing\ SR = \frac{(SR * EffPUSR * EffSRFSR * EffSSSR - SR)}{ATSR}$$

Fatigue

Fatigue (*Fat)* is a stock whose value at *t* is equal to its initial value at t_0 of 50 plus the integral of its net change from t_0 to *t:*

$$Fat(t) = \int_0^t Fat(u) * du + Fat(0); Fat(0) = 50$$

The rate at which fatigue changes (*changing Fat*) is based on the effects of propensity to use (*EffPUFat*) multiplied by the effect of social role functioning (EffSRFFat), divided by the amount of time it takes for fatigue to change (*ATFat*), which is set at 120 months.

$$changing\ Fat = \frac{(Fat * EffPUFat * EffSRFFat - Fat)}{ATFat}$$

Baseline Model

Calibration

Calibration was used to determine all parameters in the model. This means values were chosen that produced realistic outcomes in the model and, specifically, were able to reproduce the reference modes for recovery. The model was calibrated so that all three initial values of support (25, 50, and 75) produced behavior that would be expected in below average, average, and above average initial levels of support received.

Calibration was necessary because even when approximations could theoretically exist about a 'typical' amount of time for a variable to change, these are not found in the literature. Thus, the closest concepts that have been measured were used as a guide. For instance, intentions to quit change as often as monthly (J. R. Hughes, Keely, Fagerstrom, & Callas, 2005). Some people cycle through multiple episodes of use and no use within a year (Scott et al., 2005), and others rarely experience episodes of abstinence (Bohdan Nosyk et al., 2013). Each of these studies would point to different adjustment times for propensity to use. Thus, identifying an 'average' or 'typical' adjustment time makes little sense. Rather, the goal was to identify a range of adjustment times that fell within the realm of possibility and that produced realistic outcomes in the model. Indeed, most adjustment times and delays were chosen based on how participants

talked about the relative length of change. For instance, it is only "eventually" that the full impact of use on functioning becomes apparent, i.e., for fatigue from the lifestyle to set in.

The adjustment time for propensity to use determines how frequently a 'relapse' or period of abstinence occurs. The adjustment time of 5 months was calibrated to err on the side of fewer periods of significant abstinence. However, the adjustment time for propensity to use could be adjusted depending on the model purpose and on the theorized relationship between propensity and other similar concepts like intentions to quit. For instance, motivational interviewing techniques can change ambivalence, which is theoretically linked to 'propensity to use,' within the span of a single session (W. R. Miller & Rose, 2015). On the other hand, the research reviewed showed that some PWUD, especially those who use heroin, may go years without a significant period of abstinence; likewise, people can experience an increase in propensity without relapsing (in this model, that would mean propensity stays below zero).

The extensive use of calibration, the individual-level nature of the model, and its etiological focus make passing the parameter verification test challenging. Hence, the emphasis was on the relative value of parameters, though testing the sensitivity of these parameters becomes more difficult; changing only one parameter changes the relative values. To ensure that the dimensional-consistency test was passed, meaning that the mathematical equations in the model make sense, all units in the model were named according to their construct, e.g., social role functioning is in units of 'functioning,' and expectations for social role functioning is also in 'functioning' units.

The goal was to find a model that achieved a balance between approximating the reference mode and stability, so that it was not too sensitive to changes. Thus, the final baseline

model is not as close to the reference mode as would be preferred, but it is more stable than other models that came closer to the reference mode.

Replication of Reference Modes

For this model, behavior reproduction is defined as the ability of the model to reproduce prototypical patterns or stylized facts regarding the relationship between variables in addiction. Behavior reproduction generally and fluctuations in the propensity to use coincident with changes in expectations, functioning, and support specifically, were the primary focus of behavior reproduction. Relative phasing was an important test as well; for instance, it would not make sense for functioning to peak at the same time as or shortly after the propensity to use peaks. The set of parameters chosen for the final baseline model is that which approximates a recovery most closely. This means a negative Propensity to Use and high or increasing Social Role Functioning, Expectations for Social Role Functioning, and Support Received.

The recovery baseline model is shown in

. However, unlike the reference mode, support received does not increase, even as functioning and expectations increase.
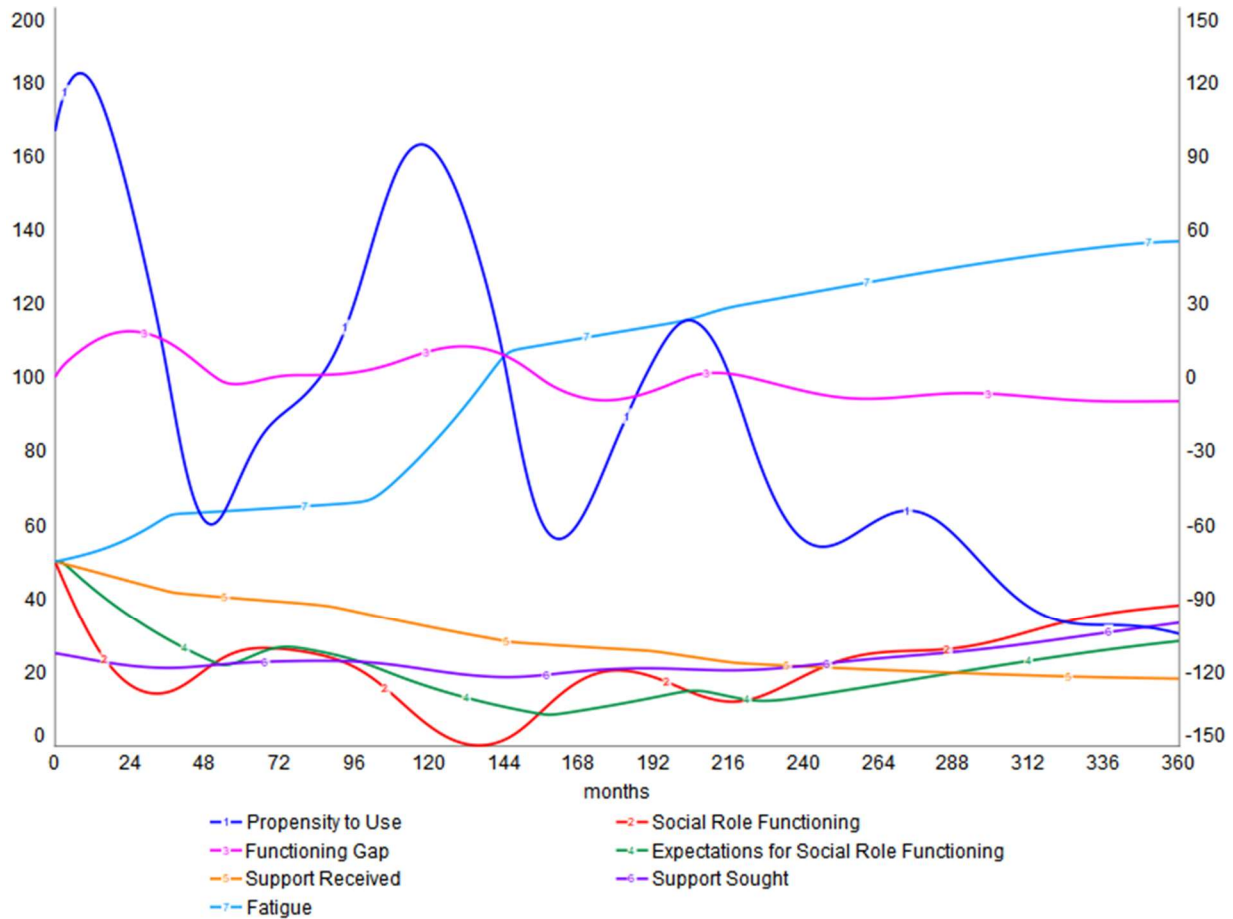
Figure 5.4. Baseline Model

Model Implications of Differing Initial Conditions

The initial strength of relationships affects support received and was a significant source of variability among the participants. Based on participant interviews, the initial support value affects the amount of functioning needed to maintain support. Participants with weaker, abusive relationships described more unpredictable levels of support, which was more contingent on their functioning compared to those who described stable, healthy support. Thus, lower initial values of support received mean that a greater level of functioning is required to maintain support.

Thus, the goal was to pass the multiple-mode test, indicating that multiple behavior modes can be produced in one model. (To a certain extent this is inherent to an individual-level

139

model, in which each parameter change could theoretically represent another individual, type of individual, or pattern of behavior.) To account for the important differential effects that low support has on PWUD, the model can be set to either "low," "average," or "high" initial values of support received. The above model was for "average" initial support, set at 50. In the low initial support model, set at 25, the oscillations in propensity continue throughout the entire model (

). Support received and expectations are lower, as expected, and Social Role Functioning falls below 0 periodically, though it does eventually rise somewhat. Fatigue rises above 200 (off the chart) which is what finally brings the oscillations below 0.
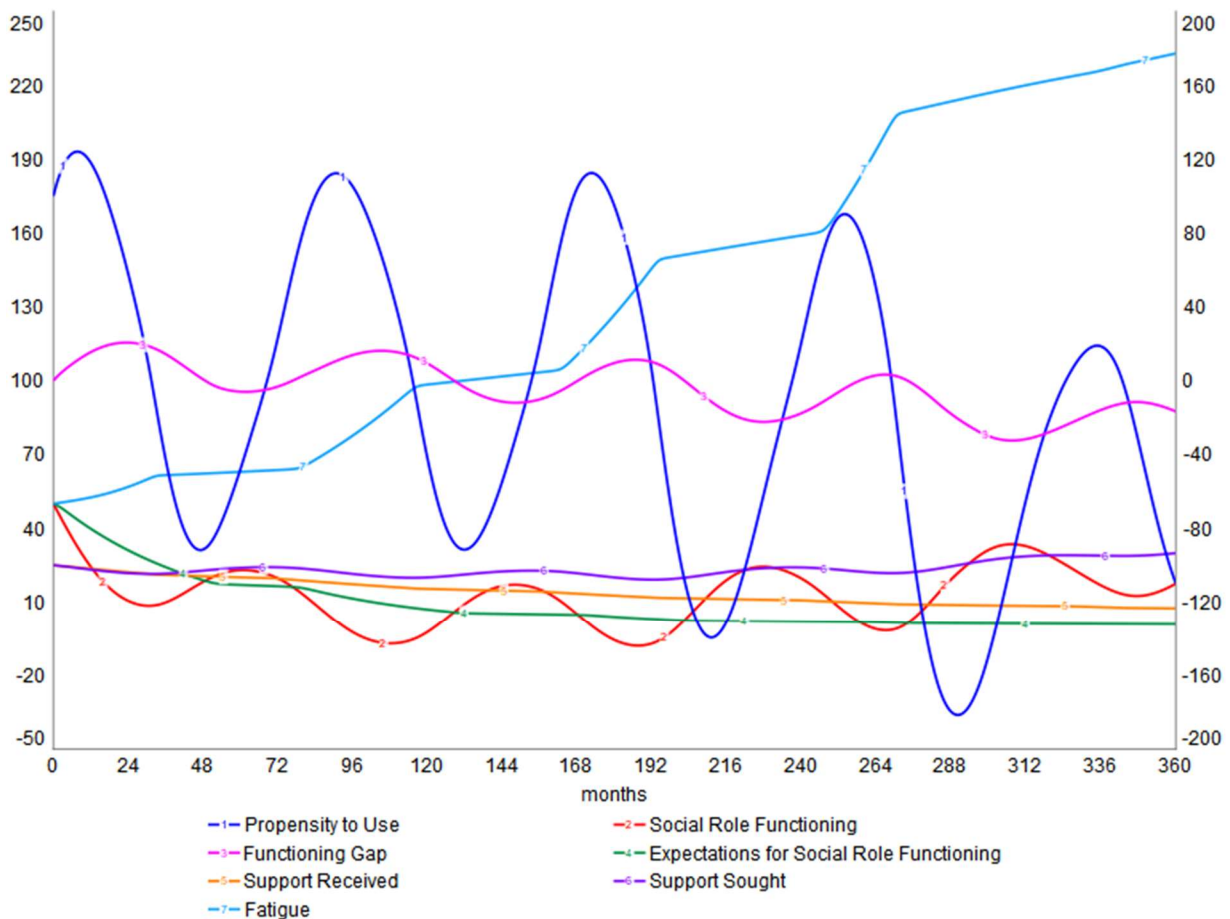
Figure 5.5. Baseline Model with Low Initial Support Received

140

The "high" initial support value is 75. In this model (Figure 5.6), propensity falls below 0 relatively quickly, causing the reinforcing loops to switch direction and functioning, expectations, and support to rise exponentially. This is the least realistic behavior mode, as research suggests that even with social support there are still relapses, delays to recovery, etc. Nonetheless, overall the behavior pattern is as expected for people with significant "recovery capital" (Cloud & Granfield, 2008), in that the chronicity of the addiction is shorter and, once propensity declines, recovery is achieved.

This unrealistic pattern is likely the result of building the model primarily to match an 'average support' reference mode. The multiple-mode test, insofar as the different initial support received values indicate multiple modes, is only weakly passed – the relationship between variables maintains consistency, but refinements are needed. For simplicity, rather than adjusting parameters in the model and reducing the ability of the model to replicate low and average initial support modes, the model parameters, which were primarily calibrated for the average initial support mode, were retained; the high initial support mode was not the focus of experiments.
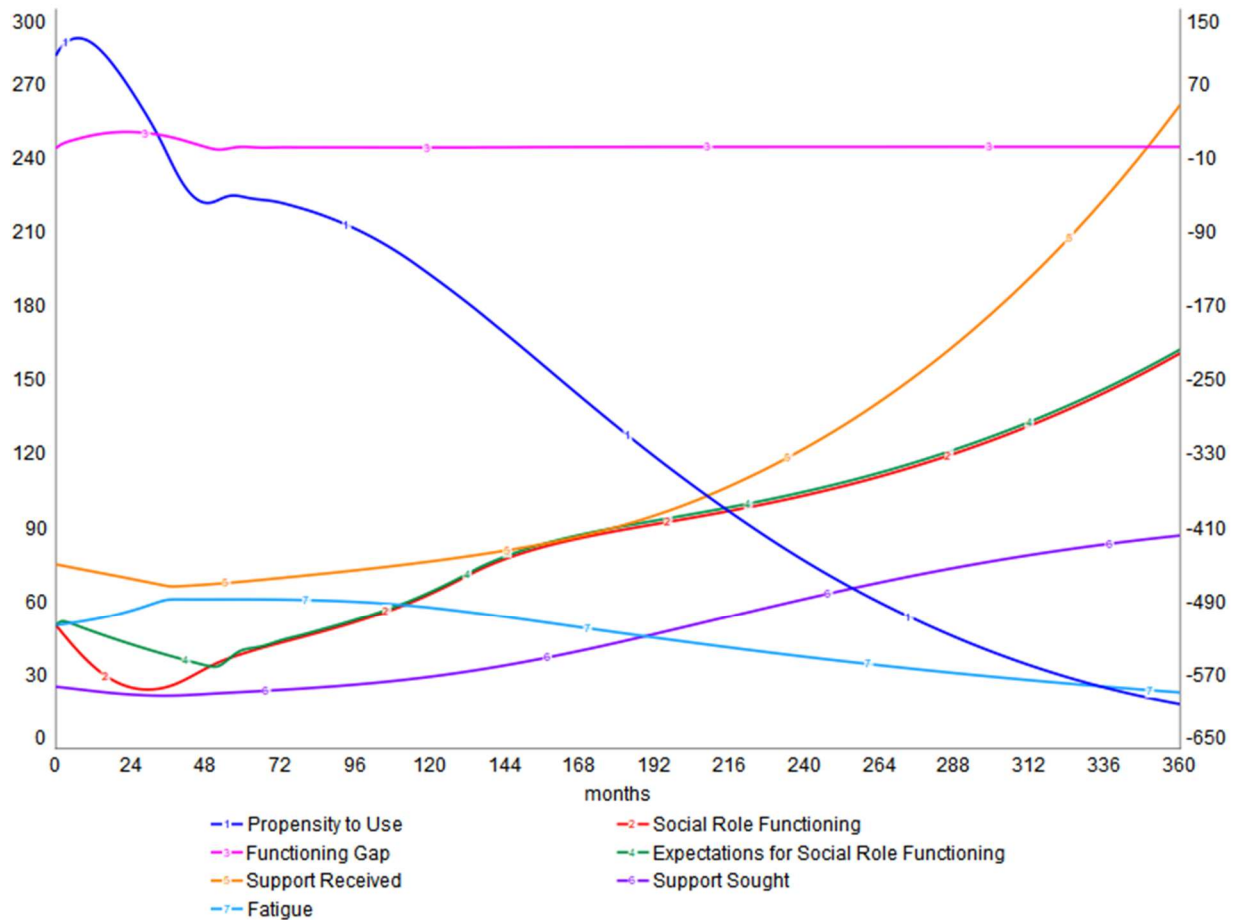
Figure 5.6. Baseline Model with High Initial Support Received

Interactions between Variables and Model Behavior

The model reproduces interactive changes in stock variables consistent with historical observations. When propensity to use increases, functioning decreases rapidly, and support received also decreases, albeit less drastically. Support sought also decreases, reflecting the ambivalence about wanting to quit that participants said delayed them in asking for help. Similar, there is a brief positive gap in functioning (meaning functioning exceeds expectations) after propensity drops below 0, which leads propensity to start rising again as the "fear of future self" balancing loop wanes. However, an unexpected behavior pattern is that even once "recovery"

occurs, functioning continues to exceed expectations (except in the case of the high initial support model).

Tests of Model Behavior

It is important to be able to understand how the baseline model responds to disturbances such as a stressful event (Forrester & Senge, 1979). Several tests using exogenous 'shocks' were used, which helped to refine the model further and increase confidence in the model. These included sudden increases and decreases in support, functioning, and expectations. All shocks were tested as pulse increases or decrease at 60 months.

A sudden increase or decrease in expectations had the expected effect; the reinforcing loop, whether "nothing to live for and nothing to lose" or the opposite, "Something to live for and everything to lose," declines or grows exponentially with just a small change, leading to large and rapid changes in the indicators of recovery. When support received is suddenly increased, recovery is delayed but more dramatic. A sudden decrease in support hastens 'remission' but there is no recovery; those reinforcing loops are never triggered.

Similarly, when functioning increases suddenly, propensity takes longer to decline, with higher peaks. This is because the rate at which expectations change has not changed; they are too slow to adjust relative to functioning, resulting in a negative gap (functioning outperforms expectations). Outperforming low expectations leads to an even greater propensity to use. On the other hand, a sudden drop in functioning leads to a sudden decline in propensity and thus a much faster 'remission' that eventually leads to a recovery. This only occurs with a sufficiently large drop in social role functioning. With smaller drops, the result is instead a continual pattern of

143

'relapse' in the model over time. This is unexpected behavior, but consistent with the logic of the model.

Modular testing was used to determine the effect of "turning off" variables in the model, by keeping them at their baseline values. Conceptually, this is equivalent to making a variable unresponsive to changes in other parts of the system. Thus, it is not meant to reproduce realistic behavior, but to determine if the model responds as would be expected. Moreover, if there is no meaningful change in model behavior when a variable is held constant, it might be superfluous to the structure.

Turning off expectations for social role functioning (keeping them at the same value throughout) resulted in a very steep decline in propensity to use, followed by oscillations that are all below 0. However, they are trending upwards by 360 months. This is because social role functioning does not decrease as precipitously when expectations are held constant, which means fatigue does not rise and therefore does not provide a self-regulating effect.

When fatigue is turned off, the shape of the pattern in propensity is the same in that there are dampening oscillations and propensity falls on average over time. However, it never falls below 0 while social role functioning and expectations decline well below 0.

Turning off social role functioning results in a much longer and larger oscillating pattern; it is only when extending to 720 months that the oscillation is detected. Propensity rises continuously and begins to gradually decline around month 250 once fatigue rises enough. Because functioning does not change, neither do expectations except a slow decrease due to support's decline over time. This behavior occurs because the lack of functional decline means there is no gap in functioning and thus propensity does not decline in response.

144

Turning off support received (holding it constant, not eliminating it) results in a model closest to producing a recovery model. Once propensity drops 0, it joins with functioning, expectations, and support to form an exponential reinforcing feedback loop in which expectations and functioning rise quickly. Turning off support sought has a negligible effect but was retained for theoretical purposes.

Summary

In conclusion, the greatest degree of confidence is in the basic model structure (the variables and how they interact in feedback loops). Within reasonable ranges of parameter values, the interactions among these variables can reproduce patterns in which the propensity to use fluctuates over time before reducing, often below 0. This can be thought of as entering remission. More importantly, the relative timing of variable changes is consistent with observed phenomena, though the frequency and magnitude of changes is more predictable than they seem to be in reality. The model responds to disturbances and modular testing in ways that would be expected, which further builds confidence in the model structure.

The lack of data on adjustment times (delays) and the precise numerical relationship between variables means there is low confidence that this set of parameters is the "true" set. Some parameter changes create only a slight difference in model behavior, while for other parameters a slight change leads to significantly different model behavior. It is difficult to discern whether these changes represent a different 'type' of individual, or a more basic problem with the model structure. Thus, conclusions drawn from the experiments are based on those where even after multiple iterations of the model, the same behavior patterns would arise.

Model Experimentation

Experiments are changes to the baseline model structure made with the goal to produce the following operationalized definition of recovery: negative values of propensity to use, and increasing or high social role functioning, expectations, and support received. Moreover, these changes must be sustained to 360 months. The primary focus is on changes to Propensity to Use. However, to avoid designing 'interventions' based on maximizing that outcome alone, other outcomes are also maximized. Thus, if any experiments result, for instance, in high social role functioning, expectations, and support received but higher values of propensity, these are discussed.

The experiments were a combination of descriptions from participants of the changes they had made and of common targets of interventions described in the literature. The changes to the model could represent multiple types of interventions, including psychosocial or medication treatment, mutual aid groups, or policy interventions. They could also represent a PWUD learning through trial and error how to stay in recovery. For each experiment, parameter values were calibrated so that there was a noticeable yet realistic change in the variable or stock being targeted. The goal was to find whether these changes, which could represent change that PWUD or loved ones perceive as meaningful in the short-term, are sustained long-term.

All experiments on the model were first tested independently to understand their impacts. Then, they were combined based on their independent impacts and their theorized interactive effects. For instance, if an independent experiment produced unintended consequences, it was apparent why this occurred, and so the combination of experiments would seek to address the source of unintended consequences. Experiments were tested in the low and average initial support modes.

Experiments were tested at various time points. This allowed for examination of the importance of timing, including whether propensity was already declining or below 0 when the intervention starts, versus above 0. The general effects of each experiment or intervention will first be described, and then graphs will be presented showing the effects of combinations of experiments on the recovery variables.

Reduce the Propensity to Use

The first experiment directly reduced the propensity to use. In terms of interventions, this is most equivalent to the use of medications to reduce craving and withdrawal symptoms, which are captured in the "propensity reinforces itself" feedback loop. Currently, there are only effective medications to treat opioid use disorder, which are three FDA-approved medications (methadone, buprenorphine, and extended-release naltrexone), each with a different mechanism (U.S. Food & Drug Administration Center for Drug Evaluation and Research, 2018). No equivalent medications exist for methamphetamine or cocaine use disorder. Compared to psychosocial treatments, medications for OUD can delay a lapse into use and, in the most optimal scenarios, spur remission (Mattick, Breen, Kimber, & Davoli, 2014; Weiss & Rao, 2017).

However, relapse after discontinuation of medications for OUD occurs in 50-90% of patients (Y.-I. Hser et al., 2016; Zhu et al., 2018). Whether medications delay a lapse into use or spur remission is partially dependent on how long they are taken and whether they are prescribed at therapeutic doses (Bentzley, Barth, Back, & Book, 2015; Fiellin et al., 2014; S. A. Martin, Chiodo, Bosse, & Wilson, 2018). Despite evidence being strongest for maintenance prescribing, i.e., for a period of months to years, buprenorphine is often used only for detoxification, and

PWUD use it for similar purposes when illicitly purchased on the street (Cicero, Ellis, &

Chilcoat, 2018).

Interview participants were much more likely to describe having had experience with

Suboxone, primarily illicitly-purchased, to stave off withdrawal symptoms. Thus, the

mechanisms of action for that medication are approximated in the model experiment. As a partial

agonist that includes both buprenorphine (an agonist) and naloxone (an antagonist), Suboxone

has two distinct mechanisms of action that decrease propensity to use. The buprenorphine is

effective in reducing withdrawal symptoms and craving by slowing or even eliminating the

"propensity reinforces itself" feedback loop. The naloxone deters opioid use because taking them

at the same time can precipitate withdrawal symptoms, thus introducing an aversive effect on

propensity that is not naturally present. Notably, it seems that only the increasing effects of this

"propensity reinforces itself" loop are affected; theoretically, reductions in propensity to use

should continue to reinforce themselves, thereby further decreasing propensity. These changes

improve social role functioning, expectations, and support beyond what it otherwise would be.

To approximate the effects of Suboxone over various time periods, the "propensity

reinforcing itself" feedback loop was altered, so that positive values of propensity no longer had

a reinforcing effect (i.e., stopping craving and withdrawal symptoms), while negative values of

propensity continue to have a reinforcing feedback effect. These effects are integrated into the

additive equation on propensity to use, meaning that expectations, the gap in functioning, and

fatigue continue to have the same effects as they would otherwise. This means that the

medication alone is not theorized to impact these other effects directly, though over time these

could be changed as propensity declines. However, changing the effect of the reinforcing

feedback loop alone does not capture the aversive effects of opioid antagonists. Thus, an

additional variable, "aversive effect of intervention," was added that further reduces propensity below what it otherwise would be. Additionally, because medications work quickly, the adjustment time for their effect was 3 months.

As expected, the model behavior proves to be sensitive to how long the experiment/intervention lasts (i.e., 2 weeks, 3 months, 2 years, or indefinitely) and to the strength of the aversive effect. This is expected because the experiment is modeled such that propensity to use is artificially suppressed; thus, we would only expect it to have long-term impacts if it is suppressed long enough to shift feedback loops. If the aversive effect is too weak or if the intervention is too short, then propensity to use only temporarily declines for the duration of the intervention. Figure 5.7 shows the effect of a one-month intervention starting at 60 months. Eventual remission (when propensity sustainably falls below 0) does not happen any sooner.
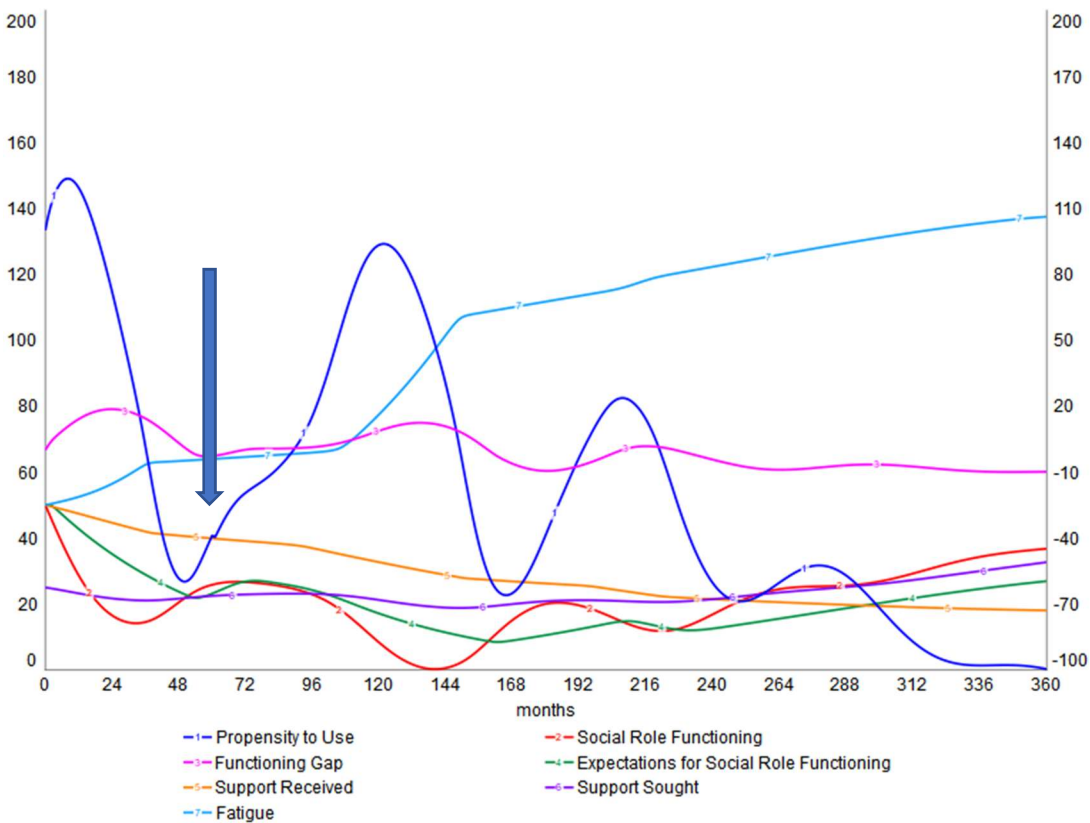
Figure 5.7. Effect of Reducing Propensity for One Month for Average Initial Support

Experiments were also done starting at month 120, when propensity to use is high, whereas it was already declining at month 60. Once the intervention ends, with no other changes made, there is a rebound effect driven primarily by the "Fear of future self" loop, wherein functioning has exceeded expectations. If Propensity did not fall far enough below 0 during the intervention, there is a 'relapse' (propensity immediately goes back to above 0). However, unexpectedly, this only happens when the intervention lasts long enough to result in significant functioning changes, but not long enough to drive propensity so far below 0 that when it rebounds it still stays below 0 (between about 1 year and 6 years in this model). If the intervention lasts *just* long enough that functioning changes but does not greatly exceed expectations (about 6-12 months in this model), then even with the rebound effect Propensity remains below 0. However, not only is this inconsistent with what is understood about best practice for medications for OUD, but it is unlikely that this intervention would be delivered alone, especially over a period of several years. Thus, in the next section, we will consider what other effects on the model's loops could arise from maintaining contact with providers over several years, which could suppress the rebound/relapse effect.

A six-month intervention with the baseline aversive effect does not meaningfully change the behavior of the low initial support received model. To prevent relapse and achieve remission – recovery is never achieved – the experiment must last the entirety of the model run, until month 360, and the aversive effect must be at least 50% stronger. Though functioning increases as a result, support and expectations do not improve enough to prevent relapse. Thus, the propensity to use rises even with the suppressive effect of the experiment; if the aversive effect is

150

either too weak or the intervention is too short, relapse occurs immediately, for similar reasons as described above.

Raising Expectations through Hope

Participant interviews, narratives in the literature, and recovery measures all feature hope, which is similar to but distinct from expectations. Hope often has no basis in the past and is almost by definition divorced from current reality. Hope exists when expectations would "realistically" tell someone to expect no different from their current situation. However, given that self-expectations are low (and so, too, are others' expectations), hope is nearly absent for many people while they are addicted. Nonetheless, it often arises early in recovery, or can even be an instigator to it.

Hope was therefore modeled as increasing the rate of changing Expectations for Social Role Functioning. It has an additive effect, which allows it to be independent of the effect of a gap in functioning and the effect of support. It is modeled as a pulse function, which produces a sharp increase. The frequency of the pulse is randomized to approximate how hope operates, which is usually not with regularity. The effect can be averaged over varying lengths of time. Each of these parameters (amount of hope, averaging time, frequency of pulse) was experimented with to understand the model behavior. The effect was allowed to run from the beginning of the experiment until the end of the model run (360 months) reflecting the random nature of hopeful moments or periods throughout the course of someone's life.

For hope to have a sustainable effect, it must increase expectations enough that propensity falls while also increasing the gap in functioning and functioning itself. If hope only increases expectations without a resultant increase in functioning, then the persistence of the gap

in functioning leads expectations to fall again. Irregular increases in hope starting at 60 months briefly raise expectations but have no other meaningful effects; the effect is to *delay* sustained remission relative to the baseline model. However, if these increases are averaged over a longer period, meaning their effects are smoothed and less erratic, remission occurs slightly earlier relative to the baseline model and with a stronger eventual recovery. Similarly, if the experiment instead starts at 120 months, regardless of the averaging time, sustained remission only occurs a few months earlier but with a stronger recovery. In the low initial support received model, the same parameters take much longer to have an effect. Nonetheless, the oscillations in propensity to use are reduced and propensity sustainably drops below 0 several years earlier compared to the baseline model. However, this model scenario is likely an optimistic one, and the model is sensitive to the parameters in the random pulse function, i.e., if the average pulse is every 3 months versus every 24 months.

As described in the Results, the initial spark of hope comes from other people rather than from within; it is exogenous. Similarly, a key reservoir of hope for loved ones is other people's recoveries. Knowing several others who have recovered typically does not occur by chance, however. Mutual aid groups and peer support services are two interventions that could increase hope, as both involve learning about other people's experiences in recovery (Best & Lubman, 2012; Kelly, 2016) and have modest evidence that they are effective in delaying relapse and an overall lower frequency of relapse (Brecht & Herbeck, 2014; Mertens et al., 2012). As described by participants, the effect is for PWUD to recognize that there is a way out, and that alternatives to their current situation exist.

To model the effect of such an intervention, the model was also run with a constant rather than random pulse frequency. This reflects regular attendance at mutual aid meetings, contact

with peer supports, or participation in recovery advocacy groups. Adjusting the pulse frequency to reflect a regularly attended intervention with realistic results required lowering the magnitude of the increase in hope compared to when it was random. This could be consistent with how these interventions work– that is, a predictable yet small amount of hope on a regular basis versus an unexpected but large amount on an irregular basis.

As with medications, the length of a mutual aid or peer support intervention has implications for whether remission is achieved earlier relative to the baseline model, as well as whether recovery is achieved. For propensity to sustainably drop below 0 in the average initial support model, the intervention must last long enough and be frequent enough to allow expectations to just slightly exceed functioning, though they never rise appreciably, which depresses functioning. Because functioning does not increase, fatigue is maintained. Thus, a too-brief mutual aid intervention results in a 'remission' that is sustained entirely by the two balancing loops of "Fear of future self" and "sick and tired." Notably, this is consistent with the fear-based nature of some 12-step groups, which emphasize the risks of returning to use ("jail, institutions, or death"), even while ostensibly offering hope for what is possible. On the other hand, if the intervention lasts long enough, functioning, expectations, and support all increase.

The low initial support model requires a much more intensive "intervention" than the average model. A much longer intervention does not prevent relapse as soon as it is stopped. It must be sustained at least until 360 months to drive down propensity and see an increase in functioning and expectations; support never increases. If the pulse frequency is increased (meaning it happens more frequently), propensity drops sooner and therefore functioning and expectations rise sooner, and support slightly increases, but the intervention still must be maintained for the entirety of the model. The modest recovery appears to be maintained by the

intervention alone, which raises expectations enough to decrease the propensity to use and increase functioning, thus shifting reinforcing feedback loops in the direction of recovery. Indeed, the balancing loops are pushing toward greater use in this scenario.

The difference between the two support models suggests that a person with low initial support would benefit from more frequently attending hopeful mutual aid meetings than someone with average initial support, which could be considered consistent with stylized facts about addiction and addiction recovery.

Expectations More Responsive to Improvements in Functioning

Participants who had experienced a significant increase in social role functioning since quitting also had higher expectations for themselves. However, as with hope, a change in expectations without a change in functioning, or vice versa, can have unexpected consequences. If functioning exceeds expectations by too much, the "Fear of future self" balancing loop weakens and pushes propensity higher. If expectations exceed functioning by too much, the gap in functioning leads to decreasing expectations, which also has the effect of increasing propensity to use. One challenge with the "hope intervention" is that due to its primarily exogenous effects, it must be sustained over prolonged periods to spur recovery, which could be unrealistic or unsustainable as an intervention. A shift in how the PWUD responds to in the gap between expectations and functioning, however, could have longer-lasting effects. This was modeled as an alternative table function in which expectations do not fall as steeply in response to a functioning gap (expectations exceed functioning), but they rise more in response to functioning exceeding expectations.

Learning to adjust expectations differently could be learned by a PWUD without outside interventions or could be facilitated by counseling or a supportive relationship. The reason it is important to include this is because several of the other experiments increase social role functioning without a concomitant increase in expectations; when only functioning increases and not also expectations, the propensity to use rises. If the PWUD cannot be responsive to increases in functioning and continues to have low expectations for themselves even when they are doing well, the model suggests this puts them at risk of relapse.

The effect of making expectations more responsive at 60 months is to delay the relapse due to a greater functioning gap, which maintains the "Fear of future self" loop, but then also to delay remission. However, once remission occurs, there is more improvement in functioning and expectations, and slightly higher support, compared to the baseline model. When the experiment starts at 120 months, as propensity is peaking, there is no immediate effect, but remission occurs slightly earlier, and the recovery is much stronger. However, this is not true for the low initial support received model. In that model, there is no meaningful impact in the short-term or long-term. This suggests that a more favorable response to a gap in functioning *alone* is insufficient for people with low support. This is because the support maintains a stronger downward effect, depressing expectations and thus functioning, while propensity continues to oscillate.

Remembering Fatigue

Participants who had used drugs reported that when they began to think about using again, they needed to remind themselves of the negative consequences that could occur if they were to relapse. This is a psychological process involving memory that decreases the propensity to use but is less direct than the effect of medications. Instead, the theory being proposed here is that, whether they are aware or not, their "sick and tired" balancing loop begins to fade as fatigue

155

declines and the negative consequences of use appear increasingly distant. Recalling the negative memories from the addicted period strengthens the "sick and tired" loop. This was modeled as a multiplier effect on the rate of change in fatigue, though the actual psychological mechanisms are more complex. Remembering fatigue does not have a clear intervention corollary, except for the skills that someone might learn in treatment. Many PWUD who are addicted never receive treatment, but they nonetheless learn over time that one way to maintain their recovery is to "never forget" the consequences of returning to the addicted lifestyle.

The effects of increasing fatigue (strengthening the "sick and tired" loop) have a small impact at their initial start, but are stronger later in the model run, when propensity is already falling. This suggests that someone could learn the "skill" of remembering fatigue early on in their addiction, which might help them to reduce their use temporarily, but that the skill might be more useful later once the "sick and tired" balancing loop is gaining in strength on its own. This is especially relevant in the low initial support received model, as the effect on propensity is barely perceptible when the experiment starts at month 60, but by the end of the model run, the effect is enough to bring propensity below 0 years sooner than in the baseline model, though oscillations remain. This allows functioning to increase and stabilize somewhat, but functioning and expectations are low, representing a shaky remission.

Increasing Support

Increasing support exogenously might represent developing a new relationship with someone who is prepared to support a PWUD's recovery. In the interviews and in the literature (Christo, 1998; Y.-I. Hser, 2007; Vergés et al., 2013), new relationships and social roles (rather than existing relationships improving) are associated with decreases in use. In the model, however, increasing the amount of support alone only serves to increase the oscillations, leading

156

to higher highs and lower lows, and does not hasten remission. This is because the increase in support does not also increase expectations, leading to functioning consistently outperforming expectations. The support does not increase expectations because of the long adjustment time (300 months), meaning that even with added support, the prior low support is still remembered (in the model, it is still being averaged). A shorter adjustment time for expectations creates much lower expectations early in the model, however. Once remission (propensity is sustained below 0) occurs the model recovery is stronger: support, expectations, and functioning are all higher than in baseline.

Changed Rules for Monitoring for Evidence

The belief that "you have to want it" affects support received by limiting PWUD from seeking support if they are experiencing ambivalence, and by reducing support from loved ones who fail to find evidence that the PWUD "wants it." Thus, a key change could be to increase the willingness to seek support and to provide it. This was tested in two ways. The first test was to remove the effects of propensity, functioning, and support sought on support received independently, which is conceptually equivalent to support not changing in response to changes in each of these variables (i.e., loved ones' support is steady and reliable, but not necessarily high). Second, the threshold for increasing support was reduced to 1 for support sought and functioning, which means that support increases even when functioning is low or there is no support sought (i.e., loved ones doing "outreach"). Propensity needed to maintain support was changed so that its effect was 1, meaning support does not change regardless of propensity.

Both these tests were performed at 0, 60, and 12 months. The latter two reflect what might happen if loved ones were to change how they respond to the PWUD in their lives after that person had already developed an addiction; this might occur if they seek family counseling,

157

for instance. Changing the rules at 0 months (i.e., for the entire model simulation) reflects what might occur if there were a cultural shift wherein the mental model that "you have to want it" led to different rules for monitoring for evidence of wanting it, if such monitoring occurred at all.

Removing Effects on Support

There is little impact on changing the rules when done at 60 or 120 months, though there is improvement in recovery variables (support, functioning, expectations) later in the model, once recovery begins. Since support is increasing, even slightly, it has a disproportionate effect on decreasing propensity and improving functioning. Removing the effects of functioning and support sought on support received has a stronger impact than removing the effect of propensity. Similar to the other experiments on support received, the effects of a more forgiving support system are delayed until propensity has already begun to decline. As expected, these effects did not hold for the low initial support model.

Changing Thresholds for Support

Changing the support sought, social role functioning, and propensity thresholds for support received had a similar effect to removing them independently; there is little immediate impact on propensity when done at 60 or 120 months. Propensity still rises above 0 as it does in the original model, i.e., "relapses." The immediate impacts on support, functioning, and expectations, and thus the eventual recovery, are stronger. Changing the thresholds at time 0 results in even stronger changes than removing the effects, which would be expected since support is increasing throughout the model run, rather than holding steady.

These interventions are unrealistic in that it is unlikely that support would not change at all in response to what a PWUD is doing (i.e., in the first test it does not increase, and in the second it continually increases). However, their effects provide insight into how the rules arising

158

from the mental model, "You have to want it," which lead to monitoring for evidence of wanting it, could shape the trajectory of addiction relapse, remission, and recovery. Thus far, it appears that their effect is on the strength of the eventual recovery, if one occurs at all, rather than on delaying recovery or contributing directly to addiction cycles. For the remainder of the experiments, the more conservative 'intervention' will be used, which is to simultaneously remove the effects of functioning and support sought on support received, at 0 ("Changed Rules for Monitoring for Evidence: Cultural Shift") and 120 months ("Changed Rules for Monitoring for Evidence: Therapy for Loved Ones")

Comparing Interventions' Independent Effects on Recovery

A series of graphs is presented below for the variables/stocks Propensity to Use, Social Role Functioning, Expectations for Social Role Functioning, and Support Received. Each variable is shown at baseline as well as after the independent effect of each of the experiments, labeled in terms of their probable intervention corollary: 1) Reduce Propensity: Medications for 1 Year; 2) Raising Expectations through Hope: Mutual Aid for 1 Year; 3) Learning to Make Expectations More Responsive: Therapy; 4) Remembering Fatigue: Life Experience; 5) Increased Support: New Relationship; 6) Changed Rules for Monitoring for Evidence: Therapy for Loved Ones; and 7) Changed Rules for Monitoring for Evidence: Cultural Shift.

Experiments 1-7 started at 120 months to reflect a realistic starting point for intervention and one that begins when propensity is peaking. Interventions 1 and 2 ended at 132 months, while the skills learned in therapy and through life experience were assumed to persist throughout the model. Experiment 7 started at the beginning to reflect what would happen if a cultural shift rather than an individual intervention led loved ones to change how they monitor

for evidence of "wanting it." Because of the negligible effect that most interventions/experiments had in the Low Initial Support model, separate graphs are not shown.

Figure 5.8 displays the model results for Propensity to Use. The strongest and most sustained effect on Propensity to Use was achieved through Learning to Make Expectations More Responsive, which is assumed to occur through a formal therapeutic intervention. Increased support and changed rules had a detrimental effect by increasing propensity beyond what it otherwise would have been. All other interventions brought Propensity below 0 sooner than would have otherwise occurred, with the exception of the 'cultural shift.'

Figure 5.9 shows the same interventions' independent effects on Social Role Functioning. The most immediate impact is seen in medications, but over the long-term its effects are not as strong as mutual aid, learning to make expectations more responsive, or remembering fatigue. Changed rules for monitoring for evidence, when instituted at 120 months as might happen when a loved one seeks therapy, have the weakest effect of any intervention and in some cases slightly decrease functioning beyond what it otherwise would have been. As with propensity, the strongest effect on functioning is learning to make expectations more responsive to improvements in functioning, though by the end of the model the effect of the new relationship (increased support) is stronger.

Figure 5.10 shows these interventions' effect on Expectations for Social Role Functioning; the patterns over time mirror those of Functioning, with an even more rapid increase in Expectations when Support has increased. Finally, Figure 5.11 shows the effects of the interventions on

Support Received. This figure demonstrates just how difficult it is to increase support absent a direct effect; none except a new relationship results in support surpassing its initial value.

Overall, the cultural shift wherein loved ones do not monitor functioning and support seeking as evidence of "wanting it" had consistently strong, positive impacts, though it did not prevent the "relapse" in Propensity to Use that occurs in the baseline model.
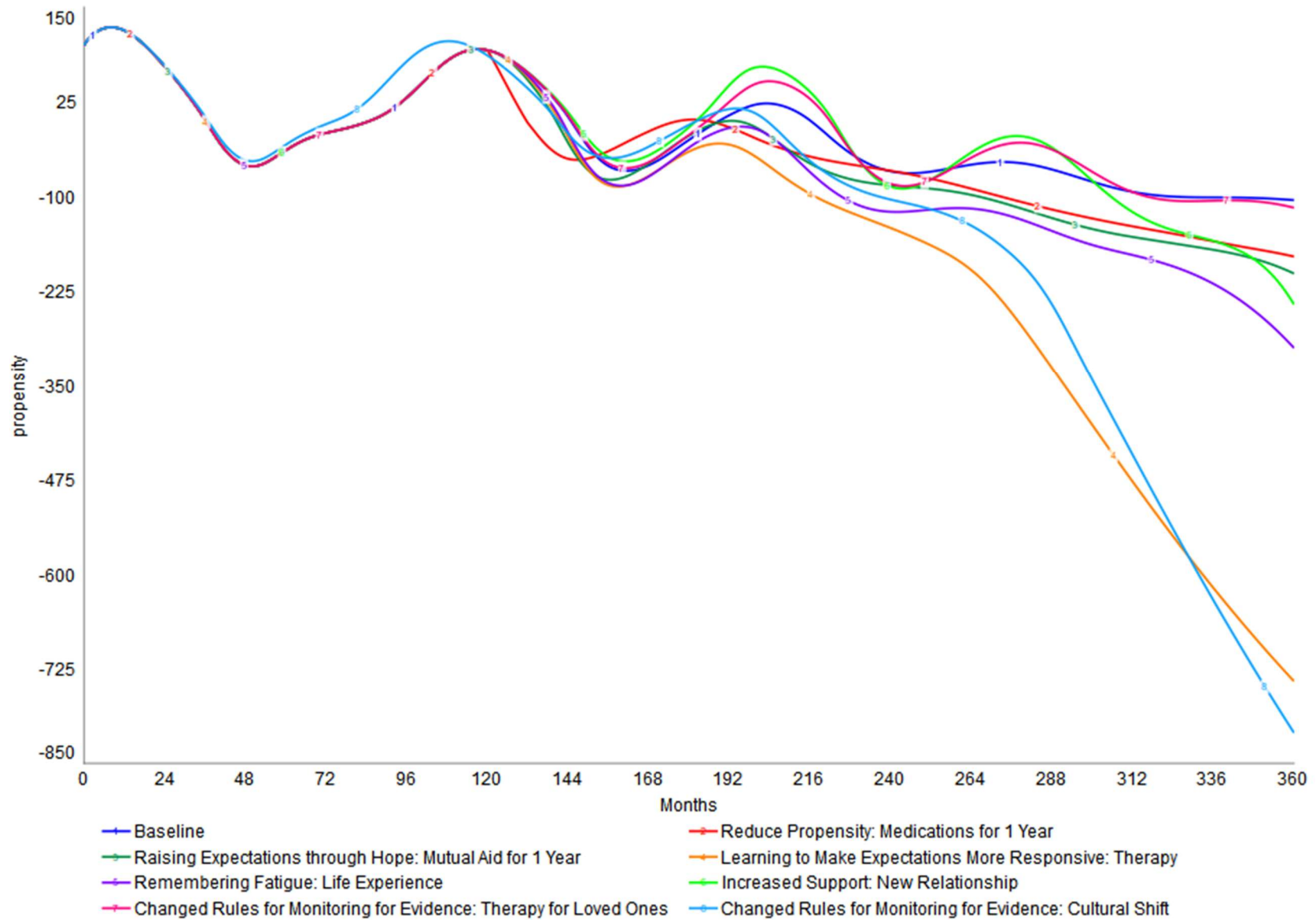
Figure 5.8. Independent Effects of Interventions on Propensity to Use
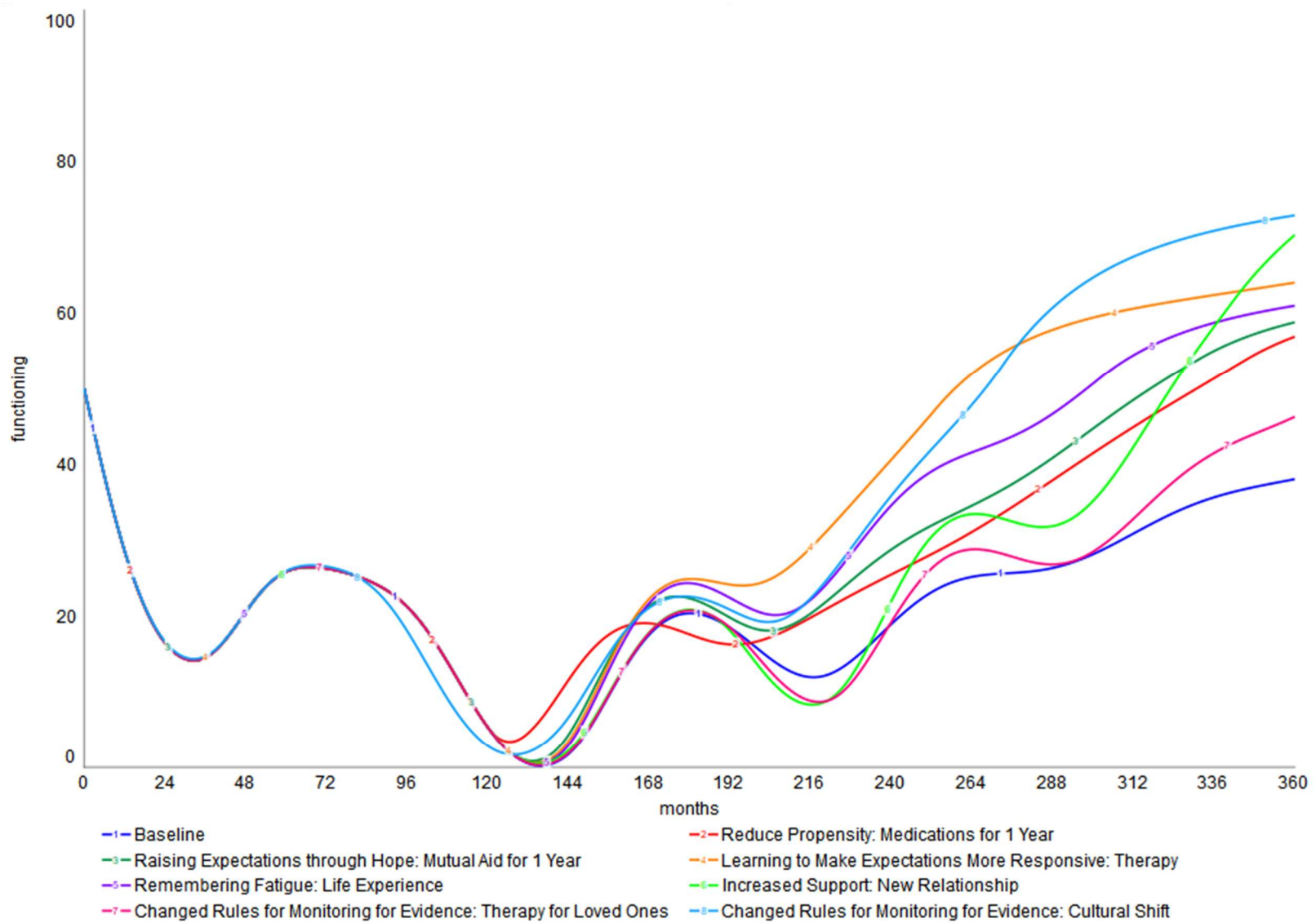
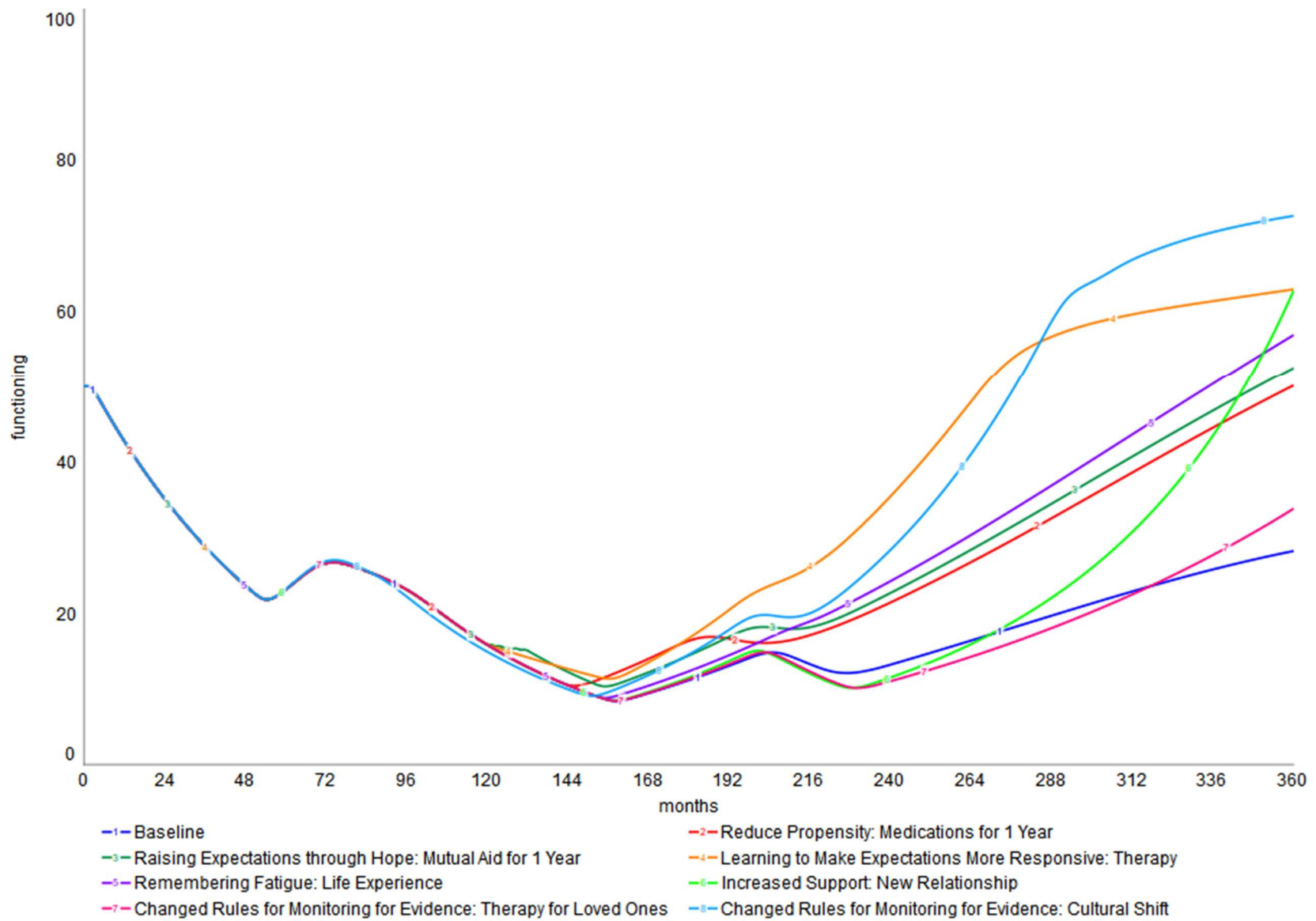Figure 5.9. Independent Effects of Interventions on Social Role Functioning

163

Figure 5.10. Independent Effects of Interventions on Expectations
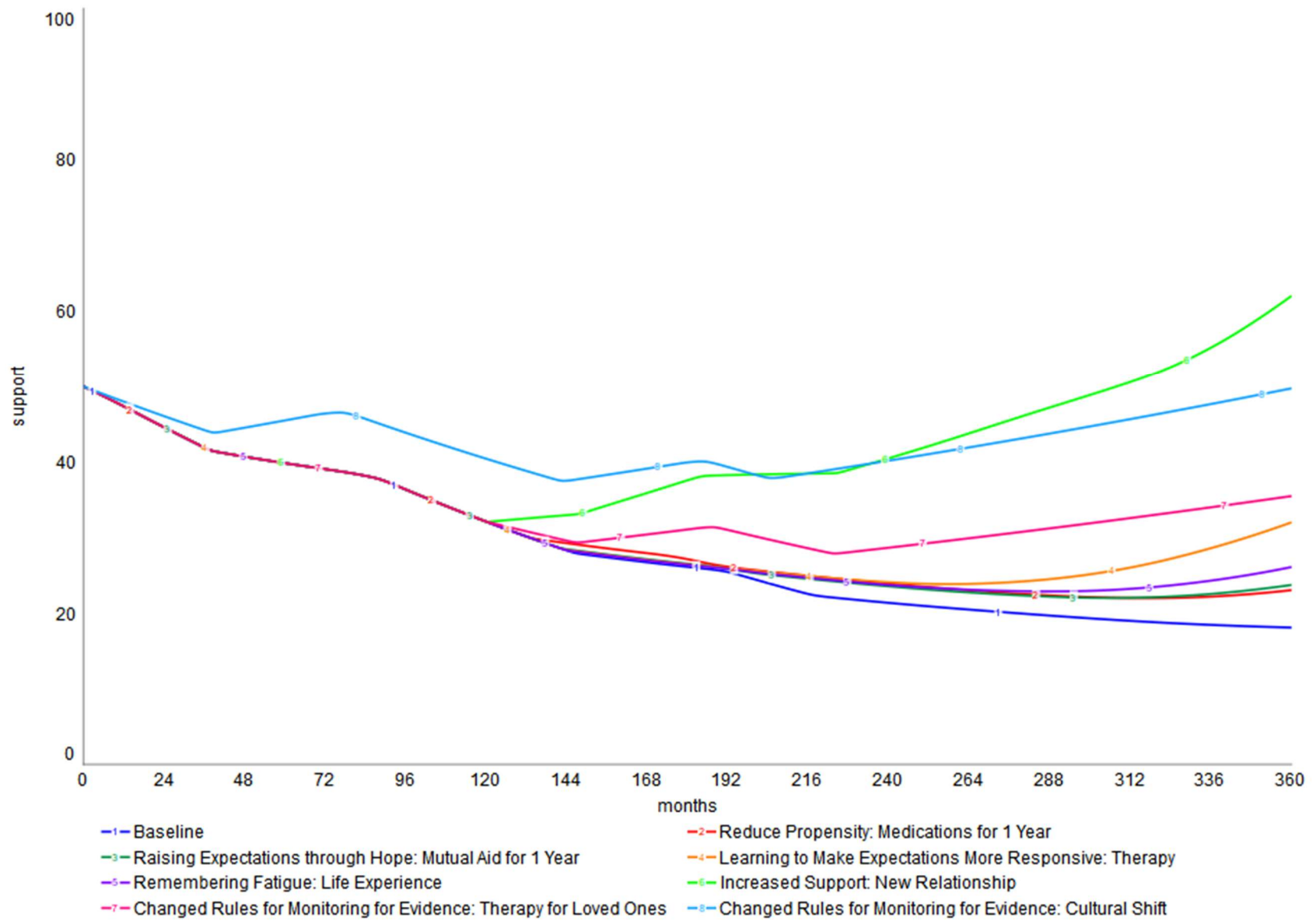
Figure 5.11. Independent Effects of Interventions on Support Received

Effects of Combined Interventions on Recovery

The last step was to explore which combination of interventions would create a sustainable recovery (sustained negative propensity to use and high or increasing social role functioning, expectations, and support received). The interventions chosen were a combination of those that most consistently showed strong impacts when tested independently, but also that could be sustainable when scaled up. Moreover, it was important to test whether combining interventions could overcome any unintended consequences or create new ones. For instance, a persistent finding of the independent effects of interventions is that an increase in functioning can lead to a relapse if there is not also an increase in expectations. Thus, learning to make expectations more responsive to these improvements in functioning was hypothesized to help overcome any undesirable effects. Because new, healthy, and stable relationships are not a formal "intervention" for many people this was not added as a potentially sustainable, scalable intervention. The life experience "intervention," in which people actively recall the fatigue associated with the drug-using lifestyle as a way to strengthen the "Sick and Tired" balancing

loop, is included in all combinations of interventions.
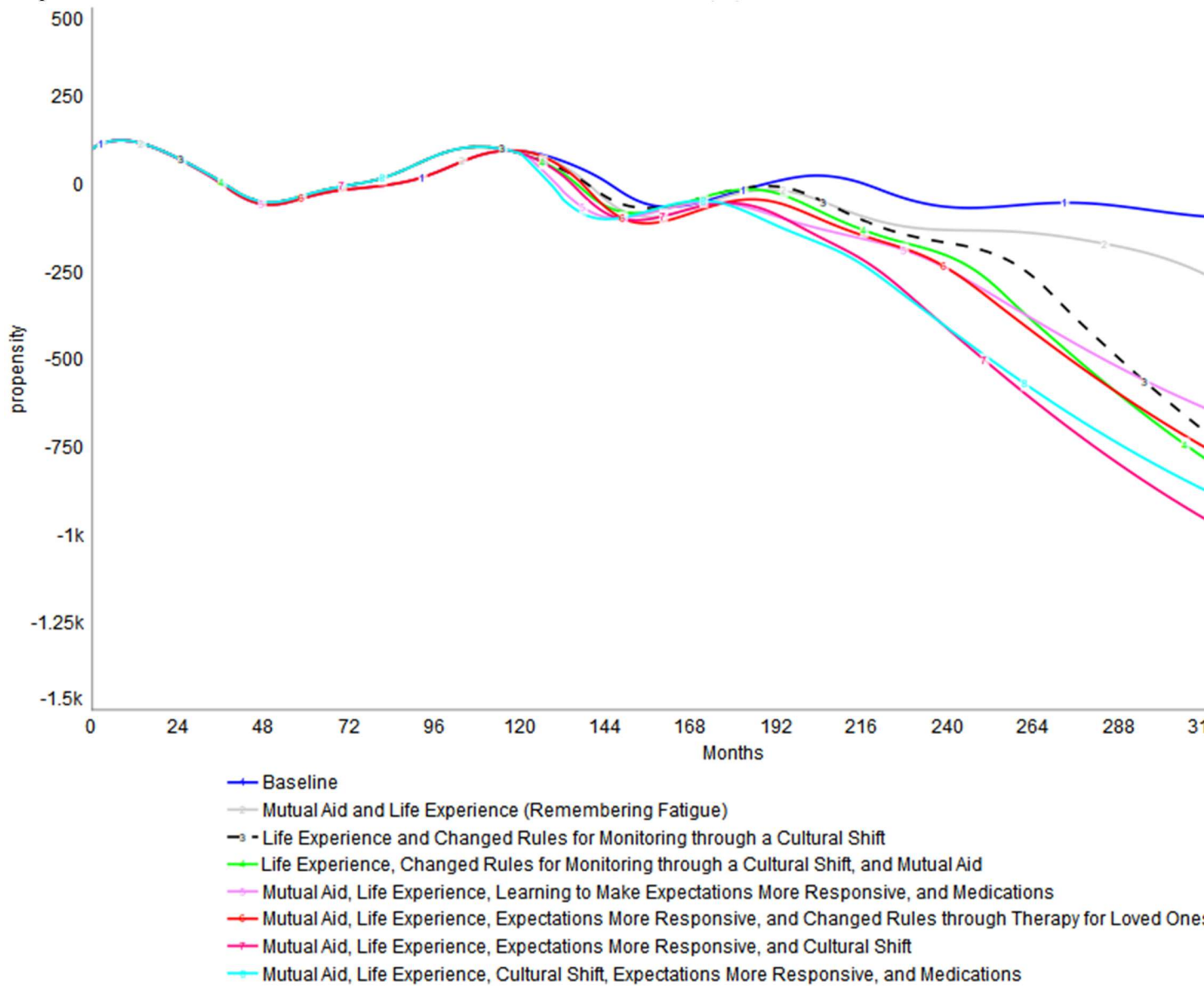
Figure 5.12-

Figure 5.15 depict the effects of each combination set of interventions on the four main recovery variables.

The experiments began with the least intensive intervention corollaries and built from there. The first combination included mutual aid, a free, widely available intervention, in addition to life experience/remembering fatigue. This set had the weakest effects of any combination. The next pair of 'interventions' was that which requires the least active

involvement for an individual PWUD: life experience and a cultural shift. Considering the lack of effort that would be required from PWUD for these changes, the effects were relatively high leverage. Adding mutual aid to this produced only marginally better results.

The next set of interventions included all the PWUD-level interventions: mutual aid, life experience, learning to make expectations more responsive (such as through therapy), and medications. These produced among the strongest positive effects on propensity, but overall lower impacts on functioning, expectations, and support than most other combinations. However, the unrealistic 'relapse' that would occur once the effect of reduced propensity/medications was removed no longer occurs once combined with other interventions. This suggests that when PWUD receive an intervention that improves their functioning over a significant length of time, i.e., several months to years, they also learn to make their expectations more responsive to functional improvements.

A similar set of interventions included the effects that therapy might have on loved ones' rules for monitoring for evidence (as opposed to a cultural shift), mutual aid, life experience, and learning to make expectations more responsive. When combined with these other interventions, the effect of loved ones changing their rules no longer has an unintended consequence on propensity to use, and the effect of support received is greater than its independent effects as well. The reasons for this are the same as above: the unintended consequence arises when there is improved functioning without improved expectations, which weakens a key balancing loop. If expectations become more responsive to improvements in functioning, while increased support is improving functioning, we would expect better outcomes.

The next set of interventions included mutual aid, life experience, making expectations more responsive, and the cultural shift. This retained a strong impact on propensity, while also

having amongst the strongest positive effects on functioning, expectations, and support. A combination of interventions that included all these plus medications produced only marginally better results.

In conclusion, changing the rules for monitoring of evidence had the single greatest positive impact on measures of recovery *except* propensity, and only when the rules are in effect from the beginning of the model. If these different 'rules' are instituted later in the model, once they have already had an opportunity to exert a detrimental effect, their impact is considerably weakened. Therefore, it was labeled a 'cultural shift' that would improve the level of support across PWUD without requiring intensive family- or individual-level interventions.

Learning how to make expectations more responsive to improvements in functioning but not to declines in functioning also had among the strongest impacts but did not have a strong impact on support. Indeed, support continues to prove to be the most resistant to change even with a combination of interventions. The primary way to increase support is to find a new relationship, but this would not be a formal individual-level intervention. A system could be developed at the community level to support people in recovery to form new, healthy, and stable relationships, though such a system is likely to be highly resource-intensive.

The strongest impacts with the fewest and least intensive individual (PWUD or loved ones)-level interventions are achieved with mutual aid, life experience, learning to make expectations more responsive, and a cultural shift. However, learning how to make expectations more responsive could require a formal therapeutic intervention, and many PWUD do not want to receive or cannot access treatment (Bose, Hedden, Lipari, Park-Lee, & Tice, 2018a). Thus, in terms of high leverage interventions, meaning disproportionate impacts are achieved relative to their efforts, the arguably most efficient combination would be life experience teaching people

how to "remember" fatigue, which as noted was assumed to be present, mutual aid (or peer support, advocacy, etc.) to serve as a constant source of hope and raised expectations, and a cultural shift that changes loved ones' rules for monitoring.
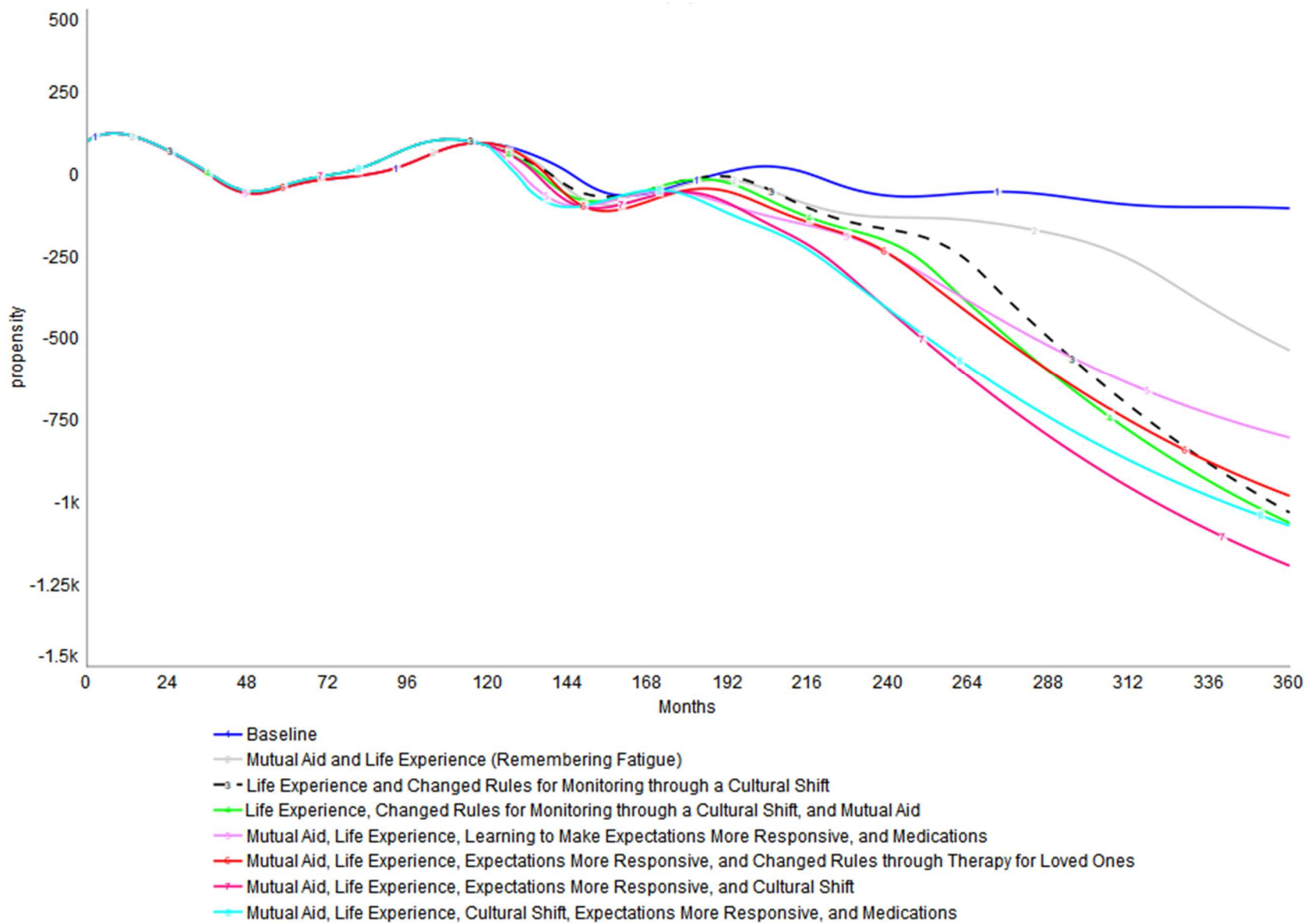
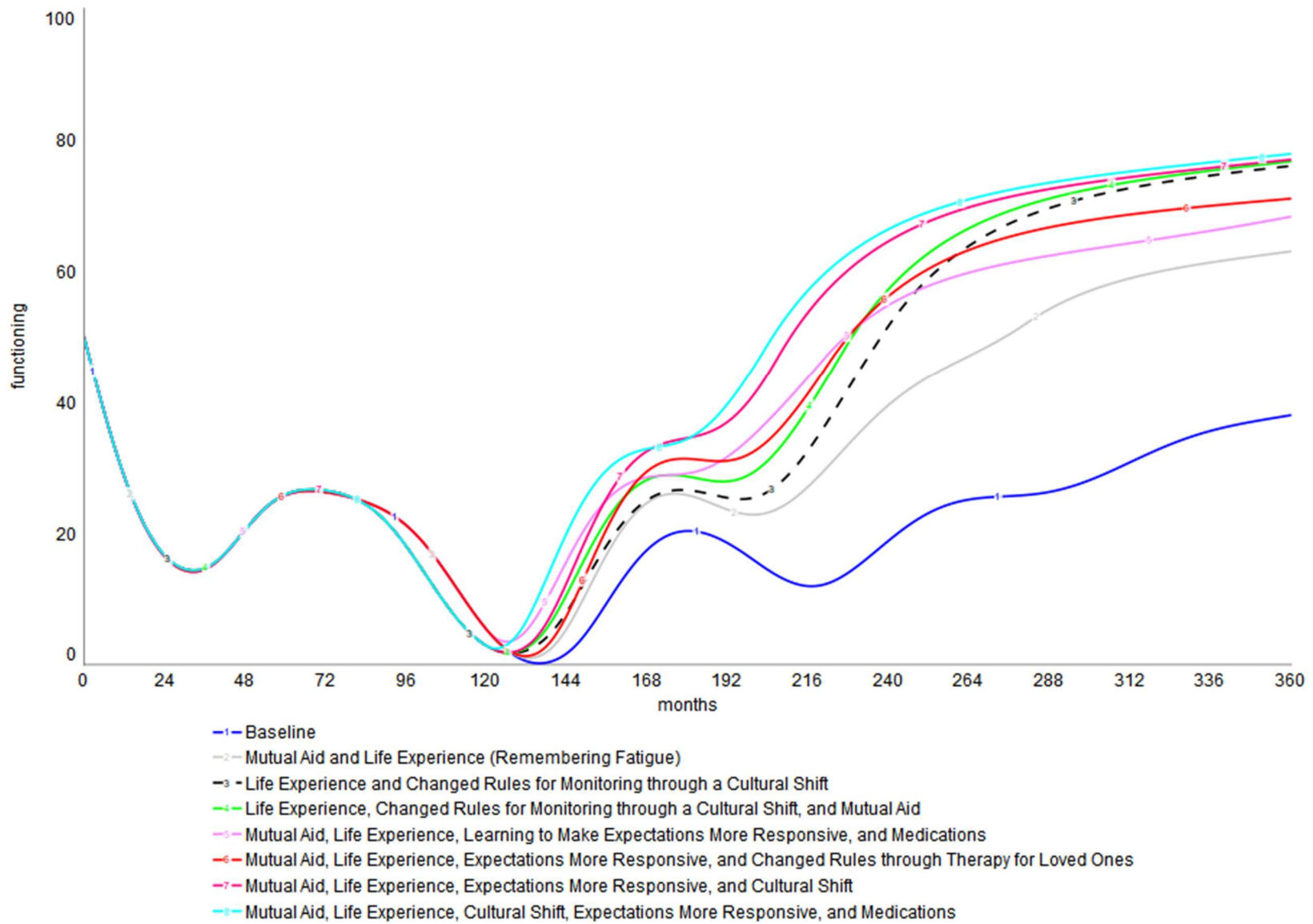Figure 5.12. Combined Effects of Interventions on Propensity to Use

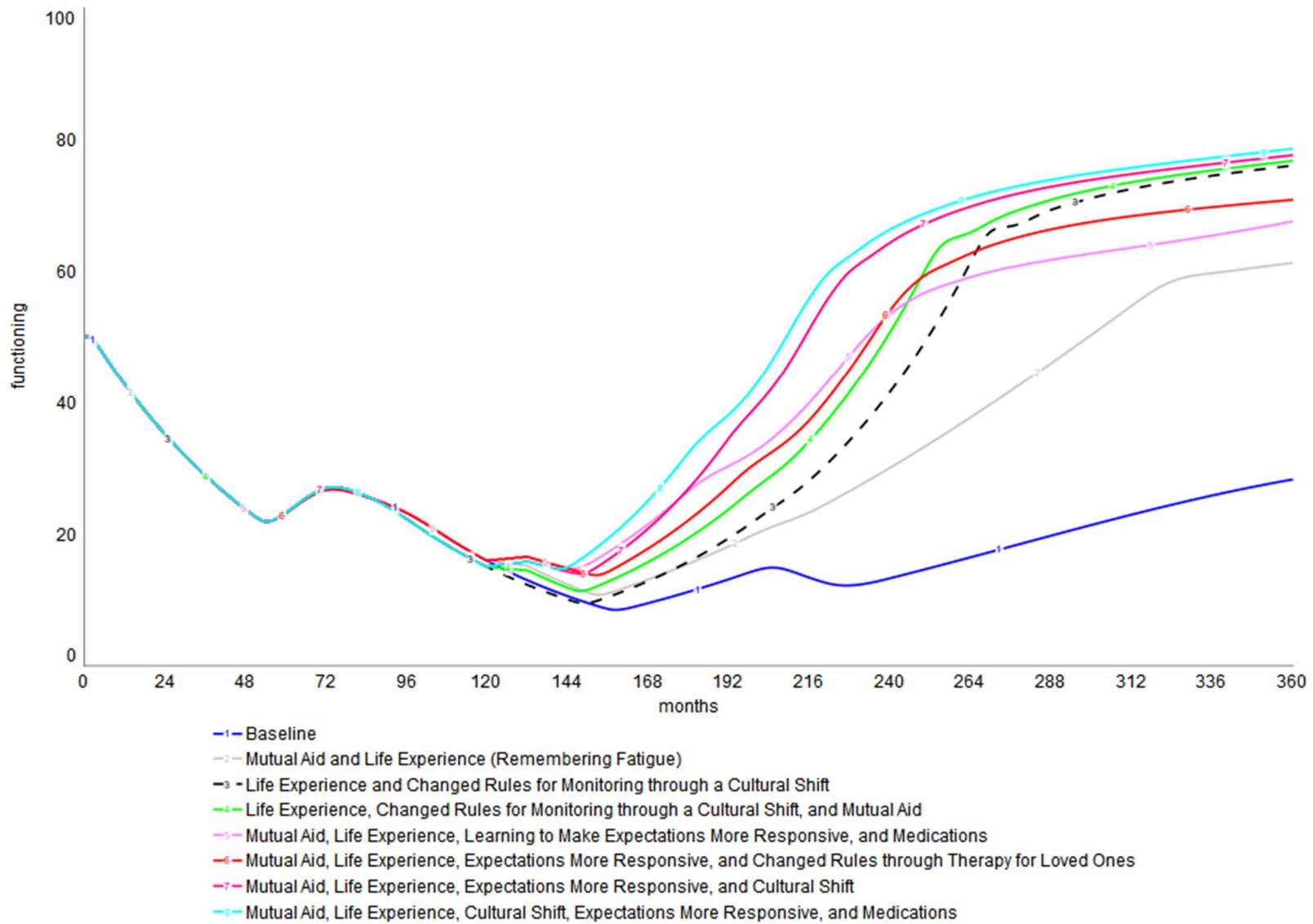Figure 5.13. Combined Effects of Interventions on Social Role Functioning

Figure 5.14. Combined Effects of Interventions on Expectations
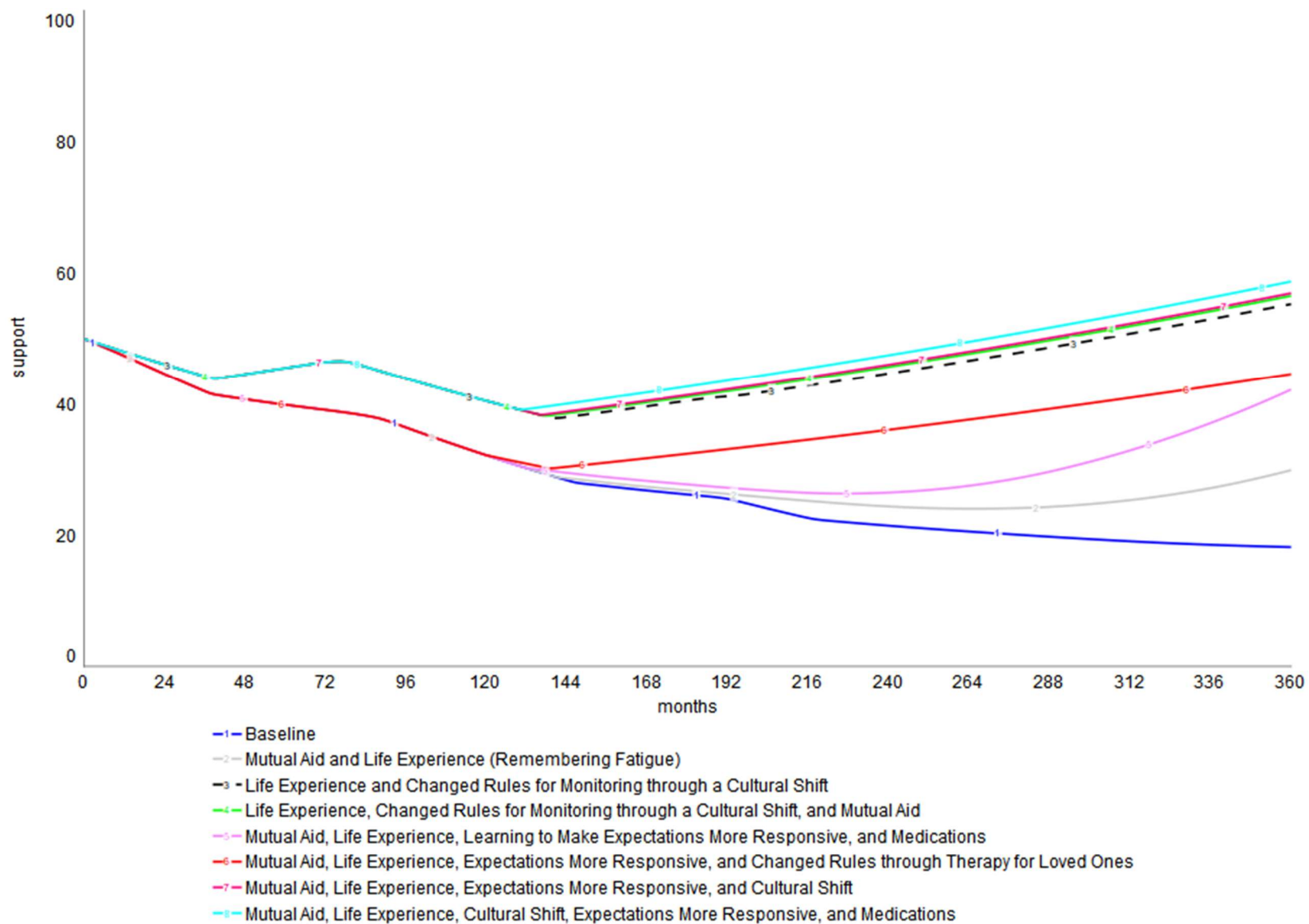
Figure 5.15. Combined Effects of Interventions on Support Received

Finally, it is important to consider these effects in the low initial support model. As noted, independently none of these interventions/experiments appreciably changed the model dynamics. Even the combinations above – including mutual aid, life experience, cultural shift, more responsive expectations, and medications – did not produce a "recovery," because support was still very low. Thus, a new relationship was also added, starting at 120 months. However, this had the unintended effect of increasing oscillations in propensity, even with all the other interventions still present. This is because by this point, expectations had fallen so low that even a new relationship with additional support was not able to overcome them. However, starting the interventions at 60 months produced better results, though there is still considerable oscillations in functioning and propensity. Nonetheless, propensity does finally fall below 0 by the end of the model when these interventions are started earlier.

The low initial support received model produces higher oscillations in social role functioning than achieved in the average support model. This is a result of calibrating the model primarily to the average support model. Indeed, except for a few values, no parameters are different for these two models, which is likely an unrealistic representation of the actual differences that exist. It is probable that these oscillations do exist, but that they are less extreme than depicted here.

Overall, there is greater confidence in the "average" initial support model, and thus the Discussion's implications will focus on the insights gained from this model.

Chapter 6: Discussion

Summary

Addiction is marked by dynamic patterns of remission and relapse. Even among those who remit, recovery (i.e., improved quality of life, relationships, and health) is elusive. This study's hypothesis was that mental models of recovery contribute to these dynamic patterns of relapse, remission, and recovery through feedback loops. Thus, to identify leverage points that can sustain change and promote recovery, it is necessary to understand these mental models and the feedback loops they create and perpetuate. This study therefore asked two questions: 1) What do people who use drugs and their loved ones believe it takes to successfully recover from addiction? and 2) Given these beliefs about recovery and the available evidence on remission, relapse, and recovery, what places to intervene and leverage points would support recovery and prevent relapse?

Mental Model

The PWUD and loved ones interviewed for this study believe that "you have to want it" to achieve addiction recovery. However, this mental model is not limited to this sample; rather, it is so pervasive that, despite its universality in the interviews, it initially seemed not worth exploring. Wasn't it obvious that "you have to want it"? Yet it became apparent that this belief had all the features of a mental model: it affected how participants behaved (i.e., whether they sought or provided support), what information they paid most attention to, and what policy or programmatic changes they believed would be helpful (namely, none would be if the person did not "want it" enough).

Despite the ubiquity of the phrase, "you have to want it," only one previous study – of tobacco smokers – interrogated it specifically (Balmford & Borland, 2008). Aptly titled, "What does it mean to want to quit?", seventy percent of the sample believed "wanting it" is both necessary and sufficient to quit. Similar to conclusions drawn in the present study, the researchers surmised that smokers believed "wanting it" was a "triumph of rational, planned actions over conditioned urges" (2008, p. 25). That such similar sentiments are found among people who are addicted to heroin and methamphetamine – substances with different legal status, much greater social stigma, and more profound negative effects on social role functioning – is striking for its implications regarding what it means to people to feel tethered to substances.

Indeed, "wanting it" is more than just wanting to quit drugs, or it would not be fraught with such meaning. "It" means wanting to become, or return to being, the true self (Weinberg, 2013), and to want what other people want: a "normal" life, with normal relationships and normal worries. A person who is addicted cannot be understood, is using "addict's thinking," and is not a true reflection of their (rational) self. In contrast, a person who has quit using drugs long-term and proven that they "want it" has demonstrated their ability to respond rationally to the negative consequences of drug use.

The mental model is therefore tautological, because proving that one "wants it" and can respond rationally to negative consequences is to no longer be addicted (National Institute on Drug Abuse, 2010). Indeed, PWUD have all the responsibilities but none of the rights of Talcott Parsons' "sick role." For those whose illnesses are recognized as legitimate, their inability to fulfill social roles and to will their illness away is accepted, as long as they seek professional help to improve their condition and follow the course of care (Parsons, 1951). But for people who are addicted, the failure to will their addiction away and their inability to fulfill social roles

is not accepted as a "right" for being ill. Instead, their failures only further their responsibility to seek help for their addiction and to actively work to get better (Parsons, 1979). The notion that getting well means achieving or regaining the capacity for 'independent achievement' is core to American values (Parsons, 1979).

Feedback Loop Structure and the Dynamic of Remission, Relapse, and Recovery

Three balancing and four reinforcing feedback loops comprise the final system dynamics model. The balancing loops are "fear of future self," "adjusting expectations," and "sick and tired." The reinforcing loops are "nothing to live for and nothing to lose," "monitoring for evidence of wanting it," "ambivalence about quitting," and "loved ones withdrawing." The mental model "You have to want it" creates two loops: "monitoring for evidence of wanting it" and "ambivalence about quitting," both of which include Support Received, and thus other people. During addiction, these loops strengthen "loved ones withdrawing" and "nothing to live for and nothing to lose." The current state of the system – relapse, remission, or recovery – is dependent on these loops' interaction with the balancing loops.

The model simulations suggest that the mental model "You have to want it" does not directly contribute to *the cyclical patterns* of abstinence (including remission) and relapse These cyclical patterns are driven by the Fear of Future Self balancing loop. As the fear waxes and wanes, propensity to use similarly rises and falls. At the same time, social role functioning settles into a (lower and lower) equilibrium, thereby changing the nature of the feared future self (MacDonald & Marsh, 2002; Paternoster & Shawn, 2009).

The mental model "you have to want it" impacts the dynamic patterns remission and recovery because of Support Received's effect on Expectations for Social Role Functioning, especially, as well as on Social Role Functioning itself. Recovery cannot be produced in the model without concomitant rises in functioning and expectations, and a key way that expectations and functioning rise is through support. In contrast to the more immediate impact of the "Fear of Future Self," which involves the more quickly changing Propensity to Use and Functioning, the impact of the slower-to-change Support on remission and recovery is cumulative. Early increases in support do not immediately lower Propensity and in some cases even slightly increase it (because Functioning increases without Expectations also increasing); however, once Propensity begins to fall, the accumulated Support Received leads to a stronger recovery due to its effect on Expectations.

There are two reasons that the variable, "Expectations for social role functioning," plays a disproportionate role in producing recovery in the model. First, it has ubiquitous influence throughout the model via several balancing and reinforcing loops. Of the seven major loops, all but two (the reinforcing loop, "Loved ones withdrawing," and the balancing loop, "Sick and Tired") include Expectations. This means that changes in Expectations ripple throughout the model by increasing the rate of reinforcing loops – in the direction of recovery rather than direction – and by strengthening the self-regulating effects of balancing loops. Second, 'Expectations' directly affects Propensity to Use in an inverse direction, so that when Expectations increase, it switches the direction of the hopelessness loop to "Something to live for and everything to lose." In contrast, absent a concomitant increase in Expectations, improved Social Role Functioning leads to a weakened "Fear of future self" balancing loop that *increases* Propensity to Use. Because Functioning and Expectations are not typically measured together

179

over time, it is difficult to ascertain whether the literature supports this theorized effect. However, one meta-analysis found that people in treatment for opioid addiction were more likely to continue using if they had less severe disorder (Brewer et al., 1998). While the authors found this "paradoxical," this effect is predicted by the present theory – namely, a lower severity of addiction likely represents a weaker "fear of future self" loop and thus a shorter period of abstinence.

The Basis of Truth in the Mental Model

Remission is produced in the model when Fatigue (with the lifestyle) finally surpasses a certain threshold and exerts a powerful balancing/self-regulating effect on Propensity to Use. Recovery is produced in the model when Propensity to Use not only falls, but also when Expectations, Functioning, and, to a lesser extent, Support Received increase via a directional shift in reinforcing loops.

Notably, either set of feedback loops could form the basis of the mental model that "You have to want it." When people witness PWUD achieving remission after becoming "sick and tired" of the lifestyle, this could be interpreted as finally "wanting it" enough. They are observing the internally-driven balancing loops that support self-regulation (Boker & Graham, 1998). Alternatively, the mental model that "you have to want it" could develop when people in recovery are visibly striving for more, i.e., they have higher expectations for themselves, meaning they "want it." In this instance, other people are observing the reinforcing loops that promote recovery.

Therefore, as far as a combination of self-regulation and high expectations (both of which could be interpreted as "wanting it") is critical to recovery (Ashford et al., 2019; Neale et al.,

2016; Substance Abuse and Mental Health Services Administration, 2012), the mental model reflects reality. However, the same cultural factors that drive the mental model also influence existing definitions of recovery. For instance, poststructural critiques have challenged the notion that drug use inherently "spoils" the identity (Slade et al., 2012; White & Evans, 2013). These critics have argued that "spoiled identity" narratives, which are often central to recovery stories, are socially constructed rather than reflecting any true relationship between the self and drug use (Fomiatti, Moore, & Fraser, 2017).

How the Feedback Structure Reinforces the Mental Model Itself

Regardless of the "true" nature of addiction recovery, observing self-regulating balancing loops or Expectations-driven recovery loops is to observe a person who has already achieved remission or recovery. Yet participants were describing what they thought it took to *initiate* recovery, and that even quitting drugs could not occur without "wanting it." This has implications for recovery because both PWUD and loved ones are, in effect, waiting for evidence of recovery before seeking or offering support for it. Aside from unintentionally weakening the eventual recovery, the effect is to reify the mental model that "You have to want it." Moreover, the emphasis on the *individual* PWUD needing to "want it" means that factors that assist recovery but are exogenous to the individual (e.g., *noncontingent* social support, community resources, and strong social welfare policy) are underestimated or excluded entirely from this mental model of recovery.

In the short-term most people might only be able to observe the power of the balancing loops, as it takes longer for the reinforcing loops to shift toward recovery, i.e., for functioning, expectations, and support to noticeably improve. If long-term abstinence is not achieved, PWUD and those around them too often assume that the failure is due to weak self-regulating/balancing

181

loops rather than to the failure of reinforcing loops to shift away from addiction and toward recovery.

Enabling and Tough Love

As the balancing loops grow in strength, beliefs in concepts like willpower and "hitting bottom" are strengthened. Loved ones, recognizing the power of the balancing loops to instigate abstinence but failing to perceive the even more powerful reinforcing loops necessary for recovery, use "tough love" approaches in the hopes of triggering a balancing loop and making someone "want it." The corollary to tough love is enabling; continuing to support a PWUD's social role functioning means they will never "see the light." If consequences experienced thus far are perceived as insufficiently severe, this can induce well-meaning loved ones to increase the penalty exacted for relapse, e.g., by cutting off support knowing that this will force a decline in functioning, thus hastening the speed at which the PWUD "hits bottom."

This dynamic can be reproduced in the model – lowered support leads to lower functioning, which triggers the "Fear of future self" loop and can temporarily reduce the propensity to use. Thus, if loved ones successfully trigger this loop, the lesson learned is that they can quickly create a gap in functioning to produce the behavior they desire. These dynamics serve to reify the mental model by reinforcing the view that self-regulation in response to negative consequences is *the* most important aspect. Any subsequent relapses could therefore be attributed to insufficient toughness or negative consequences (the PWUD has not yet hit their bottom).

However, over time, withdrawing support lowers functioning and reduces expectations for social role functioning (Grella & Stein, 2013; Y.-I. Hser, 2007; Y. I. Hser et al., 2015).

Because these changes take longer, their effects are more difficult to perceive. Lowered functioning, support, and expectations combine to strengthen the reinforcing feedback loops pushing people toward more severe addiction, reducing the chances of recovery. Their continued high propensity to use, low functioning, and low support-seeking – the behaviors which loved ones constantly monitor – further reinforce loved ones' view that they do not "want it" enough. Consequently, after "tough love" approaches fail to yield long-term results, loved ones increasingly perceive that nothing can change the person with addiction except the addicted person themselves (Orford et al., 2005, 2010). They shift from attempting to make the PWUD "want it" to concluding that "you can't make someone want it."

The Role of Other People in Recovery

Absent outside 'interventions,' expectations can only be endogenously increased in the model if functioning or support also increase *and* expectations respond more quickly to functional improvements than they do in the baseline model. More responsive expectations could arise endogenously, but they might also necessitate outside interventions such as therapy or, at the least, significant support. However, support could only be meaningfully increased exogenously by introducing, in effect, a new relationship that did not carry the 'history' of the addiction. Finally, expectations can be increased exogenously through hope, which arises from hearing or learning about others' recovery experiences and envisioning a path forward that they had previously not considered. In sum, an individual can independently achieve abstinence and, possibly, remission (defined as the lack of symptoms/problems), but *recovery* must include other people (Bohnert et al., 2009; Brewer et al., 1998; Costenbader et al., 2006).

However, even these interventions can have unintended consequences. For instance, if there is a sudden influx of hope that is not followed by increased functioning, the gap between

expectations and functioning increases, which spurs the "Fear of Future Self" loop but also drives down Expectations over time, leading to relapse. Thus, increases in expectations must be followed by increases in functioning. Given that opioid and stimulant users have lower recovery capital than people who have resolved problems related to other substances (Kelly et al., 2018), improved functioning could be especially difficult for them to achieve.

Theorized Requisites for Remission and Recovery in Terms of Feedback Loops

The following requisites for shifting to the healthy, stable state space of recovery were presented in the background section based on the extant literature. Keeping in mind that this present theory is guided by interviews as well as the extant literature, many of these requisites can be found in the key feedback loops of this model. Namely:

1. A global choice framework, which supports prioritization of conventional social roles 'be' goals over 'do' goals, is found in the "Nothing to live for and nothing to lose" reinforcing feedback loop becoming "Something to live for and everything to lose." An increase in Expectations for Social Role Functioning has shifted goals.

2. Supportive relationships that support social roles by providing alternative rewards, fear of losing these rewards, and increasing expectations, is found both in the "Something to live for and everything to lose" loop, and in a reversal of the "Loved ones withdrawing" reinforcing loop, which increases Support Received.

3. The skills to manage ambivalence about drug use is found in learning to maintain the strength of the balancing loops, "Fear of Future Self" and "Sick and Tired," which fade over time if not actively strengthened. "Fear of future self" will naturally stay active if Expectations outpace Functioning by *just* the right amount.

4.   Self-efficacy regarding the skills to manage ambivalence is less apparent in this model. Self-efficacy in addiction research is often referred to only in narrow circumstances regarding drug use. However, for participants, the tension around self-efficacy involved social role functioning, and whether they believed they had the ability to be a good parent, partner, family member, etc. They recognized that their ability to stay abstinent affected their social role functioning, but so did their ability to get a job, pay their bills, and keep up a home. In this model, that would suggest self-efficacy might also be captured in Expectations for Social Role Functioning but could be distinguished in future iterations.

5.   The ability to accurately monitor change, thus sustaining change behaviors, was not explicitly included in the theory or model. Expanding to a sample of people in longer-term recovery would more clearly explicate how they learn to monitor change. The "Monitoring for evidence of wanting it" loop, driven by loved ones, is the closest, but its result is too often a decrease in support.

Concepts like "hitting bottom" (Narcotics Anonymous, 1988), motivation, and willpower are similar enough to the mental model "You have to want it" to suggest they represent a fundamental paradigm or mindset about addiction itself. Thus, it is likely that this belief is so pervasive that it cannot be isolated in studies on addiction; it is woven into the very fabric of how we think about, discuss, and measure addiction and recovery. Just because there is evidence of the existence of these links and feedback loops does not mean that they necessarily *must* exist for people to recover from addiction. Meadows (1997) argues that the most powerful leverage point is changing mindsets or paradigms, and it is possible that the mindset or paradigm that "you have to want it" must change before the loops perpetuating the mental model change.

185

Implications for Social Work Practice and Policy

There are six main implications of the study's findings for social workers: 1) recognizing delays in improvements as benefits accumulate; 2) working with PWUD to make their expectations responsive to even small improvements in functioning; 3) supporting the use of medications for opioid use disorder by aligning their purpose with mental model; 4) developing community resources for peer support and relationships; 5) advocating for policy changes that remove barriers to improved social role functioning; and 6) supporting a cultural shift that expands the mental model that "You have to want it."

Recognizing Delays in Improvements as Benefits Accumulate

At the individual- or family-practice level, the model results highlight the importance of continuing to work with clients even when progress is not obvious. Several experiments (e.g., remembering fatigue, increased support) did not have immediately strong impacts, but had their strongest effects later in the model simulation once other 'forces' aligned, e.g., fatigue with the lifestyle had begun to depress propensity to use. Social workers do not have counterfactual data available to them, but the underlying logic of the model helps to explain why this would be the case: namely, interventions take time to accumulate their benefits, but once they reach a critical point and interact with preexisting dynamics, they can "trigger" reinforcing feedback loops that build momentum toward even stronger outcomes.

Making Expectations More Responsive to Improvements in Functioning

Making expectations more responsive to improvements in social role functioning produced consistently strong effects, in part by counteracting the unintended consequences of functional improvements. The focus on expectations is consistent with prior conceptual research

on the role of future orientation in recovery, e.g., having an orientation toward the future (Lewis, 2015), making choices within a global framework that supports social role functioning (Heyman, 2009), and choosing "be" goals over "do" goals (Webb et al., 2010).

Thus, social workers should guide people in early recovery to recognize small successes in their social role functioning and set new goals for themselves. This is especially important if a PWUD's loved ones continue to have low expectations for them; there are long delays in their personal "cumulative biographic image," (Biernacki, 1986) as well as the perceptions of loved ones. For example, one interviewee who was a regular attendee of 12 step meetings and interacted regularly with "old timers" noted how he recently had a pleasant conversation with his grandmother that did not involve asking for money. His next goal was to be able to pay her back a little bit of the money he owed her every time he saw her. He was expressing increased expectations that he was capable of being a good family member.

Supporting the Use of Medications for Opioid Use Disorder

Over their lifetime, only one-third of people with a drug use disorder receive any formal treatment for their disorder (Compton et al., 2007; Grant et al., 2016; Substance Abuse and Mental Health Services Administration, 2014). However, while accessibility and affordability barriers are formidable, they are not the primary barriers to treatment receipt for people with drug use disorders (DUD). Rather, most people with a DUD do not believe that they need treatment and, even among those who do perceive a need, the majority of men and women find it unacceptable (e.g., they are not ready to quit, they do not think it would help, they want to quit on their own) (Ali, Teich, & Mutter, 2015; Andrade et al., 2014; L.-Y. Chen, Strain, Crum, & Mojtabai, 2013; Grella, Karno, Warda, Moore, & Niv, 2009; Mojtabai et al., 2011; Mojtabai & Crum, 2013; Substance Abuse and Mental Health Services Administration, 2014).

This study suggests that treatment might be perceived as unnecessary or unacceptable because treatment is only useful if the PWUD "wants it," and at that point its primary utility is to aid a PWUD to quit using. Treatment is not perceived to have a role in improving social role functioning, support, or expectations, as the implication is that these must be accomplished independently to prove that one truly "wants it." Similarly, the unwillingness to use medications expressed by several participants could be explained by more than just the desire to be drug-free (Truong et al., 2019; Yarborough et al., 2016). Using medications challenges the ability to prove or find evidence of "wanting it." If you cannot do it on your own, then you must not really want it. And if you don't really want it, then treatment isn't going to help. The hard part, it is believed, is getting through withdrawal. In this context, it is easier to see why treatment is not perceived as necessary, and why street Suboxone is viewed as a viable alternative to get through withdrawal (Cicero et al., 2018).

The use of social pressure to get people into treatment means that often, social workers' contact with PWUD will be due to coercion (Goodman et al., 2011; Opsal, Kristensen, Vederhus, & Clausen, 2016; Storbjörk, 2012). PWUD will need to be convinced of the value of social work counseling if they perceive their primary need to be supporting in quitting. This represents an opportunity for social workers to understand clients' mental models and present an argument for how medications fit within that – as support for quitting. Thus, social workers will need to establish relationships with prescribing providers. As trust in both providers builds over time, PWUD might increasingly recognize the value-add of therapeutic counseling for supporting recovery as well.

Developing Community Resources for Relationships, Mutual Aid, and Peer Support

Because of the challenge in improving existing relationships that have been damaged by addiction and years of abuse, social workers should promote resources for people in recovery to build new relationships, especially romantic relationships. These are a critical, and sometimes the only, source of reliable support for recovery. This can be difficult for people to achieve without formal avenues through which to do so, especially in small towns where "everybody knows everybody," and where the low population density and lack of transportation mean there are only so many people with whom new relationships can be formed.

At the community-level, social workers should strive to improve resources and create opportunities for people in various stages of recovery to interact with each other, following the model of recovery community centers. Mutual aid meetings such as Narcotics Anonymous can be useful for many (Gossop, Stewart, & Marsden, 2008), while others find groups such as SMART Recovery more useful, though its outcomes are weaker (Beck et al., 2017). The evidence base for these informal interventions is modest, as the people who attend meetings regularly are different from those who do not. However, there is also a push toward integrating peer recovery supports services into medical and behavioral health teams; these services have a growing evidence base (Reif et al., 2014) and are theoretically based in the same behavioral change theories as mutual aid, especially social control and social learning theory (Moos, 2008).

Mutual aid groups and peer recovery supports share a common feature of providing hopeful role models who can demonstrate that it is possible to achieve recovery (thus increasing expectations for social role functioning) *and* model the skills needed to do so. Observing others'

ability to engage in a given behavior increases self-efficacy beliefs about the ability to perform that behavior (McAlister et al., 2008; Moos, 2008).

The ideal outcome would be for expectations to consistently surpass functioning just enough that people continually strive for improvement and maintain the "fear of future self" balancing loop – though it might be more accurately called "striving for future self" – but not so much that the gap leads to adjusting expectations downwards, which creates hopelessness. However, increasing expectations could prove quite difficult. Service providers' perceptions of what it means to be in recovery (not how to get there) are considered unrealistic or idealistic by PWUD service users, who noted that it is impossible in some cases to become healthy after years of marginalization (Neale, Tompkins, et al., 2015).

Advocating for Policy Changes that Remove Barriers to Improved Functioning

Indeed, expectations for social role functioning will never increase sustainably if functioning fails to improve. Yet many existing policies strengthen the "nothing to live for and nothing to lose" loop by preventing improvements in functioning, which exerts influence well after remission is achieved. Social workers must work to remove policy barriers to improved functioning for individuals who are or have been addicted. This is especially true for populations whose ability to sustain remission and achieve recovery is affected by their race and gender (Y.-I. Hser, Huang, et al., 2008; Lopez-Quintero et al., 2011).

Employment is associated with remission (Grella & Stein, 2013) as well as higher recovery scores (Neale et al., 2016) and was often noted in interviews as a key step toward achieving social role functioning goals. Indeed, addiction, addiction recovery, and material

conditions are closely interrelated. Several definitions of recovery include material conditions such as a stable home and income (Gordon, Ellis, Siegert, & Walkey, 2013; Neale et al., 2016; Substance Abuse and Mental Health Services Administration, 2012), while poverty-level income is a strong predictor of drug use disorder (Compton et al., 2007; Grant et al., 2016).

Stable income is not a guarantee of remission, but it is difficult to imagine a *recovery* without it. Finding stable income – whether through employment or government benefits – is increasingly difficult, especially for people who have been addicted and are likely to have a spotty work history. Recent reports describe people being denied jobs due to their utilization of medications for opioid use disorder (U.S. Equal Employment Opportunity Commission, 2018). People who have been criminally convicted for drug-related crimes, in addition to the years of incarceration, probation, and parole they have served, must also report their convictions on job applications in many states (Duane, Vigne La, Lynch, & Reimal, 2017; Elderbroom & Durnan, 2018), and often lose eligibility for federal benefits including student financial aid (U.S. Department of Education Federal Student Aid, n.d.), and housing subsidies (Curtis, Garlington, & Schottenfeld, 2013). Many people who have been addicted simply lack a strong work history, are disabled, or otherwise unemployable. Social workers should advocate to strengthen safety nets to ensure that people in recovery have a stable income and safe home.

Supporting a Cultural Shift That Expands the Mental Model "You Have to Want It"

Finally, social workers can support a cultural shift that expands the mental model, "You have to want it." Currently, this mental model means that a PWUD who is addicted must prove, in effect, that they are no longer addicted – that they are capable of rationally responding to negative consequences – before loved ones will commit further support. Such sentiments are also

expressed by others who monitor PWUD: health care providers, probation officers, judges, etc. In expanding the mental model, self-regulating balancing loops and the role of Expectations would retain their rightful place as critical for recovery. An expansion means that people consider how multiple forms of support are critical, including noncontingent/unconditional social support, clinical care, income supplements, and pharmaceuticals, etc. Such an expanded mental model would encompass the use of medications *first* to stabilize PWUD *so that* they are given the space to improve their relationships*,* increase their social role functioning, and adjust their expectations in response to these improvements (Winograd et al., in press).

Practically speaking, this might mean social workers become actively involved in public health discussions and debates on the topic, that they engage people who use this language at speaking events, that their course curriculum interrogates these sorts of cultural beliefs and mental models, or that their clinical supervision includes regular meetings to assess to what extent these beliefs are held by staff.

Part of expanding the mental model means reconsidering what the primary goals are. In the model, when social role functioning and support seeking do not affect support received, the dynamics of all the loops involving support change, which in turn affects expectations. However, even as this rule change produced the strongest eventual recovery, it did not prevent the "relapse" in Propensity to Use that also occurs in the baseline model. This highlights the importance of which outcome an intervention – or even an entire system – is optimized to achieve. If the majority of PWUD, their loved ones, providers, and policymakers gear their interventions toward abstinence, with outcomes such as relationship quality or support considered secondary, this could increase the likelihood that remission, but not recovery, is

achieved. It also means that there could be resistance to a change in the mental model if it perceived to make things worse.

A cultural shift such as that proposed would not be easy. Mental models of addiction recovery, which fundamentally are about what it means to an acceptable, worthy person, cannot be disentangled from notions of the independent, rational Self in modern capitalist society (Tootle, Ziegler, & Singer, 2015). This has important implications for how people's mental models of recovery are interpreted, changed, or expanded; they, too, are likely to reflect broader Western cultural values of independence and responsibility for the Self (intentionally capitalized) (Parsons, 1979).

Implications for Research

Motivation

"Wanting it" extends the research on concepts like motivation, intention to change, readiness to change, commitment to change, sobriety, or abstinence, and committed action, all of which have been operationalized and measured with the goal of more accurately predicting drug use outcomes. Findings are mixed about whether any of these concepts meaningfully predict drug use outcomes, even in the short term (Field, Adinoff, Harris, Ball, & Carroll, 2009; Kelly & Greene, 2014). When there is an association, it is fairly weak (Apodaca & Longabaugh, 2009).

The simulation model provides insight into why these associations are weak. Namely, the measurement of concepts like motivation or commitment are likely measuring the "Fear of Future Self" and "Sick and Tired" balancing loops. For instance, the Commitment to Sobriety Scale asks respondents to rate their agreement with the statement, "I have had enough of drugs and alcohol" (Kelly & Greene, 2014) which reflects the sentiment of the "Sick and Tired" loop.

193

Even an abstinent person might possess motivation or commitment to change when they are asked (often while in treatment) if "staying sober is the most important thing in my life (Kelly & Greene, 2014). But the "fear of future self" balancing loop creates oscillating patterns in this commitment that are not necessarily perceived in the moment, if ever. Thus, the motivation or commitment to quit can be present yet still be insufficient for sustainable behavior change.

"Wanting it" is distinct from motivation and commitment in important ways. Primarily, it is more than a promise of future action, which is how many 'commitment' scales are worded. Rather, from the perspective of loved ones and others who are also surveilling the PWUD and who wield even more power (e.g., probation officers, drug court judges, treatment providers), "wanting it" must include *evidence of past actions* that are believed to reflect the sincerity of their underlying motivations (i.e., their underlying propensity to use). It is this requirement of evidence of past actions that is hypothesized to create unintended consequences that weaken recovery.

Future research into concepts like motivation or commitment would benefit from taking this dynamic view of addiction. Longitudinal measurement using, e.g., ecological momentary assessment (Timms, Rivera, Collins, & Piper, 2014), could capture how these factors change over time in response to changing functioning, expectations, support, or fatigue with the lifestyle. These data could be used to construct an individual-level model similar to that developed in this study but on a shorter time scale, to identify opportunities for high leverage point interventions.

Mental Model's Effect on Perceptions of Treatment and Other Interventions

Future research could explore to what extent belief in the mental model "you have to want it" predicts perceived need for treatment, perceived utility of treatment for addiction, and acceptance of medications specifically. This would provide guidance on how to change the mental model so that more people were willing to access treatment and medications. For instance, mutual aid and treatment are perceived as unlikely to be helpful if the PWUD does not "want it." Indeed, treatment often is of low quality (Buck, 2011; McGovern, Saunders, & Kim, 2013; Olmstead, Abraham, Martino, & Roman, 2012) and therefore less likely to be helpful, but participants attributed poor treatment outcomes to PWUD insufficiently "wanting it." It will be important to disentangle the reasons for the low acceptability of treatment so that more people can access high-quality treatment.

Participants also expressed skepticism about the value of medications that curb craving. Resistance to medication is thought to arise from stigma, fear of dependence, or belief that it is "just another addiction" (Truong et al., 2019). The mental model suggests that the resistance is subtler than that; removing craving removes the opportunity to prove one "wants it." Indeed, medications are effective in achieving and sustaining *abstinence* compared to treatment as usual (Mattick et al., 2014). However, medications cannot directly support *recovery*, i.e., they alone cannot help someone become the kind of person they want to be – to achieve the 'it' in "wanting it." This distinction reflects the fact that there are multiple goals in recovery beyond abstinence. Medications help people to meet one goal – abstinence – but increased functioning, support, and expectations might require psychosocial therapy (Dugosh et al., 2016) or, at the least, something other than medications. Thus, future research could explore how people feel about medications

195

specifically in supporting their *recovery* and not just their abstinence. This could lead to better messaging that encourages people to use these medications to support their abstinence (if that is what they want) *so that* they can achieve recovery (Winograd et al., in press).

Finally, legal coercion such as drug court is perceived to incentivize people to "work the system," by faking "wanting it." They do not know if they can trust the improved social role functioning of someone who had been in drug court or prison. The extent to which this cynicism affects support once the legal coercion has ended will be important to know. The drug court system could be creating unintended consequences by inadvertently making it harder for people to prove to their loved ones that they *genuinely* "want it."

Moreover, this mental model is not limited to PWUD and their family members. Future research should explore the extent of the mental model in the health care and addiction treatment systems as well as systems such as criminal justice, where PWUD have frequent contact with judges, lawyers, and probation officers. These professionals, who have considerable power of the lives of PWUD, could be basing their decisions on some amorphous "feeling" about whether someone "wants it." This could be creating inequities across multiple systems if these feelings are driven by bias or prejudice.

Limitations

Lack of Data to Parameterize Model

Lack of data is a common challenge in system dynamics modeling (J. Homer, 2014), and this challenge can be managed in several ways. In this study, all parameters were calibrated due to the nature of the model being individual-level and because the concepts included are not traditionally reported in the literature. This means that some aspects of the model are highly

sensitive to changes in these parameters, yet what these parameters are meant to represent (typically, how long something takes to change) might not actually be as critical to the system's functioning as this sensitivity would suggest. Hence, the focus of model building and experimentation was more on how the feedback loops operated and what changes created consistent patterns in how these feedback loops behaved.

As a result of these higher-level insights, rather than a follow-up study that measured these concepts in depth among individuals, a more useful next step would be to test the hypotheses generated by the model and, if necessary, build a population-level model that would be more easily supported by data collection.

Lack of Data to Construct Reference Modes

Because longitudinal data were not collected for this study, the construction of the reference modes – which in turn informed the model calibration – relied heavily on extant literature, which tends to include individuals with more severe addictions. The dynamic patterns of people who have less severe addictions might look different. The average DAST-10 score in the sample was 8, which indicates probable severe drug use disorder. However, the lack of longitudinal data in the present study means that we cannot know where along the spectrum of severity the participants fell *over time*.

Likewise, only three participants were reached for a second interview. This included one PWUD who, in the intervening period, had attended a Narcotics Anonymous meeting for the first time. She had expressed skepticism about their value during the interview, but her husband's suicidality and alcohol use disorder had threatened her own 5-year recovery from

methamphetamine use disorder, so she turned to NA for assistance. Additional data like this from other participants would have enriched the study further.

Homogenous Sample and Need to Triangulate with Extant Research

The generalizability of the theory is limited by this homogeneous sample, which was nearly all white, mostly young adult PWUDs from a single county in Missouri. To mitigate against this, extant research was also consulted when developing concepts and interactions between them. Dynamic simulation modeling frequently relies on triangulation of data from multiple sources (Roux, 2015). Triangulation allows for flexibility but also challenges model confidence if samples in extant research are dissimilar to the population represented in the model.

There are reasons to believe that the structure of the model could be different for non-white PWUD. Social historical conditions shape the experience of drug use – and thus possibly also the experience of addiction recovery – differently for whites versus African Americans. For instance, African Americans were more likely to report using drugs for pleasure while whites more often reported using to avoid withdrawal (Bourgois et al., 2006). These reasons for using could also carry over into their reasons for quitting. People of non-white race or who have Hispanic ethnicity have more severe and longer-lasting addictions (Y.-I. Hser, 2007; Lopez-Quintero et al., 2011), which could mean their addictions are either represented by the more extreme dynamics produced in the model, or they could be different dynamics altogether.

On the other hand, the belief that "You have to want it" does not on its face appear to be limited to just white PWUD and their loved ones. The mental model seems at least in part drawn from the ethos of the 12 steps, which is attended by a diversity of individuals. Moreover, the

stigma surrounding drug use and its consequences for social role functioning and support are certainly not limited to white users either (Mateu-Gelabert et al., 2005).

The loved ones represented an even more homogenous sample, as they tended to be mothers of (white) people who use heroin. There were intriguing differences in this small sample that suggested income and/or education played a role in how strongly the "You have to want it" mental model was endorsed. Specifically, these parents' support was less contingent on functioning and drug use, and they were more likely to express a brain disease view of addiction. They had spent time learning about addiction and medications for OUD and were supportive of its use for their loved one. They were also active in parent support and advocacy groups. However, there were too few people who expressed this potentially alternative mental model, so it did warrant discussion in the present study. Their stance might represent the direction in which a cultural shift should go, though further work is warranted to learn if their approach is more advantageous for recovery.

Future Directions

Participatory and Community-Based Modeling

Social role functioning, increased expectations, and a variety of sources of support require commitment from the community and local and state government (White, 2009). Developing these resources and ensuring they are sustainable requires working with communities to build on their strengths and existing resources. Identifying ahead of time potential unintended consequences and limits to sustainability is important. Community-based system dynamics and other participatory modeling approaches could be used to develop a shared language and vision among multiple stakeholders, whose philosophies of addiction recovery or

attributions of change might differ (Maffina et al., 2013; Orford, Hodgson, Copello, Wilton, & Slegg, 2009).

Participatory and community-based system dynamics modeling (Hovmand, 2014) can work with communities to move beyond philosophical differences by focusing on the underlying loops that drive recovery – whether on an individual-level as described in this study, or on a community- or population-level. Together, they can develop a shared, and improved, mental model of recovery and shared strategy (Black & Andersen, 2012) that accounts for the varying perspectives, meaning that it more accurately reflects how the multiple parts of the relevant complex adaptive system interact and contribute to or exacerbate the problem. Much of this work occurs around the visual model itself, which creates a boundary object – a visual tool that can be manipulated as needed to plan and design interventions (Luna-Reyes et al., 2018; Star & Griesemer, 1989). Recent research has highlighted the particular value derived from participants building the model themselves, including more structured and rational decision-making (McCardle-Keurentjes, Rouwette, Vennix, & Jacobs, 2018; Stave, Dwyer, & Turner, 2019)

Network and Space-Based Analysis: Agent-Based Modeling

As part of creating environments that are supportive of sustainable recovery, communities must focus on creating the *conditions that support the emergence* of recovery-supportive social spaces that serve as an acceptable alternative to drug-using social spaces. For this, agent-based modeling (ABM) could prove quite useful.

ABM models individuals and their processes, behaviors, and interactions, rather than variables (Macy & Willer, 2002; Tubaro & Casilli, 2010). ABM simulates from the "bottom up" the dynamic, adaptive, and spatial interactions between heterogeneous individuals (Epstein,

2006; Gilbert, 2008; Hammond, 2015). "Bottom up" means that rules for behavior are specified at the individual level, and the model simulation generates behavior at the group level, making it well-suited for modeling across levels. ABM is most useful when spatial or geographic, network-based, and interpersonal interactions are critical to understanding a problem. Thus, with regards to addiction recovery, an agent-based model could extend the findings presented here to determine how autonomous interactions between PWUD, peers in recovery, loved ones, etc. (D. A. Marshall, Burgos-Liz, IJzerman, Crown, et al., 2015; Polhill, 2010) could support increased functioning and expectations, as well as explore emergent behavior.

Conclusion

This is the first known individual-level dynamic simulation model that goes beyond drug use to also present a viable theory for quitting, remission, and recovery, and to do so with primary empirical research. Prior dynamic simulation models in the field of drug use and addiction include how drug use epidemics 'spread' in a population (M. H. Agar & Wilson, 2002; J. B. Homer, 1993), the effects of addiction on a community (Levin, Roberts, & Hirsch, 1975), highly abstract "toy" agent-based models based on theorized mechanisms affecting drug use (Galea, Hall, & Kaplan, 2009), and models of addictive behavior alone with a focus on mood instability (Golüke, Landeen, & Meadows, 1981).

The grounded theory stands on its own, offering a deeper understanding of long-standing beliefs about the nature of addiction. Rather than accepting at face value the widely held belief that "you have to want it" to recover from drug addiction, this theory interrogates the ways that such a mental model can inadvertently exacerbate the experience of addiction by pushing expectations and functioning lower and lower, as loved ones and PWUD go in search of tautological evidence.

A further strength of the study is that it builds on existing research in addiction and addiction recovery across multiple fields to suggest that many of the existing concepts in the field might be better understood in terms of feedback loops and their interactions over time. This feedback-based approach to addiction recovery explores the phenomenon as it is: dynamic, complex, interactive.

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APPENDIX

Table 1. Variables and Equations

Variable	Type (Units)	Description	Equation and Initial Value
Propensity to Use (PUse)	**Stock (propensity)**	**The inclination, tendency, or preference toward drug use.**	$PUse(t) = \int_0^t PUse(u) * du + PUse(0); PUse(0) = 100$
Changing propensity to use (changing PUse)	Flow (propensity/month)	The rate of change in propensity to use.	$Changing\ PUse =$ $\frac{(EffPUPU + PUseDiscGap + PUseDiscExp + PUseDiscFat)}{ATPUse}$
AT change propensity to use (ATPuse)	Delay (month)	How long it takes the propensity to use to change.	5
Effect of propensity on propensity (EffPUPU)	Table Function (propensity)	The reinforcing effects of propensity to use on itself.	(-100,0) (-80, 0) (-60, 0) (-40, 0) (-20, 0) (0, 0) (20, 10.18) (40, 17.61) (60, 21.82) (80, 24.51) (100, 25)
SRF change per propensity (SRFPUse)	Constant (functioning/ propensity)	Per unit change in social role functioning with each unit change in propensity to use.	-0.3
Propensity discrepancy from functioning gap (PUseDiscGap)	Converter (propensity)	How much propensity is adjusted based on the gap between expectations and functioning.	$\frac{GapFunc}{SRFPUse}$
expectations needed to maintain propensity (ExpPUTh)	Constant (functioning)	The level of social role expectations needed to maintain propensity to use.	50

[226]

Expectations gap (ExpGap)	Converter (functioning)	How far expectations have fallen below what is needed to maintain propensity.	$ExpPUTH - ExpSRF$
Propensity discrepancy from expectations gap (PUseDiscExp)	Table Function (Propensity)	How much propensity is adjusted based on the gap between expectations and expectations needed to maintain propensity.	(-50, -15.66) (-40, -15.35) (-30, -13.97) (-20, -12.21) (-10, -8.38) (0, 0) (10, 6.39) (20, 11.14) (30, 13.51) (40, 14.28) (50, 14.51)
AT expectations gap affects propensity (ATExpPUse)	Delay (month)	The time it takes for the gap between expectations and expectations needed to maintain propensity to affect propensity.	2
Maximum fatigue tolerated (FatPUTh)	Constant (fatigue)	How much fatigue with the lifestyle a PWUD can have before their propensity to use begins to decline.	70
Fatigue gap (FatGap)	Converter (fatigue)	The gap between fatigue and the maximum fatigue tolerated.	$Fat - FatPUTh$
Propensity per fatigue (PUseFat)	Constant (propensity/ fatigue)	Per unit change in propensity for each unit of fatigue.	-0.5
Propensity discrepancy from fatigue (PUseDiscFat)	Converter (propensity)	How much propensity changes based on fatigue with the lifestyle.	$FatGap * PUseFat$

[227]

Social Role Functioning (SRF)	**Stock (functioning)**	**How well the PWUD is performing in social roles such as parent, partner, or family member.**	$SRF(t) = \int_0^t SRF(u) * du + SRF(0); SRF(0) = 50$
changing social role functioning (changing SRF)	Flow (functioning/ month)	The rate of change in social role functioning.	$Changing\ SRF = \dfrac{(EffPUseSRF + EffSRSRF - SRF)}{ATSRF}$
AT social role functioning (ATSRF)	Delay (month)	How long it takes for social role functioning to change.	28
effect of propensity to use on social role functioning (EffPUSRF)	Converter (functioning)	How much SRF changes in response to propensity to use.	$PUse * SRFPUse$
social role functioning change per support (SRFSR)	Constant (functioning/ support)	Per unit change in functioning for each unit of support received.	0.5
effect of support received on social role functioning (EffSRSRF)	Converter (functioning)	How much functioning changes in response to support received.	$SR * SRFSR$
Expectations for Social Role Functioning (ExpSRF)	**Stock (functioning)**	**What the PWUD expects of themselves in terms of social role functioning.**	$ExpSRF(t) = \int_0^t ExpSRF(u) * du + ExpSRF(0); ExpSRF(0) = 50$
changing expectations for social role	Flow (functioning/ month)	The rate of change in expectations	$changing\ ExpSRF = \dfrac{(ExpSRF * EffGapExp * EffSRExp - ExpSRF)}{ATExpSRF}$

[228]

functioning (changing ExpSRF)			
AT change expectations (ATExpSRF)	Delay (month)	How long it takes for expectations for social role functioning to change.	40
Gap in functioning (GapFunc)	Converter (functioning)	How far above or below the PWUD functioning is relative to their expectations.	$GapFunc = ExpSRF - SRF$
effect of gap on expectations (EffGapExP)	Table function (dmnl)	How the gap between PWUD expectations and functioning affects expectations.	(-5, 1.82) (-4, 1.81) (-3, 1.73) (-2, 1.61) (-1, 1.39) (0, 1.10) (1, 0.70) (2, 0.49) (3, 0.41) (4, 0.36) (5, 0.35)
averaging time for gap on expectations (ATGapExp)	Delay (month)	How far back the gap is averaged when adjusting expectations.	3
effect of support received on expectations (EffSRExp)	Table function (dmnl)	How other people's support affects PWUD's expectations.	(0, 0.40) (0.2, 0.39) (0.4, 0.44) (0.6, 0.55) (0.8, 0.77) (1, 1.00) (1.2, 1.36) (1.4, 1.71) (1.6, 1.86) (1.8, 1.97) (2, 2.00)
support needed to maintain expectations (SRExpTh)	Constant (support)	Minimum level of support is needed for a PWUD to maintain their expectations.	50
AT support affect expectations (ATSRExp)	Delay (month)	The time it takes for support received to affect expectations for social role functioning.	300
Gap in functioning (GapFunc)	Converter (functioning)	How far above or below the PWUD functioning is relative to their expectations.	$GapFunc = ExpSRF - SRF$

[229]

Support sought (SS)	Stock (support)	The amount of support currently sought by the PWUD.	$$S(t) = \int_0^t SS(u) * du + SS(0); SS(0) = 25$$	
changing support sought (changing SS)	Flow (support/month)	The rate of change in seeking support.	$$Changing\ SS = \frac{(Max\ SS - SS) * EffPUseSS}{ATSS}$$	
AT support sought (ATSS)	Delay (month)	The time it takes for support seeking to change.		60
Support sought per propensity (SSPUse)	Flow (support/ propensity)	Per unit change in support sought for each unit of propensity to use.		-0.1
Effect of propensity on support sought (EffPUseSS)	Converter (support)	How propensity affects support seeking.	$$PUse * SSPUse$$	
Support Received (SR)	Stock (support)	The amount of support the PWUD is currently receiving.	$$SR(t) = \int_0^t SR(u) * du + SR(0); SR(0) = 25, 50, 75$$	
changing support received (changing SR)	Flow (support/month)	The rate of change in support received.	$$Changing\ SR = \frac{(SR*EffPUSR*EffSRFSR*EffSSSR - SR)}{ATSR}$$	
AT support received (ATSR)	Delay (month)	How long it takes to change support received.		120
Effect of Propensity to Use on Support Received (EffPUSR)	Table function (dmnl)	The time it takes to learn of the PWUD's use and how far into the past loved ones consider when changing their support.	(-2, 0.59) (-1.6, 0.61) (-1.2, 0.62) (-0.8, 0.66) (-0.4, 0.77) (0, 1) (0.4, 1.08) (0.8, 1.127) (1.2, 1.18) (1.6. 1.21) (2, 1.21)	
propensity needed to maintain support (PUSRTh)	Constant (propensity)	The maximum propensity to use 'allowed' before support is decreased.		-10

[230]

AT propensity affect support received (ATPUSR)	Delay (month)	How far back propensity to use is averaged before adjusting support, plus how long it takes to perceive a change in propensity.	2
Effect of Social Role Functioning on Support Received (EffSRSRF)	Table function (dmnl)	How social role functioning affects support received.	(0, 0.76) (0.2, 0.76) (0.4, 0.79) (0.6, 0.81) (0.8, 0.87) (1, 1) (1.2, 1.10) (1.4, 1.15) (1.6, 1.18) (1.8, 1.21) (2, 1.21)
social role functioning needed to maintain support (SRFSRTh)	Converter (functioning)	Minimum amount of functioning needed to maintain support.	60 for low init support; 50 for average, 20 for high
AT functioning affect support (ATSRFSR)	Delay (month)	How far back the loved one averages functioning when changing support.	6
support sought needed to maintain support received (SSTh)	Constant (support)	How much a PWUD needs to seek support before loved ones provide support.	40
Effect of Support Sought on Support Received (EffSSSR)	Table function (dmnl)	How support sought by PWUD affects support received from loved ones.	(0, 0.81) (0.2, 0.82) (0.4, 0.82) (0.6, 0.83) (0.8, 0.89) (1, 1) (1.2, 1.10) (1.4, 1.15) (1.6, 1.18) (1.8, 1.20) (2, 1.21)
AT support sought affect support received (ATSSSR)	Delay (month)	How far back the loved one considers previous support sought when changing support.	12

[231]

Fatigue (Fat)	Stock (fatigue)	The amount of fatigue with the lifestyle and drug use experienced by the PWUD.	$Fat(t) = \int_0^t Fat(u) * du + Fat(0); Fat(0) = 50$
changing fatigue (changing Fat)	Flow (fatigue/month)	The rate of change in fatigue.	$changing\ Fat = \frac{(Fat*EffPUFat*EffSRFFat-Fat)}{ATFat}$
AT fatigue (ATFAT)	Delay (month)	How long it takes for fatigue to change.	120
Propensity needed to maintain fatigue (PUseFatTh)	Constant (propensity)	Level of propensity above which fatigue increases.	30
AT propensity affect fatigue (ATPUseFat)	Delay (month)	Amount of time over which propensity is averaged when affecting fatigue.	6
effect of propensity to use on fatigue (EffPUFat)	Table function (dmnl)	How the propensity to use affects fatigue.	(0, 0.70) (0.2, 0.71) (0.4, 0.72) (0.6, 0.77) (0.8, 0.84) (1, 1) (1.2, 1.20) (1.4, 1.30) (1.6, 1.37) (1.8, 1.41) (2, 1.44)
Point at which functioning maintains fatigue (SRFFatTh)	Constant (functioning)	The level of functioning above which fatigue begins to fall.	SRF(0)
Effect of social role functioning on fatigue (EffSRFFat)	Table function (dmnl)	How fatigue changes as functioning falls above or below its initial value.	(0, 1.68) (0.2, 1.66) (0.4, 1.63) (0.6, 1.55) (0.8, 1.30) (1, 1.00) (1.2, 0.77) (1.4, 0.65) (1.6, 0.60) (1.8, 0.58) (2, 0.55)
AT functioning affect fatigue (ATSRFFat)	Delay (month)	Amount of time over which functioning is averaged when affecting fatigue.	36

[232]