

Novel Behavioral Economic Approaches for Measuring Substance Use Severity and Motivating Change

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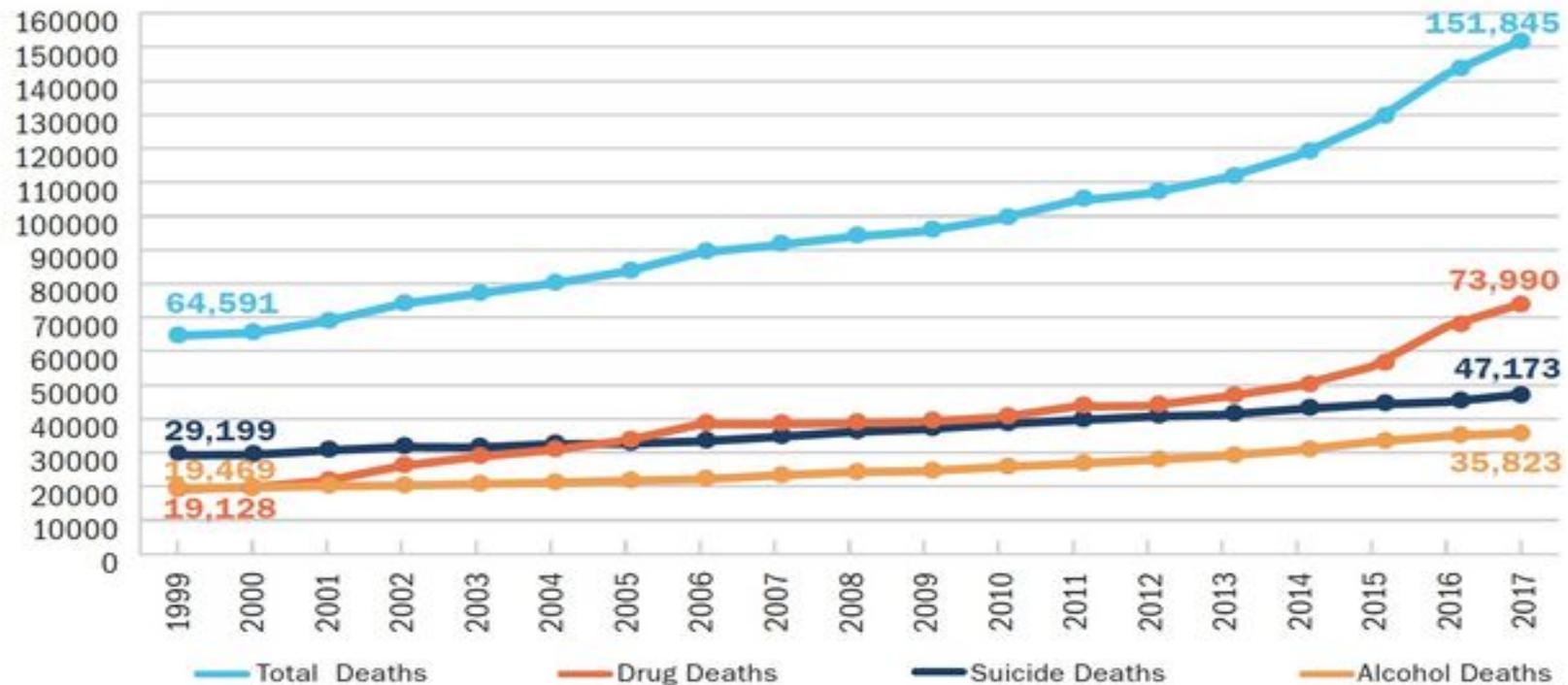
Acknowledgements

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America is experiencing unprecedented increases in “deaths of despair”

Annual Deaths from Alcohol, Drugs, and Suicide in the United States, 1999–2017



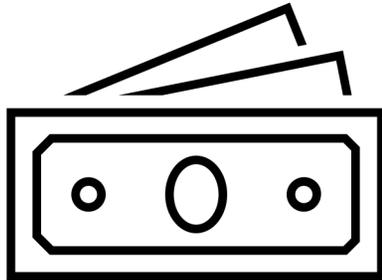
Source: Trust for America's Health and Well Being Trust analysis of data from National Center For Health Statistics, CDC

Behavioral Economic and Reinforcer Pathology

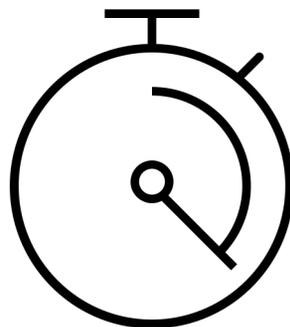
Models of Alcohol and Drug Use

Focus on choice: behavior is allocated to an activity based on the **cost/benefit ratio** of that activity relative to other available activities

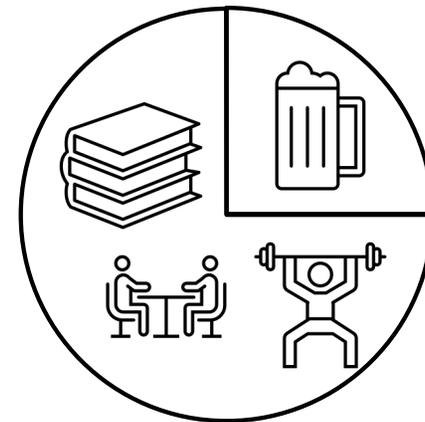
levels of drug use are sensitive to:



Price



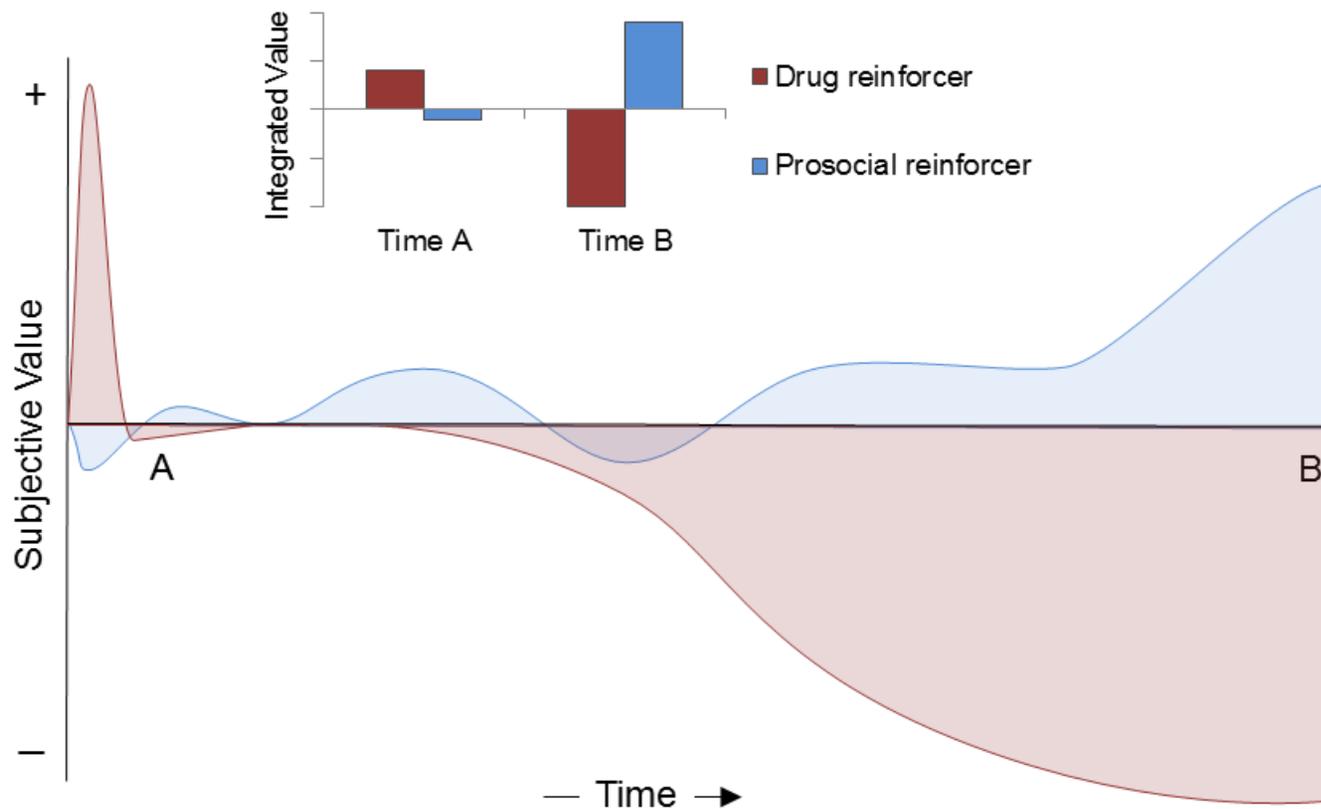
Delay to
Reward



Alternatives

Addiction = drugs have greater reinforcing value than available alternatives

Reinforcer Pathology: Why do people sometimes choose drug rewards even in the presence of alternatives?



Bickel, Johnson, Koffarnus, MacKillop, & Murphy (2014). *Annual Review of Clinical Psychology*.

Figure 2. Depiction of the accrual of reinforcing value of two commodities over time. The y axis represents relative subjective value, and the x axis represents time over a course of years. The red curve depicts the reinforcing value of choosing to engage with a drug reinforcer, such as alcohol, at different time points. The blue curve represents the reinforcing value of

Behavioral Economic Measures of Substance Use Risk/Severity

- **Reinforcing Efficacy:** *individual differences* in the extent to which an individual *wants* or values a substance
 - Demand curves²⁻⁵
 - Relative substance-related activity participation and enjoyment (reinforcement-ratio)^{2,5}
- Ability to experience and access to **substance-free reward**⁹
 - Reward Probability Index (RPI)⁶, measures of anhedonia
- **Intertemporal choice or future orientation:**
 - Delay discounting, Consideration of future consequences, Relative discretionary monetary allocation^{7,8}

¹ Murphy et al., 2005; ² Murphy & MacKillop, 2006; ³ Dennhardt, Yurasek, & Murphy, 2015 ⁴ Roma, Hursh, & Hudja, 2015; ⁵ Morris et al., 2017, ⁶ Carvalho et al., 2011, ⁷ MacKillop et al., 2011; ⁸ Tucker et al., 2019; ⁹ Acuff, Dennhardt, Correia, & Murphy, 2019.

Alcohol Reinforcing Efficacy: Hypothetical Alcohol Purchase Task (Demand Curve Measure)

"Imagine that you and your friends are at a bar from 9pm to 2am to see a band. The following questions ask how many drinks you would purchase at various prices. The available drinks are standard size beer (12oz), wine (5oz), shots of hard liquor (1.5oz), or mixed drinks with one shot of liquor. Assume that you did not drink alcohol before you went to the bar and will not go out after."



How many drinks would you have if they were free?_____

How many drinks would you have if they were \$.25 each?_____

How many drinks would you have if they were \$.50 each?_____

How many drinks would you have if they were \$1.00 each?_____

How many drinks would you have if they were \$2.00 each?_____

How many drinks would you have if they were \$3.00 each?_____

How many drinks would you have if they were \$4.00 each?_____

How many drinks would you have if they were \$5.00 each?_____

Murphy and MacKillop (2006).
*Experimental and Clinical
Psychopharmacology.*

Demand Curve Measures of Reinforcing Efficacy

Consumption Curve

Intensity:

consumption at minimal price

Elasticity:

slope of the demand curve

- to what degree to participants respond to changes in price

Breakpoint:

Price when consumption is 0

Expenditure Curve

O_{max} :

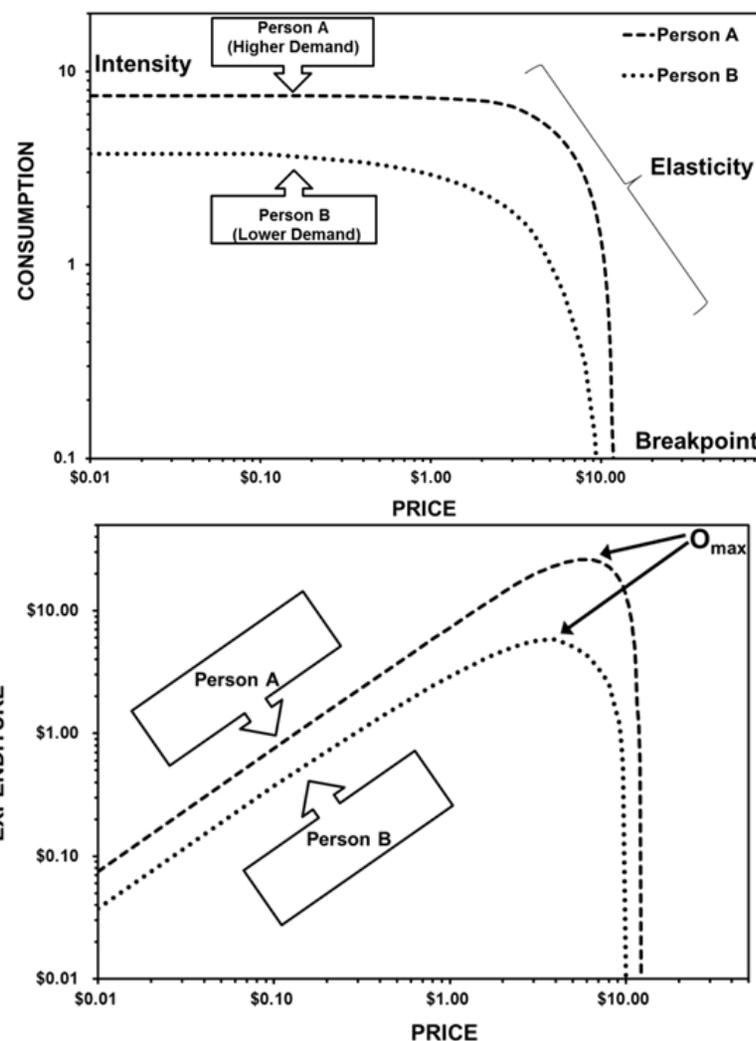
Maximum expenditure

P_{max} :

Maximum inelastic price

*Indices are reliable and correlated with actual drink purchases in lab

(Amlung et al., 2012; Acuff & Murphy 2017)

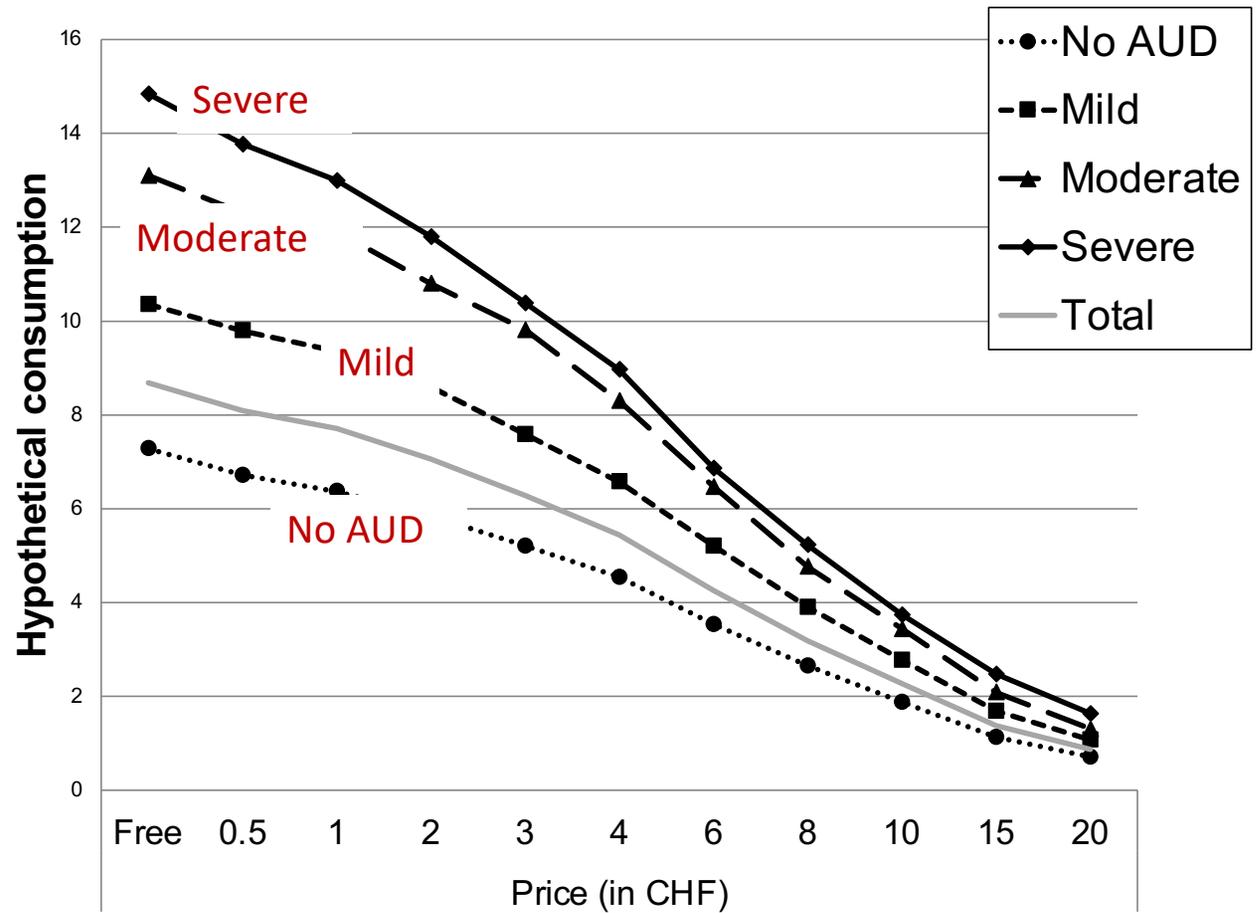


High/Inelastic Demand is Uniquely Associated with Alcohol and Drug Problem Severity

- Higher demand is associated with:
 - greater levels of alcohol/drug problems^{1,7,8}
 - craving²
 - impulsivity³
 - drinking to cope⁴
 - cigarette smoking⁵
 - comorbidity (depression and PTSD)⁶

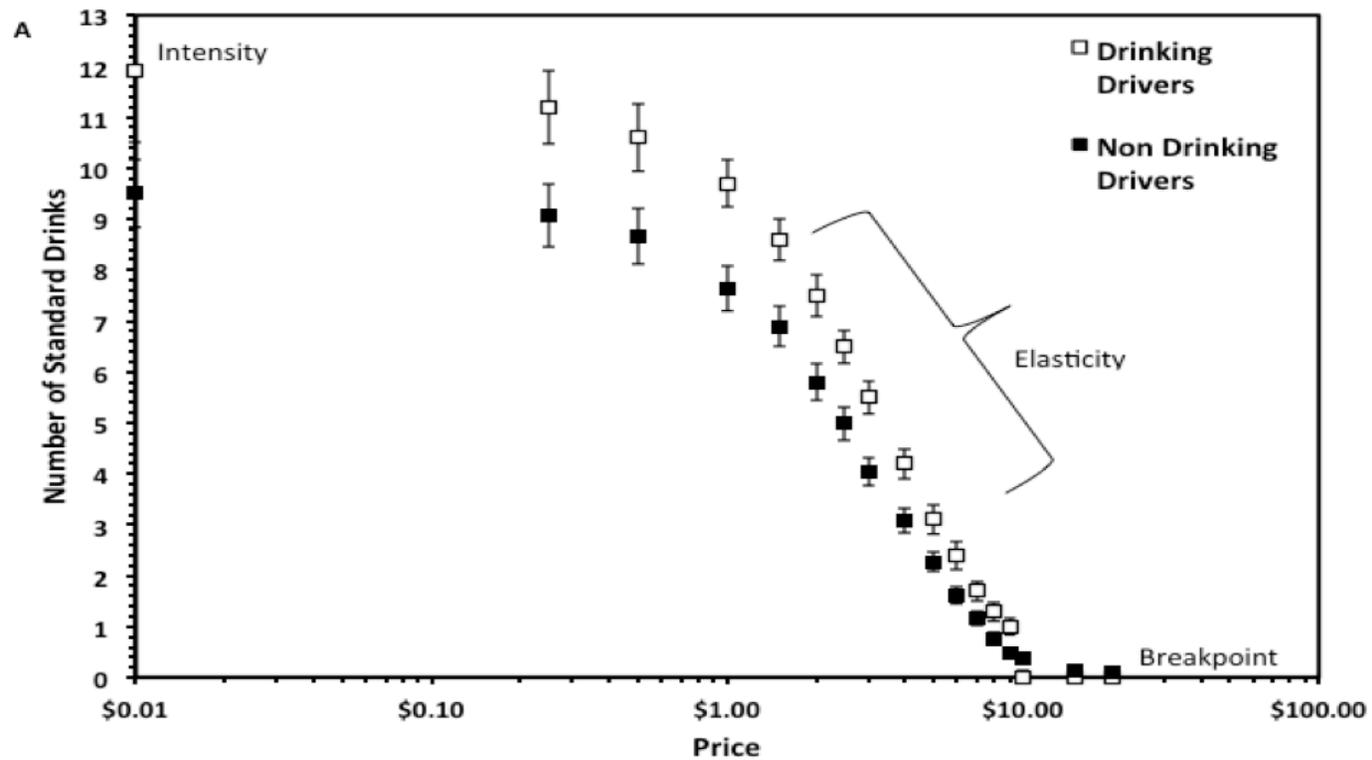
¹Murphy & MacKillop, 2006; ²MacKillop et al., 2010; ³Smith et al., 2010; ^{4,5}Yurasek et al., 2011, 2013; ⁶Murphy et al., 2013; ⁷Skidmore & Murphy, 2014; ⁸Morris et al., 2017

Alcohol Demand and DSM-5 Alcohol Use Disorder (AUD) Symptoms in a Large Swiss Population Sample (N = 4790 men)



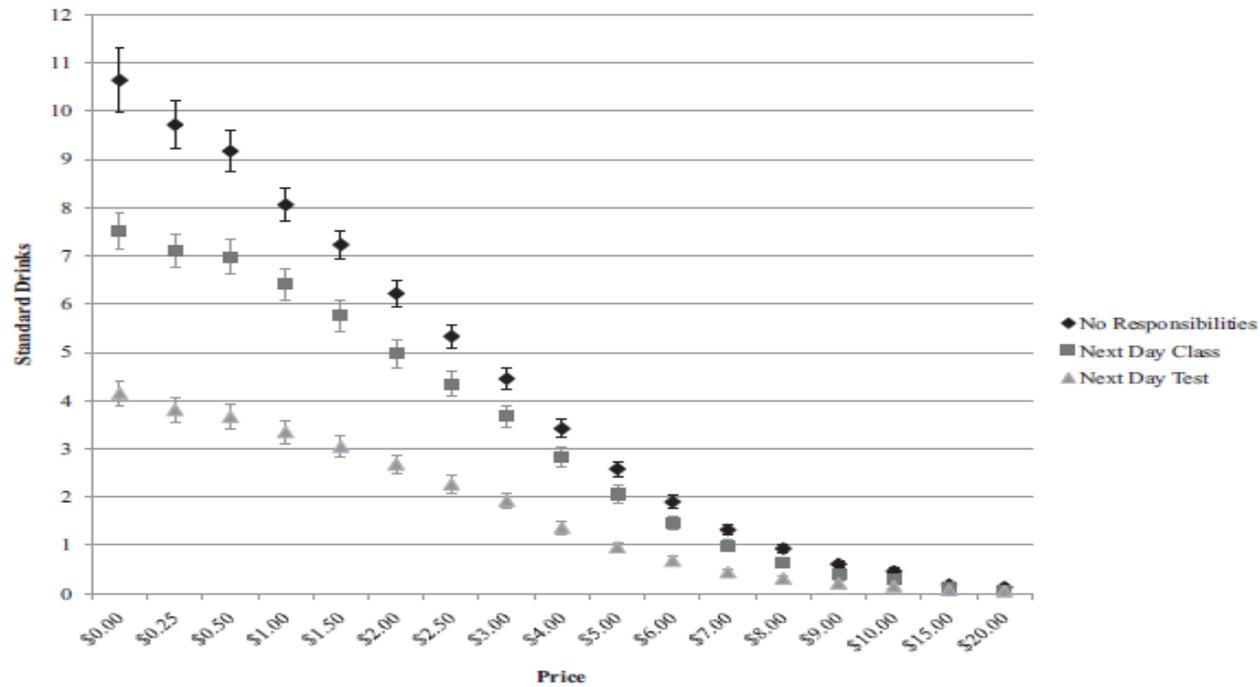
Bertholet, Murphy, Daeppen, Gmel, & Gaume (2015). *Drug and Alcohol Dependence*

Elevated Alcohol Demand Uniquely Predicts Drinking and Driving



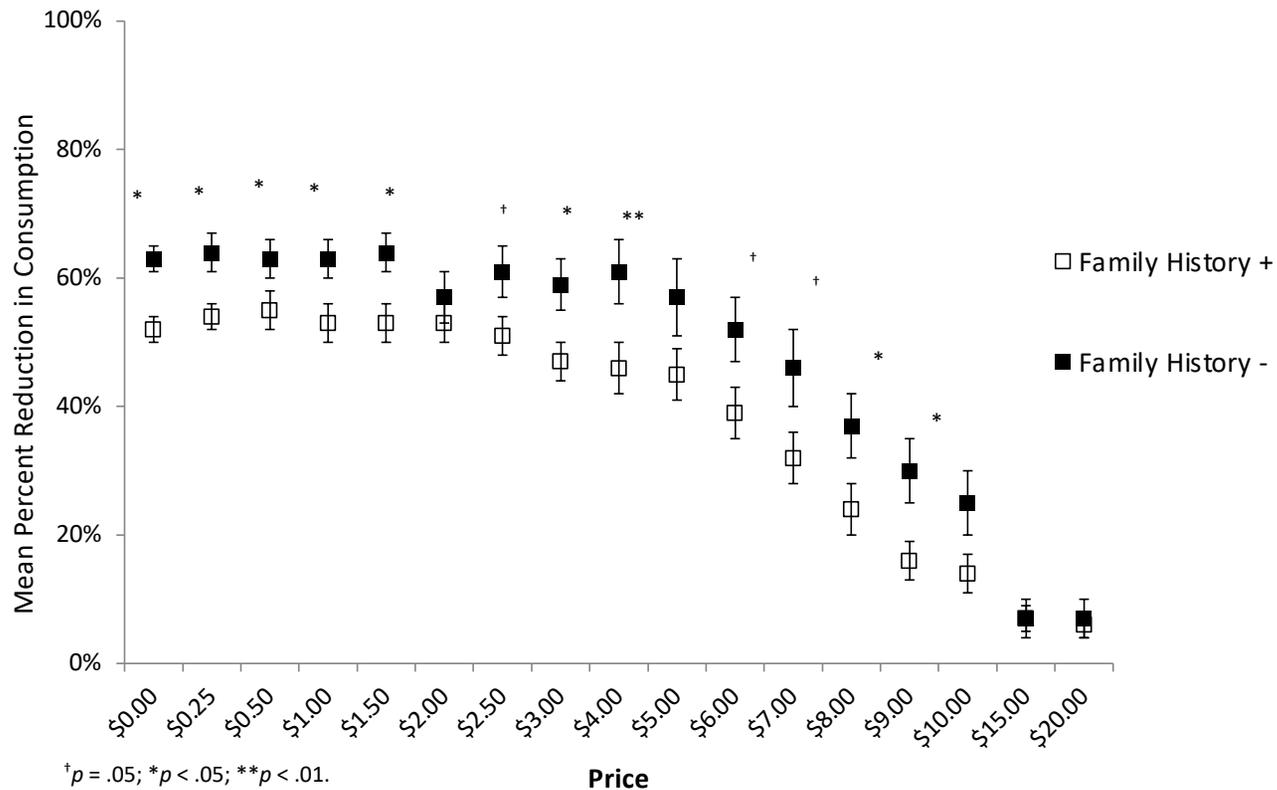
- Teeter & Murphy (2015). *ACER*; Teeters, Meshesha, Pickover, & Murphy (2014). *ACER*

Demand for Alcohol is Sensitive to Next-Day Contingencies



Skidmore & Murphy (2011). *Psychology of Addictive Behaviors*.

Family History is Related to Less Sensitivity of Demand to Next-Day Contingencies

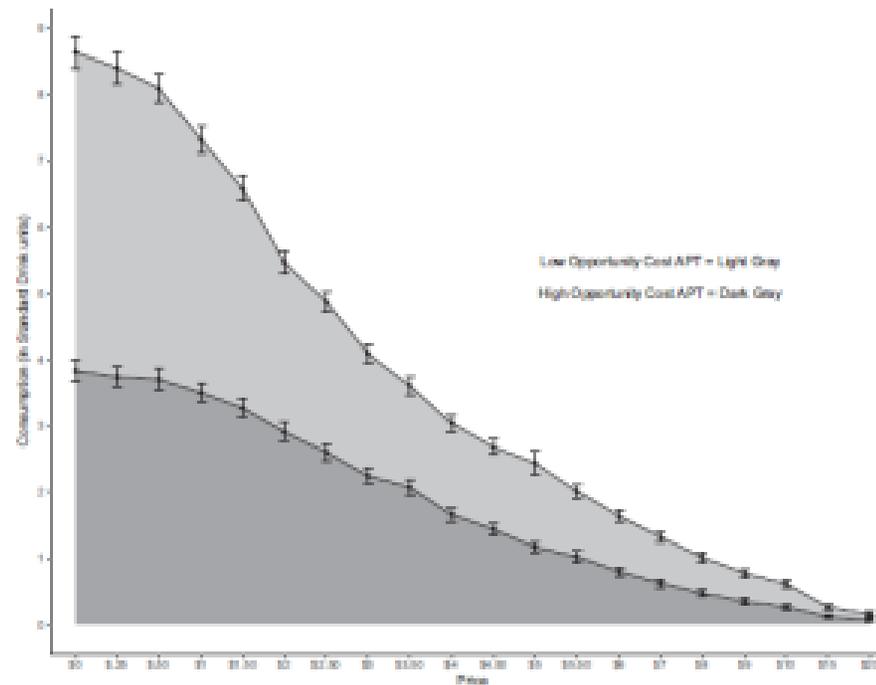


Murphy, Yurasek, Dennhardt, Meshesha et al. (2014). *Journal of Studies on Alcohol and Drugs*.



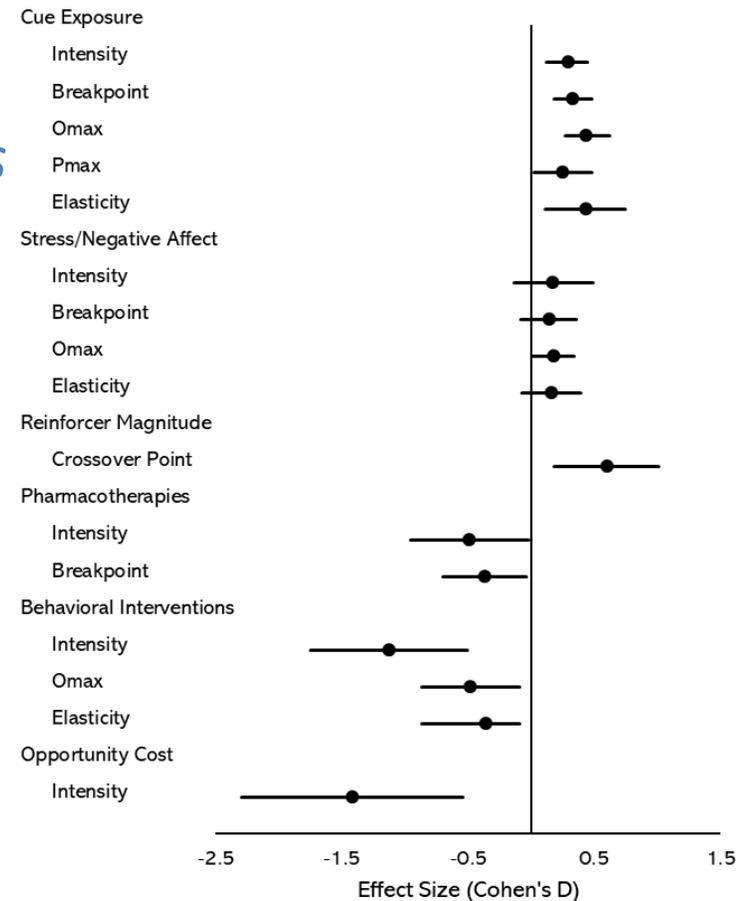
High Opportunity Cost Demand as an Indicator of Weekday Drinking and Distinctly Severe Alcohol Problems: A Behavioral Economic Analysis

Keenan J. Joyner , Lidia Z. Meshesha, Ashley A. Demchak, Brian Bonart, Matthew P. Martens, and James S. Murphy



Experimental manipulations of behavioral economic demand for addictive commodities: A meta-analysis

- The strength of a substance reinforcer is affected by:
 - Cue exposure
 - Stress
 - Magnitude
 - Opportunity Cost
- Pharmacotherapies and behavioral treatment reduce demand



Acuff, Amlung, Dennhardt, MacKillop, & Murphy (2019).
Addiction

Relative substance-related activity participation and
enjoyment (reinforcement-ratio) Measures of
Reinforcing Efficacy

Modified Reinforcement Survey: Adolescent Reinforcement Survey Schedule

<u>Activities</u>	Frequency with alcohol or drugs	Frequency without alcohol or drugs	Enjoyment with alcohol or drugs	Enjoyment without alcohol or drugs
1. Go places with siblings or family members				
2. Talk with friends				
3. Read a book				
4. Go on a date				

Frequency

0 = 0 times

1 = once a week or less

2 = 2-4 times per week

3 = about once a day

4 = more than once day

Enjoyment

0 = unpleasant or neutral

1 = mildly pleasant

2 = moderately pleasant

3 = very pleasant

4 = extremely pleasant

Frequency X Enjoyment = Obtained Reinforcement

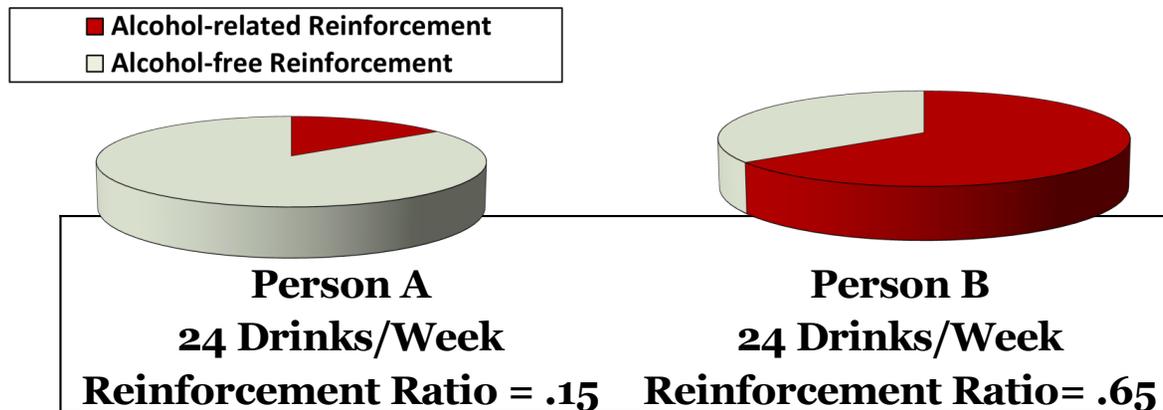
Correia & Carey (1999). *Psychology of Addictive Behaviors*; Acuff et al., 2019.

Relative Behavioral Allocation and Enjoyment Related to Substance Use vs. Other Activities

Reinforcement Ratio:

Substance-Related Reinforcement

$$\frac{\text{Substance-Related Reinforcement}}{\text{Substance-Related Reinforcement} + \text{Substance-Free Reinforcement}}$$



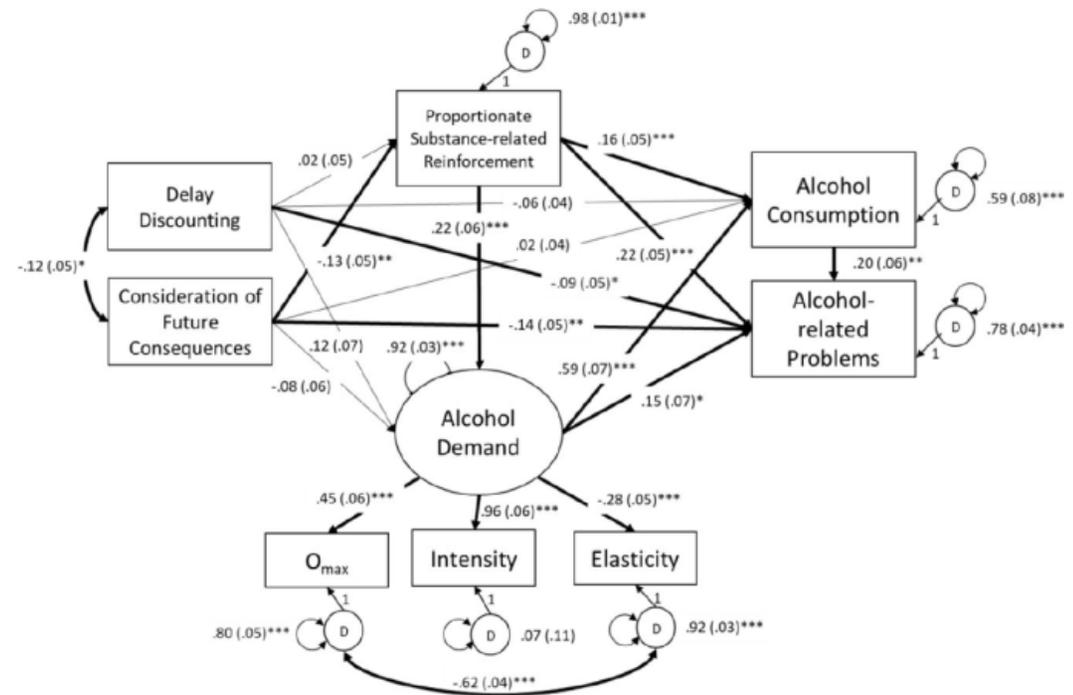
-reliable, and associated with alcohol use and problems

(Hallgren et al., 2016; Magidson et al., 2017; Morris et al., 2017; Skidmore et. al 2014)

Structural Equation Model of Reinforcer Pathology

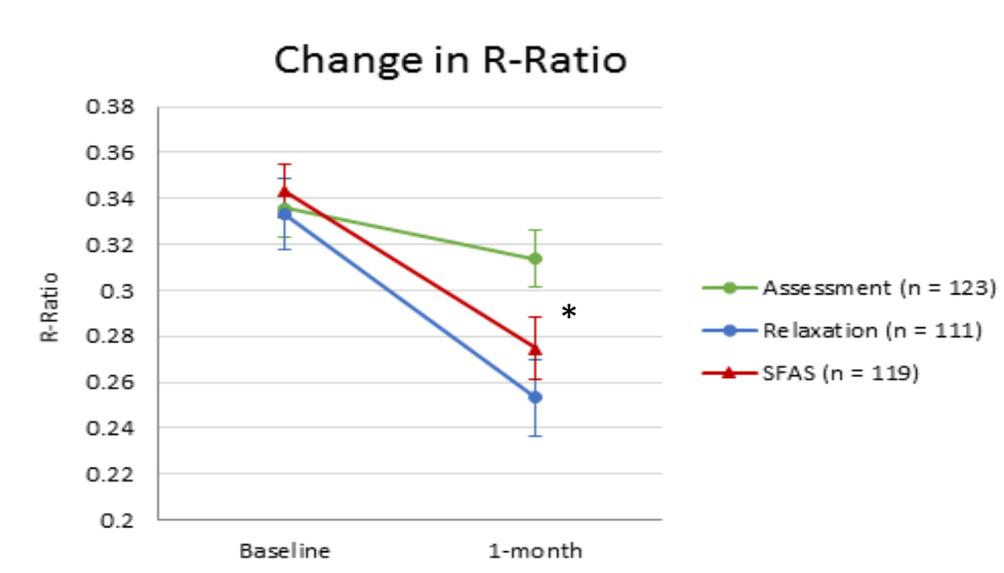
Variables Predicting Alcohol Use and Problems

- Alcohol demand and proportionate substance-related reinforcement independently associated with greater alcohol consumption and problems
- Consideration of Future Consequences was associated with alcohol-related problems and proportionate substance-related reinforcement but was not significantly associated with alcohol consumption or alcohol demand
- Small counter-intuitive association b/t delay discounting and alcohol problems



Acuff, Soltis, Denhardt, Berlin, & Murphy, *ACER*. (2018)

Behavioral Treatment Reduces Reinforcement Ratio, Change in R-Ratio following intervention may be a marker of successful treatment

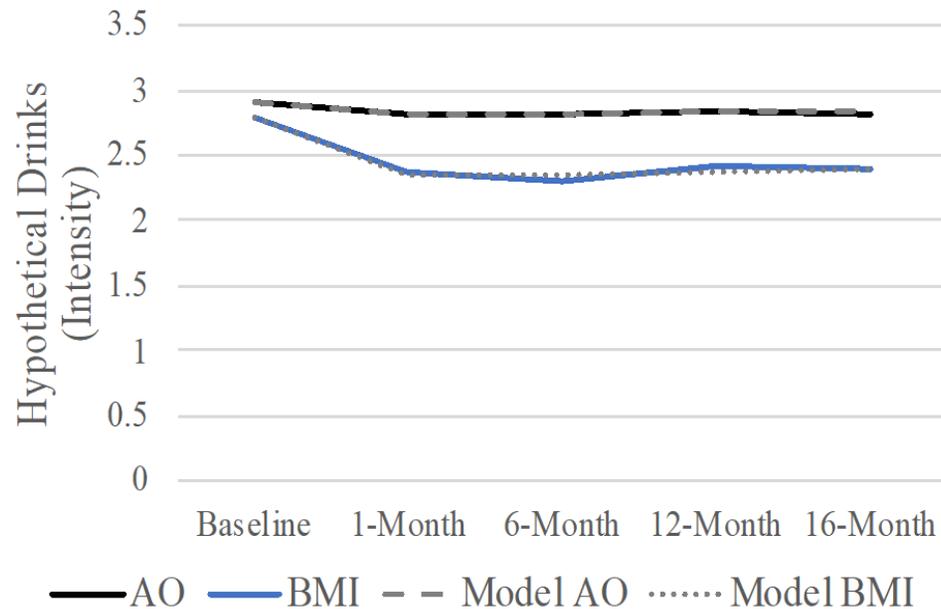
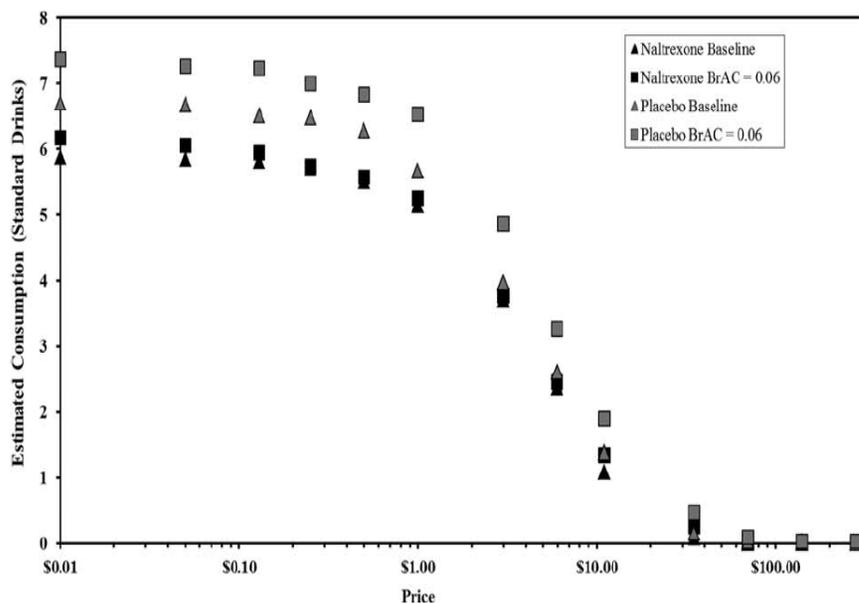


Brief motivational interventions reduce reinforcement-ratio relative to control at 1-month, and change in reinforcement-ratio mediates treatment outcomes over 16-months¹⁻⁴

- Similar results with natural recovery samples (relative alcohol-related discretionary expenditures⁵)
- Similar results with weight loss intervention (relative food-free reinforcement)⁶

¹Dennhardt et al. (2014); ²Murphy et al. (2005); ³Murphy et al. (2015); ⁴Murphy et al. (2019) ⁵Tucker et al 2009; ⁶Buscemi et al 2014

Pharmacological and Behavioral Treatment Reduces Alcohol Demand, Change in demand immediately following intervention may be a marker of successful treatment



Naltrexone

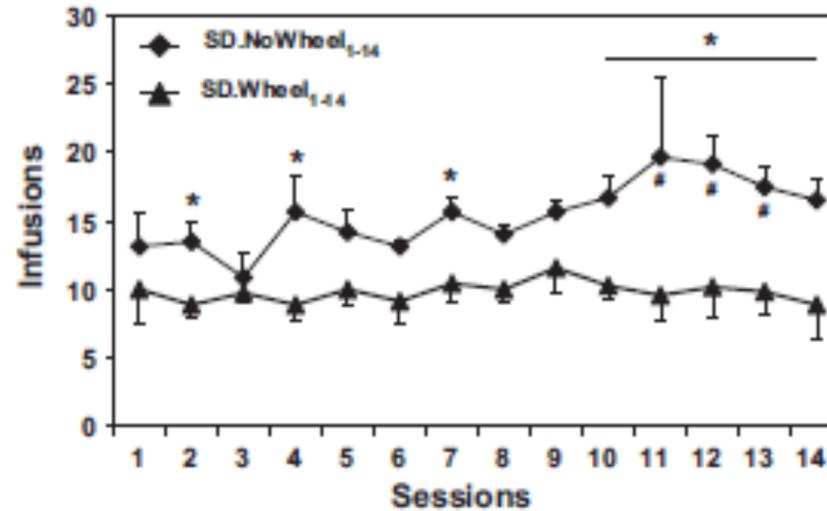
Bujarski, MacKillop, & Ray (2012) *ECP*.

Motivational Interviewing

Murphy, Dennhardt et al. (2015). *JCCP*.

Soltis, Acuff, Campbell, Mun, Dennhardt, Borsari, Martens, & Murphy (under review)

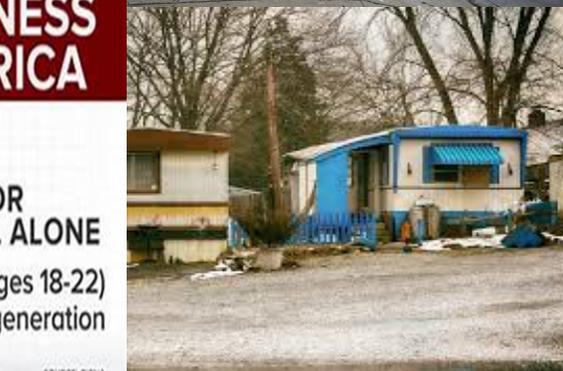
Reward Deprivation is a Risk Factor for Drug Self-Administration and Addiction



Alexander et al., 1978; 1981; Higgins et al., 2004; Miller et al. (2012).
Drug and Alcohol Dependence; see also Ginsberg and Lamb (2018).

Factors Contributing to Reward Deprivation Among Humans

- Poverty, lack of access to quality education
 - association b/t drug use and poverty is mediated by reward deprivation
 - Andrabi, Khoddam, & Leventhal, 2017
 - Discrimination, systemic racism (racial trauma)
 - Environments that lack access to social/leisure activities
 - Mental health conditions (depression, social skill deficits)
 - Medical conditions that cause pain or limit activities
 - Transitions/life events –
 - Unemployment, divorce, moving, diminished access to hobbies/sports
 - Chronic alcohol and drug use erodes natural sources of reward
 - impairs health, work, relationships; reduces neural sensitivity to drug-free reward
- Addiction is both a “brain disease”
& an “environmental disease”**



**LONELINESS
IN AMERICA**

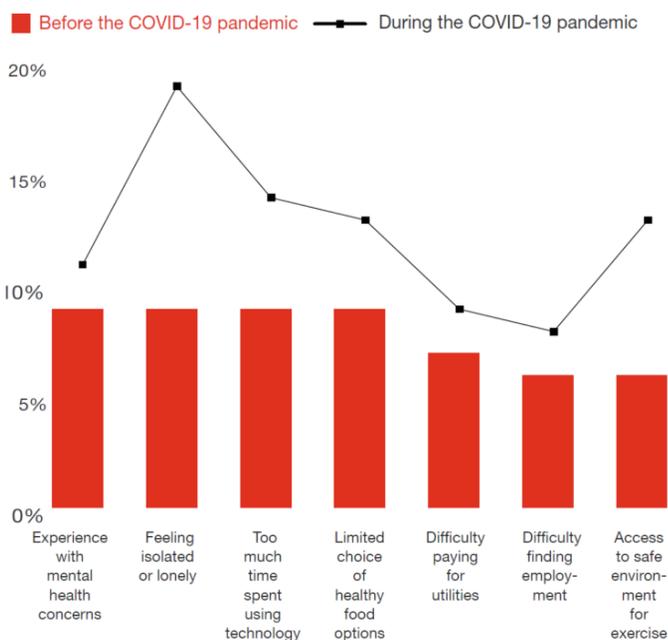
46%
SOMETIMES OR
ALWAYS FEEL ALONE

■ GEN Z (adults ages 18-22)
is the loneliest generation

COVID-19 Pandemic Reward Deprivation and Mental Health

Which, if any, of the following challenges in your daily life are impacting your ability to adopt a healthy lifestyle?

Please select all that apply.



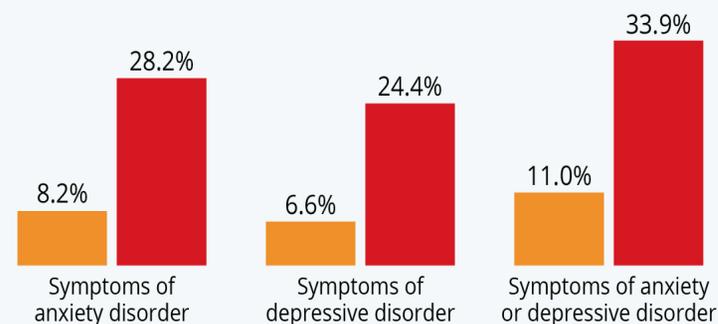
Note: Selected options displayed. Other options included: Not getting enough sleep, lack of motivation to become healthier, smoking, access to affordable housing, alcohol consumption, etc.

PwC Health Research Institute COVID-19 Consumer Survey, April 2-8, 2020

Pandemic Causes Spike in Anxiety & Depression

% of U.S. adults showing symptoms of anxiety and/or depressive disorder*

■ January-June 2019 ■ May 14-19, 2020



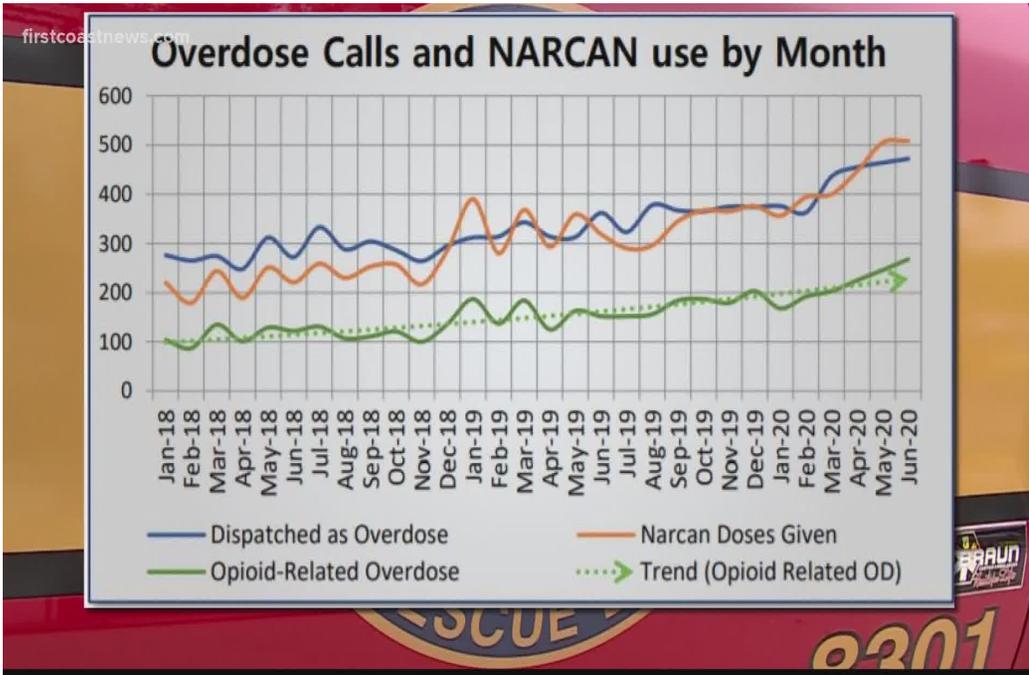
* Based on self-reported frequency of anxiety and depression symptoms. They are derived from responses to the first two questions of the eight-item Patient Health Questionnaire (PHQ-2) and the seven-item Generalized Anxiety Disorder (GAD-2) scale.

Sources: CDC, NCHS, U.S. Census Bureau



statista

COVID-19 Pandemic and Alcohol and Drug Use



ALCOHOLIC BEVERAGES BOOM ONLINE DURING COVID-19

Alcohol Weekly Sales Growth vs. Year Ago



Source: 1) Nielsen Retail Measurement Services, Total US All Outlets Combined (xAOC) including Convenience and Liquor Stores, 2) Nielsen e-commerce measurement powered by Rakuten Intelligence, Total US, 1-week periods, latest period to Apr. 25, 2020

Copyright © 2020 The Nielsen Company (US), LLC. All Rights Reserved.

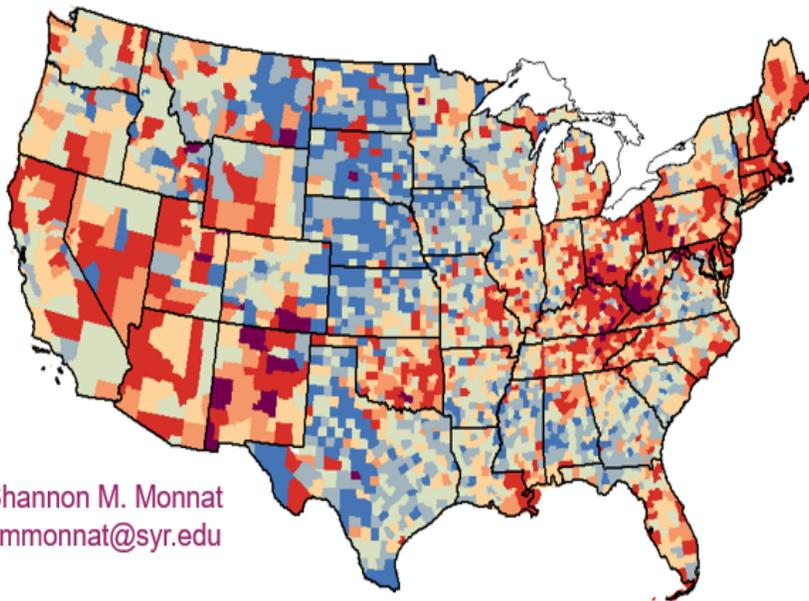
BEER. WINE. & LIQUOR
Delivered right to your door in under an hour.



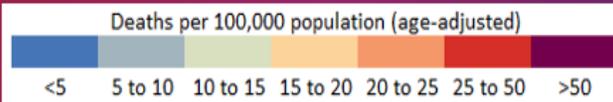
Acuff, Tucker, & Murphy (in press).
Experimental and Clinical Psychopharmacology

Context/Reward Deprivation and The Overdose Epidemic

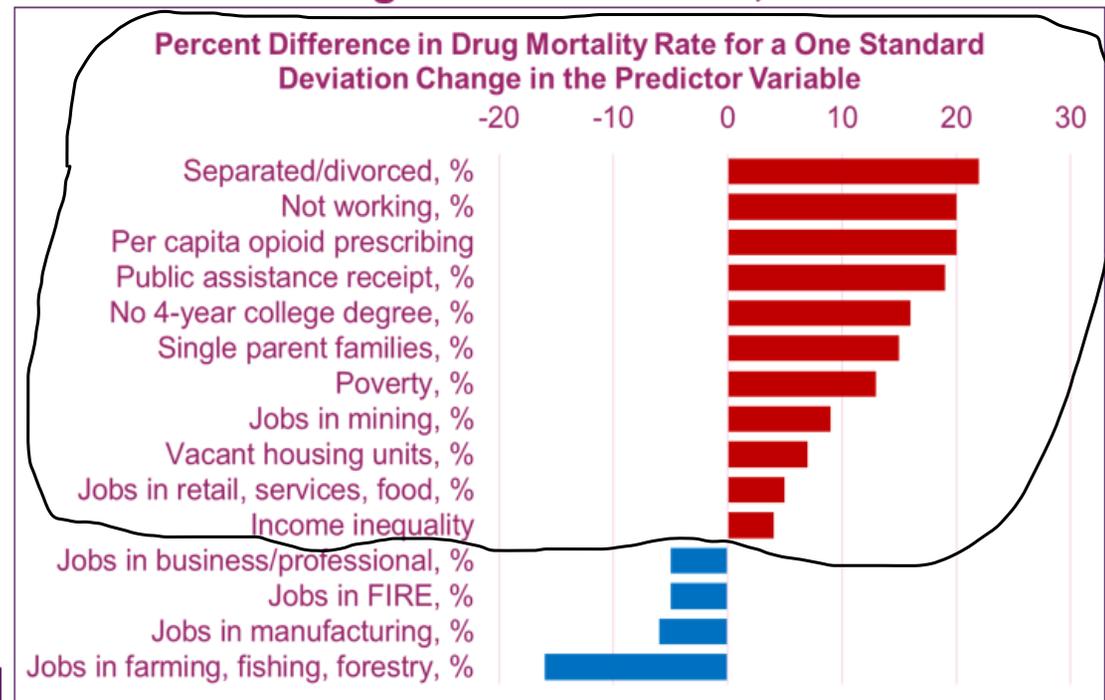
Fatal Drug Overdose Rates are Much Higher in Some Places than Others



Shannon M. Monnat
smmonnat@syr.edu



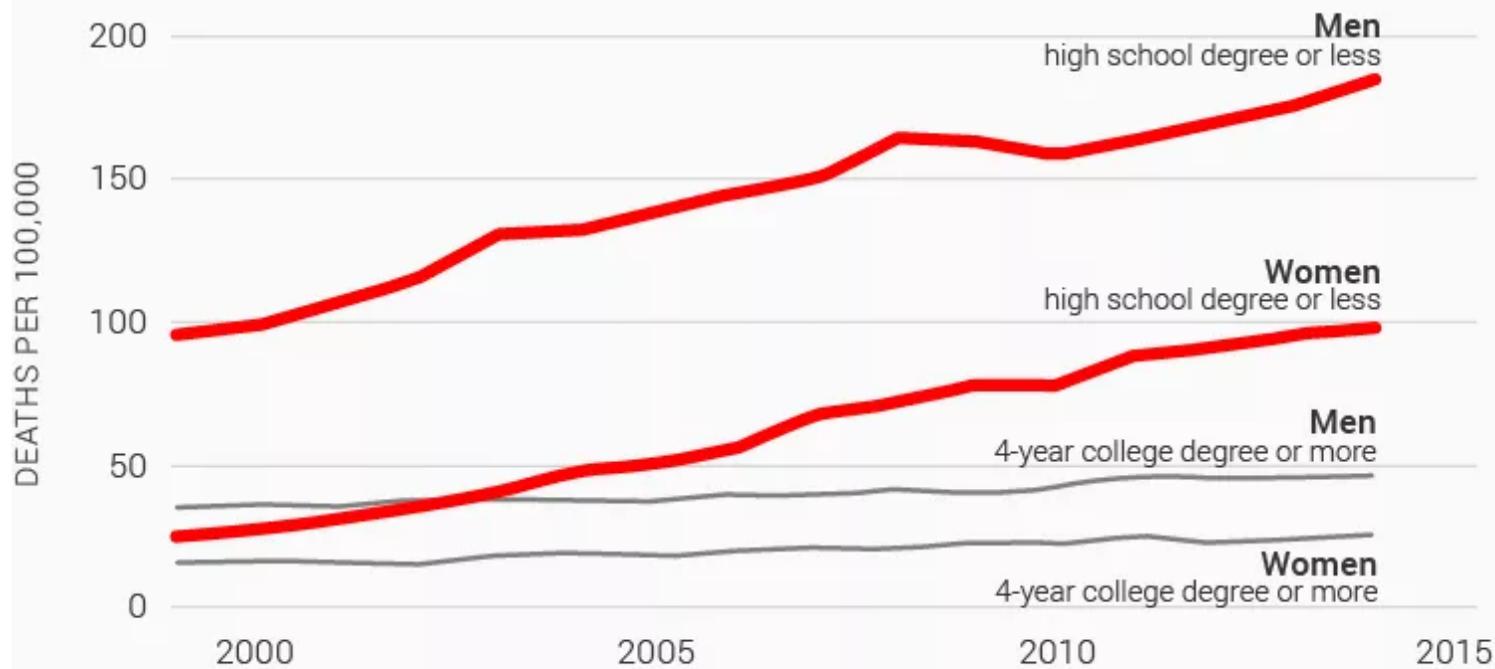
Factors Contributing to Geographic Differences in Fatal Drug Overdose Rates, 2014-16



Monnat, Shannon M. 2018. "Factors Associated with County-Level Differences in U.S. Drug-Related Mortality Rates." *American Journal of Preventive Medicine* 54(5):611-619.

White non-Hispanic midlife mortality from “deaths of despair” in the U.S. by education

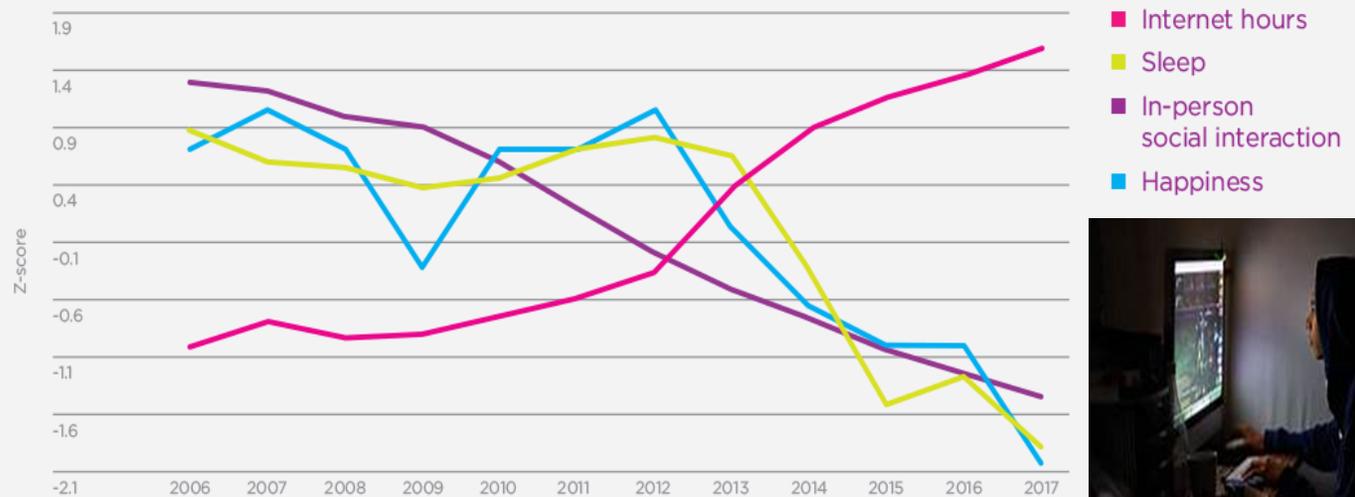
Ages 50-54, deaths by drugs, alcohol, and suicide



Source: “Mortality and morbidity in the 21st century” by Anne Case and Angus Deaton, Brookings Papers on Economic Activity, Spring 2017

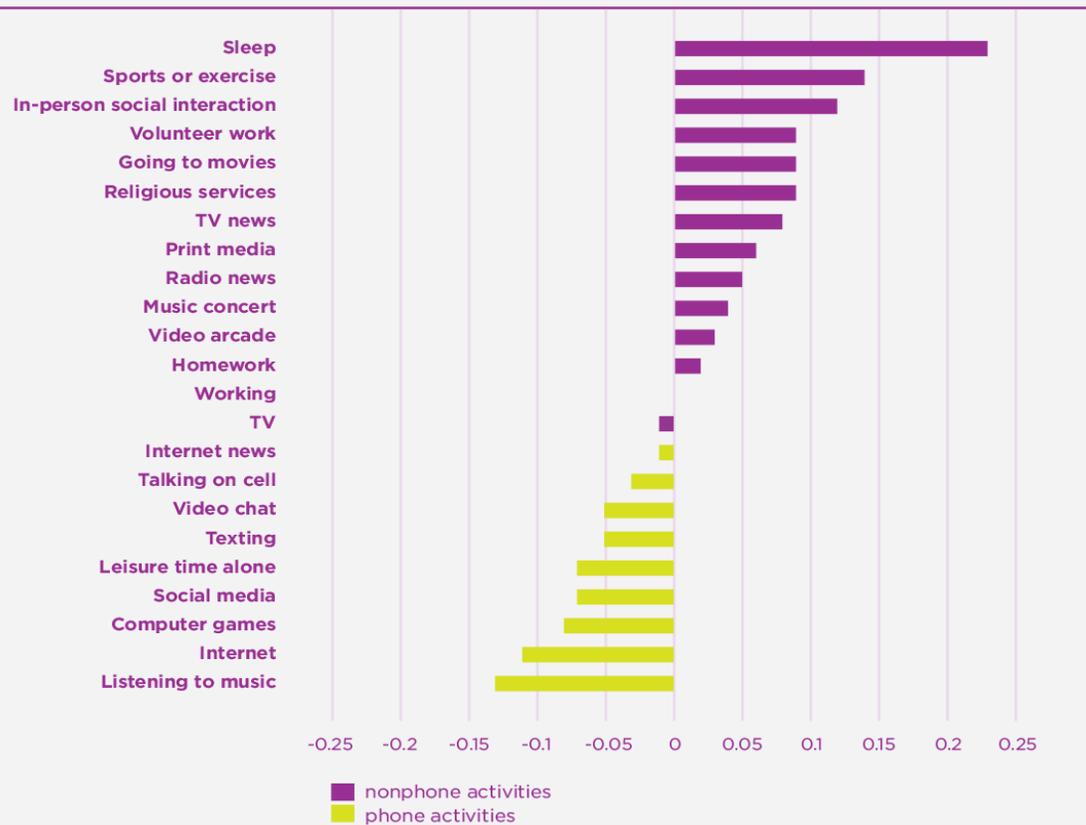
Significant Cultural Shifts May be Increasing Reward Deprivation

Figure 5.4: Time spent on the internet, sleeping more than 7 hours a night most nights, frequency of in-person social interaction across 7 activities, and general happiness, standardized (Z) scores, 8th and 10th graders, Monitoring the Future, 2006-2017

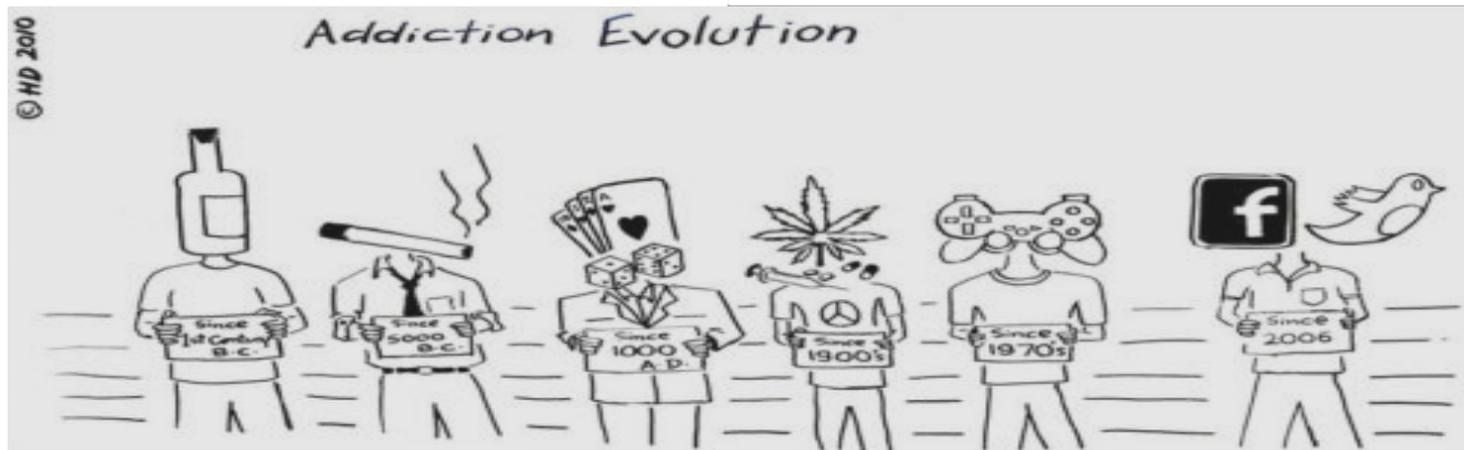
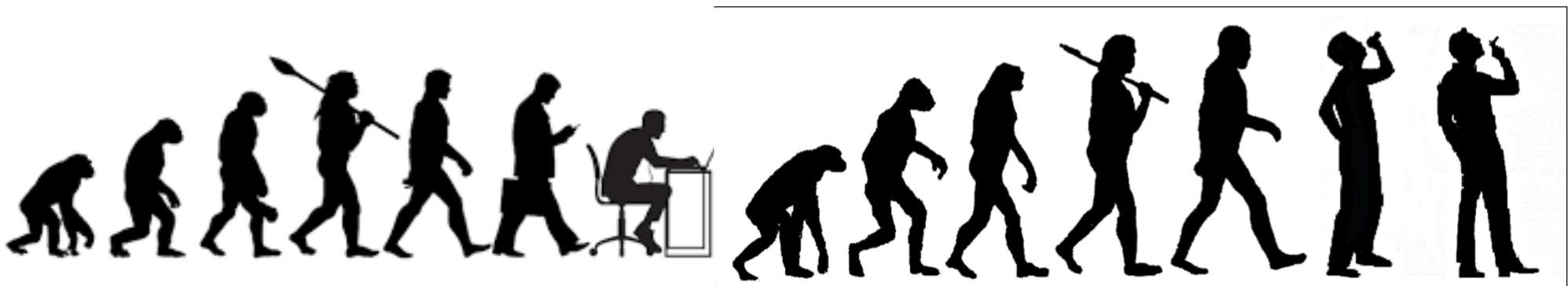


Significant Cultural Shifts May be Increasing Reward Deprivation

Figure 5.5: Correlation between activities and general happiness, 8th and 10th graders, Monitoring the Future, 2013-2016 (controlled for race, gender, SES, and grade level)



To Understand the Role of Reward and Environmental Context in Addiction (risk and recovery), we need to Understand Our Evolutionary Context



Until the past few centuries survival required sustained effort in goal directed activities, outdoor physical activity, and social cooperation





- Thus, we are biologically ill-equipped for social isolation, sedentary lifestyles
- We are prepared for “scarcity” & especially motivated to pursue short-term “low effort” rewards when they are available (next meal was uncertain)



- We are ill-equipped for food abundance & easy access to drugs and other low effort yet potent reinforcers (electronics)
- **Social activity, physical activity, and activities that increase our social status may be especially potent rewards**



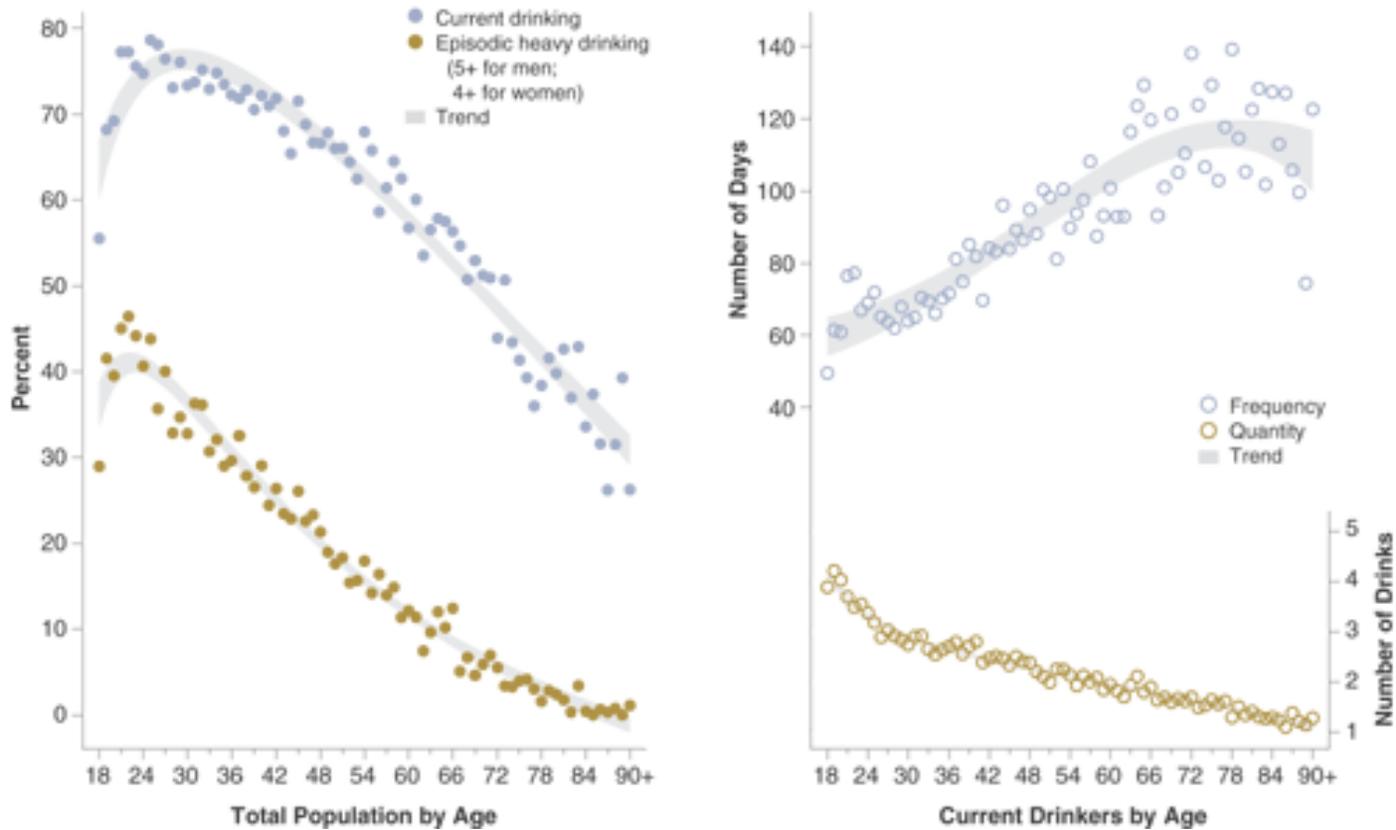
And drug rewards are often associated with social reward, especially for young adults

- lab studies demonstrate alcohol (at low doses) is an effective social lubricant
- naturalistic studies indicate that greater drinking quantity is associated with more “enjoyment”
- reductions in drinking are associated with reductions in social reward

Sayette et al 2012; Murphy et al. 2005, 2006



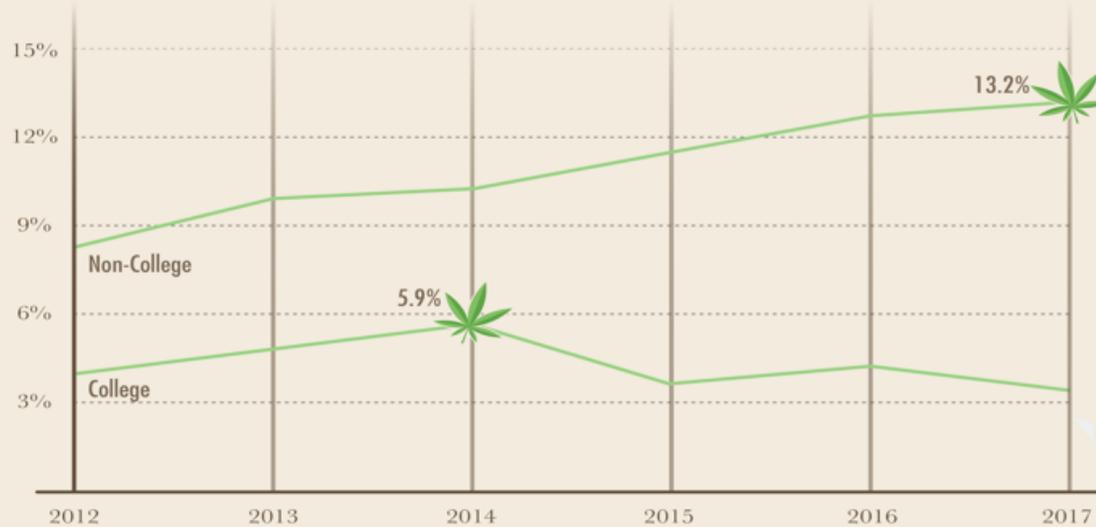
Drinking as a Function of Age



Chen et al. (2004/2005). *Alcohol Research and Health*.

Cannabis Use among Young Adults

DAILY[†] **MARIJUANA** USE CONTINUES TO RISE FOR NON-COLLEGE YOUNG ADULTS



In the past five years, daily[†] marijuana use has continued to rise for non-college young adults, reaching its highest level in 2017 at **13.2%**.

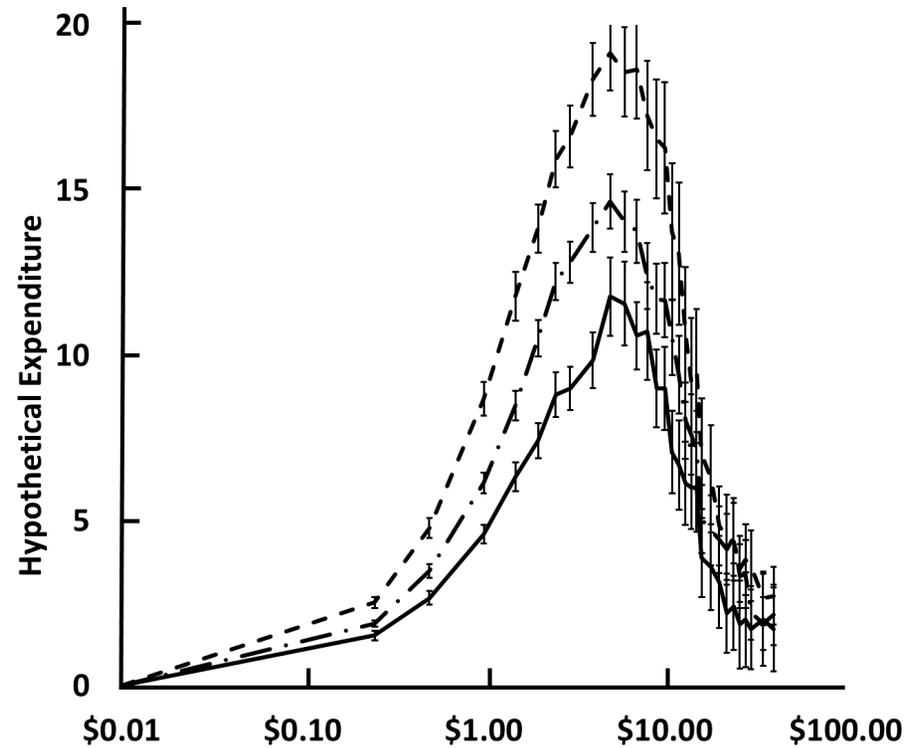
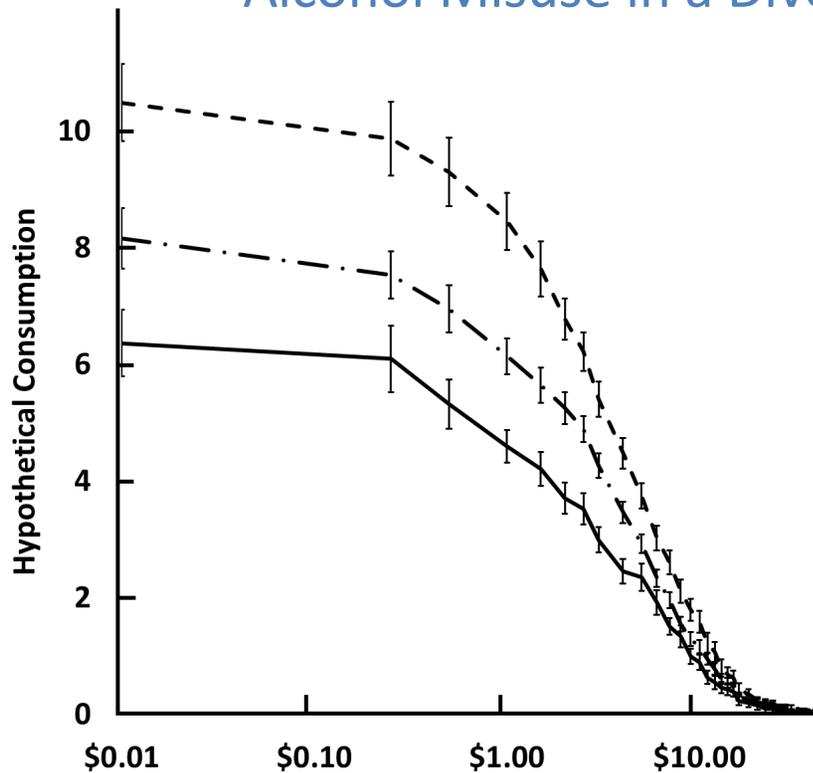
Daily[†] use is almost three times higher in the non-college group.

[†]Daily use is defined as use on 20 or more occasions in the past 30 days.



(NIDA, 2018)

Integrating Behavioral Economic and Social Network Influences in Understanding Alcohol Misuse in a Diverse Sample of Emerging Adults

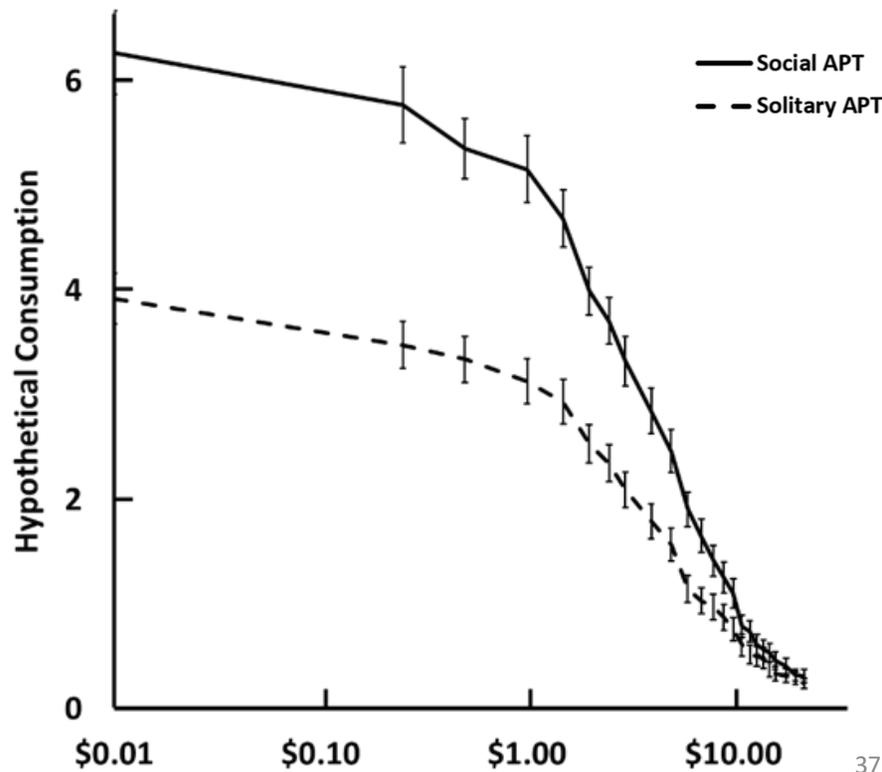


- 0 Binge Drinking Friends
- · - 2 Binge Drinking Friends
- - - 4 Binge Drinking Friends

Acuff, MacKillop, & Murphy (2020), ACER



Using Demand Curves to Quantify the Reinforcing Value of Social and Solitary Drinking



Acuff, Soltis, & Murphy (2020), ACER

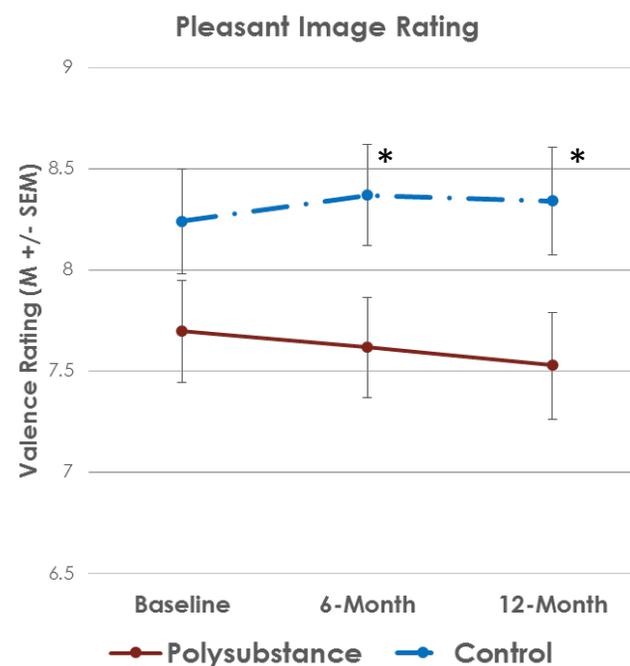
Measuring Substance-Free Reward and Reward Deprivation

Understudied relative to other behavioral economic variables (demand and delay discounting)

Challenging to identify and quantify the reinforcing value of all activities in an individual's environment compared to measuring the reinforcing value of alcohol/drugs, or delay discounting

See review by Acuff, Dennhardt, Correia, and Murphy (2019). *Clinical Psychology Review*.

Young Adult Prescription Opiate Users Show Blunted Response to Drug-Free Stimuli



- Participants – prescription opioid users vs. matched controls
- Covariates – age, gender, depression, ethnicity
- **Baseline value predicts 12 month change in alcohol use**

Meshesa, Pickover, Teeters, Murphy (2017). *The Psychological Record*. See similar studies with fMRI (Meuller) and EEG (Bartholow)

Reward Probability Index (Carvalho et al., 2011)

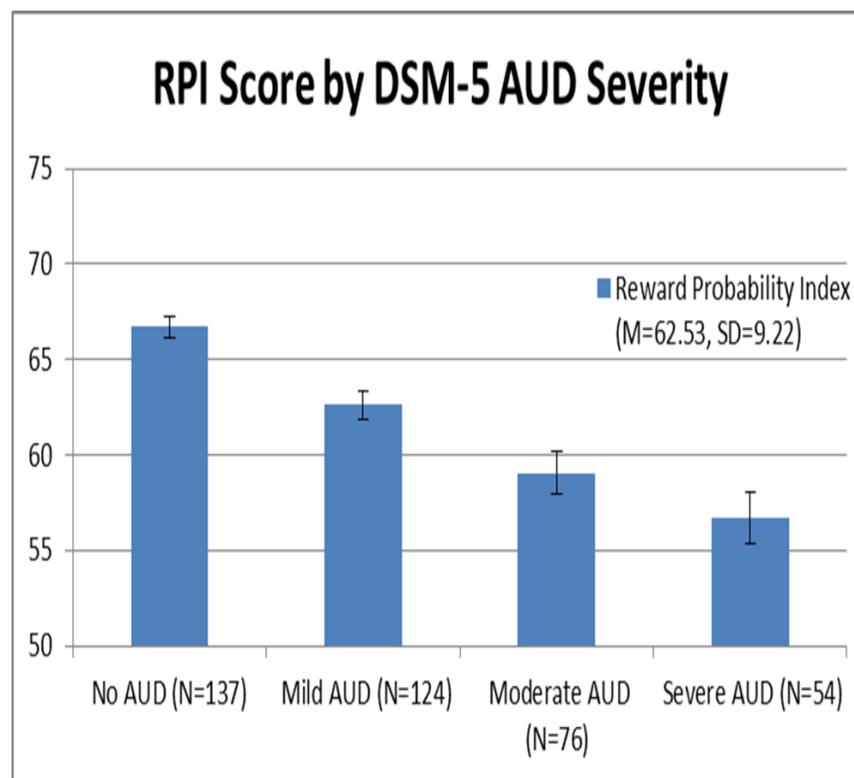
May measure more historical and persistent reward deprivation

- Environmental Suppressors (reward availability)
 - *My behaviors often have negative consequences.*
 - *I have few financial resources, which limits what I can do.*
 - *Changes have happened in my life that have made it hard to find enjoyment.*
- Reward Probability (ability to experience reward)
 - *I feel a strong sense of achievement.*
 - *There are many activities that I find satisfying.*
 - *I have many interests that bring me pleasure.*

Are AUD Symptoms Associated
with Chronic Deficits in Reward
Among Emerging Adults?

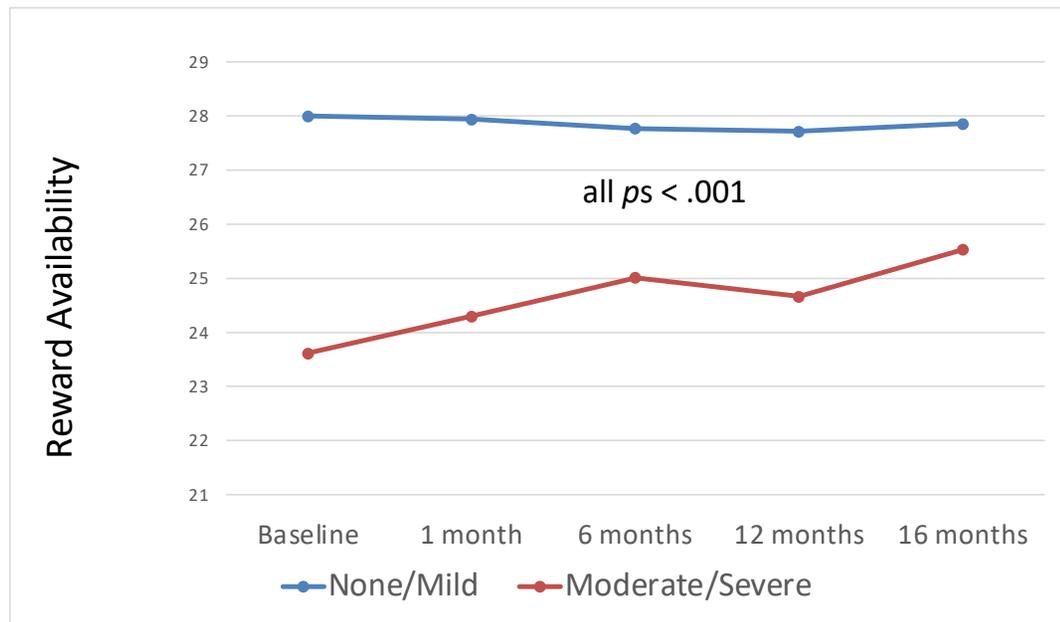
Are AUD Symptoms Associated w Chronic Deficits in Reward Among Heavy Drinking Emerging Adults?

- Baseline analyses:
RPI Total and environmental suppressors are associated with AUD symptoms beyond drinking level, depression, and demographics



Joyner, Pickover, Soltis, Dennhardt, Martens, & Murphy (2016). *Alcoholism: Clinical & Experimental Research*.

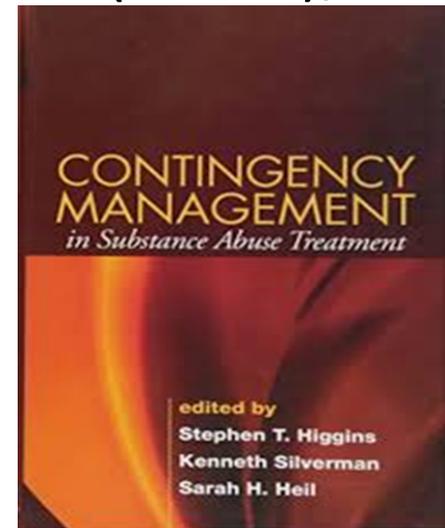
Moderate/Severe AUD Symptoms are Associated with Persistent Deficits in Reward Availability over a 16-month Timeframe



Linear growth curve models (controlling for drinking & demographics) demonstrated moderate/severe AUD group ($n = 130$) showed gradual increase in reward over time but remained lower than group of heavy drinkers with none or mild AUD ($n = 261$)

Behavioral Economic Research Provides Support for Treatments that Increase Substance-free Reward

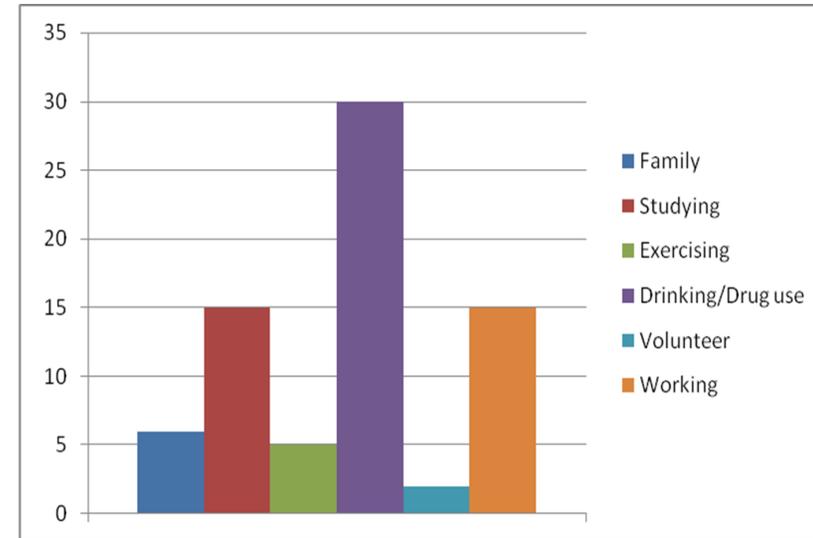
- Intensive treatments for treatment seeking populations: contingency management, community reinforcement, behavioral activation, Mindfulness Oriented Recovery Enhancement (MORE); 12-Step Interventions
- Also necessary to develop brief approaches to increase reward for non-treatment seeking populations or as an adjunct to standard treatment



Davis, Kurti et al. 2016. *Preventive Medicine*; Fazzino, Bjorlie, & Lejuez, 2019. *JSAT*.

Substance-Free Activity Session (SFAS)

- Single session behavioral economic supplement to brief motivational alcohol intervention
 - ✦ Goals are to increase:
 - positive and enjoyable substance-free activity and commitment to college/life goals (studying, internships, exercise, etc.)
 - the salience of delayed rewards
 - the extent to which behavior (e.g., attending class, internship, studying) is viewed as part of a pattern leading to delayed rewards
 - Understanding of the costs of drinking/drug use on other important goals/rewards



How does this fit with your values and long term goals?

What is the current and future value of each of these activities?

How would this need to change to be more aligned with your future goals?

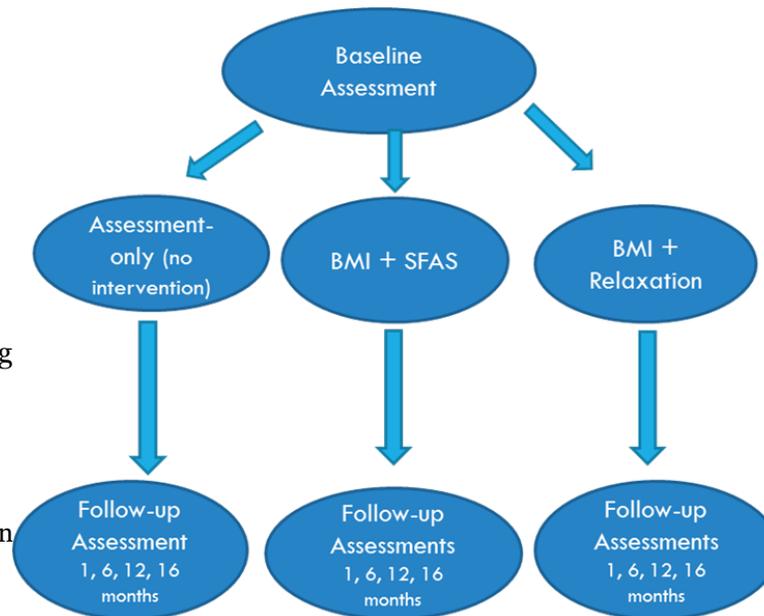


Other Substance-Free Activity Session (SFAS) Elements

- Personalized feedback on specific career requirements, how they can pursue local internships etc.
- Personalized feedback on coping with stress/depression
- Personalized feedback on substance-free leisure activities *e.g., You mentioned you enjoy photography, here is information on a campus photography club....*
- Goal setting, info on mobile apps to facilitate goal progress
- Phone/text booster contact incorporated in current trials

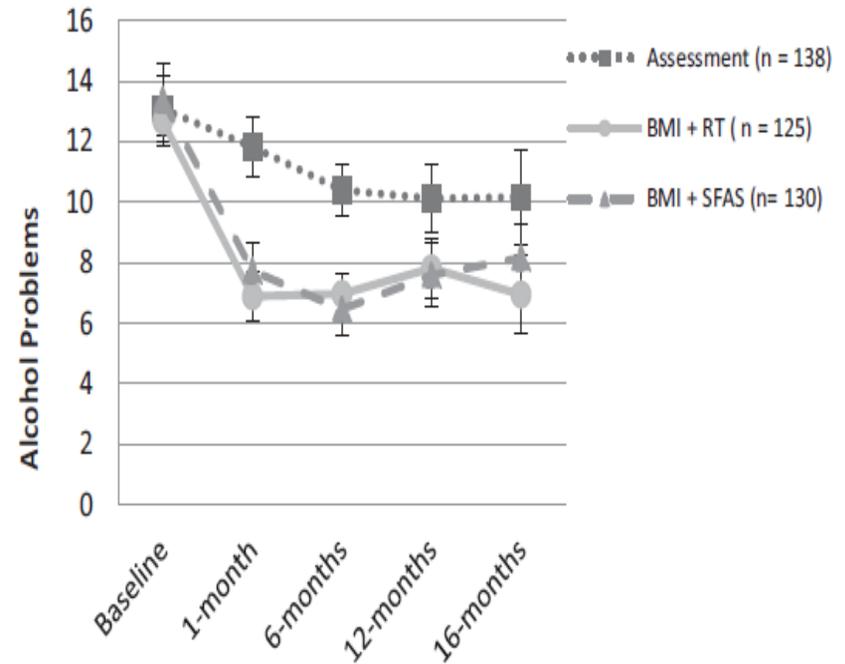
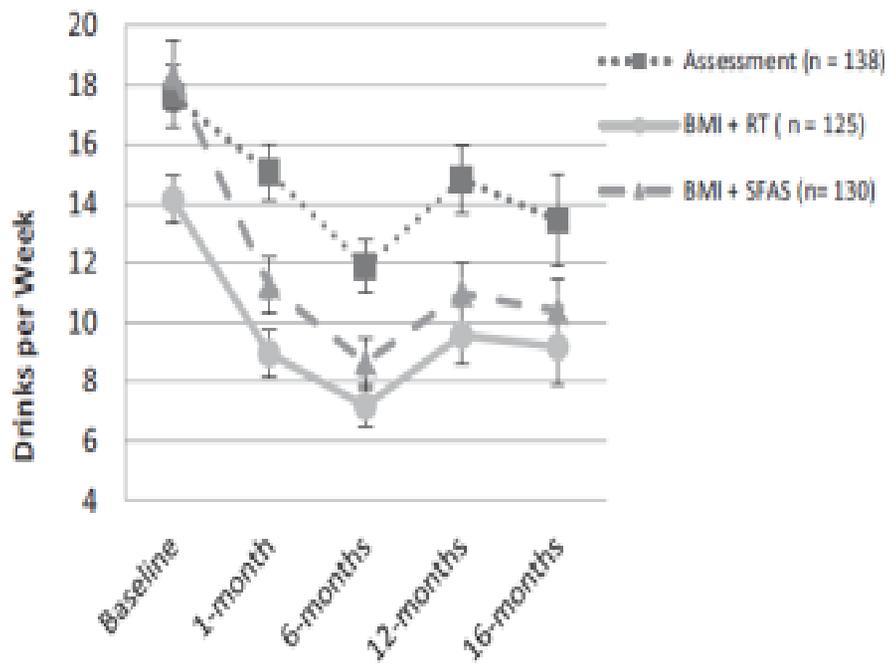
RCT of Two-Session (plus booster) Brief Interventions for Heavy Drinking College Students

- Despite small effect sizes, there has been very little research aimed at enhancing brief intervention efficacy by adding novel theoretically grounded intervention elements
- Participants (N = 393) recruited from 2 public universities (all reported recent heavy drinking):
 - Were randomized to:
 - 1) Standard alcohol-focused BMI session + Behavioral Economic Substance-Free Activity Session (SFAS; N = 130)
 - 2) Standard alcohol-focused BMI + Individual Relaxation Training (active control) (N = 125)
 - 3) Assessment-only (N=138)
 - Phone booster sessions (beginning of spring semester) for SFAS & Relaxation participants
- Follow-ups assessments:
 - 1-month follow-up rate = 93%
 - 6-month follow-up rate = 88%
 - 12-month follow-up rate = 87%
 - 16-month follow-up rate = 79%



Murphy, Dennhardt, Martens, Borsari, Witkiewitz, & Meshesha (2019).
Journal of Consulting and Clinical Psychology.

Two Session BMI + Substance-Free Activity Session (SFAS) or Relaxation Training is Associated with Enduring Reductions in Drinking and Problems (larger effects compared to most single-session interventions)

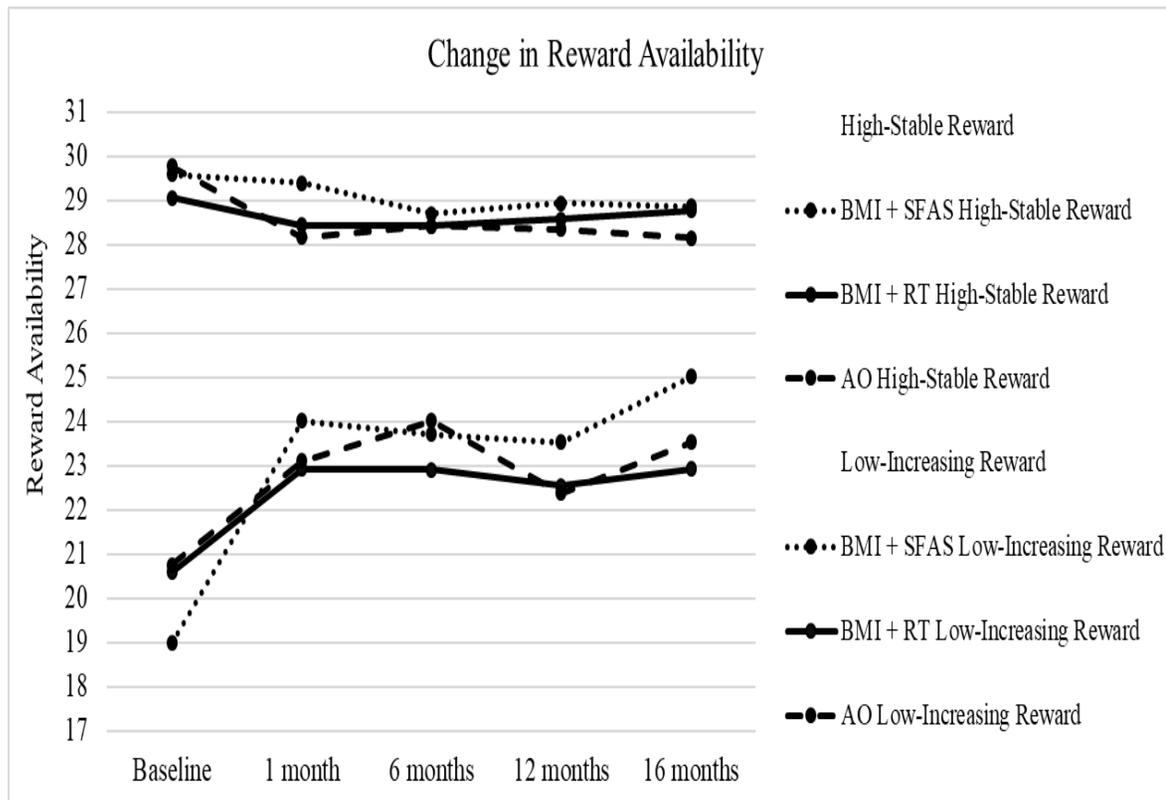


-Results mediated by increased protective behaviors and substance reinforcement

-Both conditions also improved anxiety, depressive symptoms, & self-regulation

Murphy et al. (2019). *Journal of Consulting and Clinical Psychology*.

Impact of Treatment on Reward Availability Trajectory Groups (Growth Mixture Models)



For students in the LR trajectory, BMI + SFAS led to greater increases in reward availability and reduced rates of Moderate/Severe AUD at 1, 6, and 12 months compared to BMI + RT and AO conditions, and also at 16 months compared to AO.

Murphy, Campbell, Joyner, Dennhardt, Martens, & Borsari (under review).

SFAS as a Booster with Adult Alcohol Treatment Outpatients

Journal of Substance Abuse Treatment 113 (2020) 108002



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Pilot trial investigating a brief behavioral economic intervention as an adjunctive treatment for alcohol use disorder[☆]

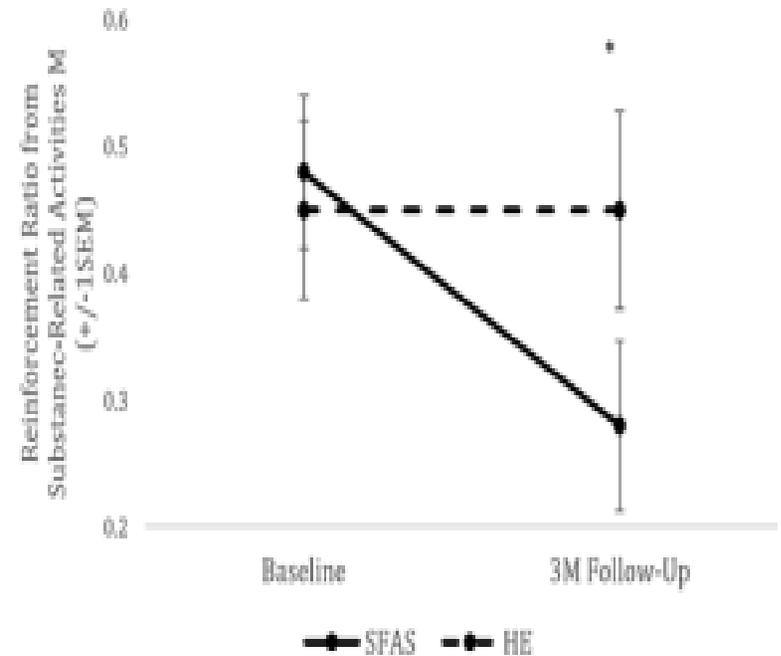
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Summary and Implications

- Results provide support for:
 - behavioral economic “reinforcer pathology” models of young adult AUD¹
 - research examining the role of reward deprivation as a factor in the development and course of AUD, including response to brief intervention²
 - measurement advances that allow for precise quantification of substance-free reward⁹
 - treatments that directly target substance-free reward^{3, 8}
 - Behavioral Activation⁴, Community Reinforcement/Contingency Management⁵, Mindfulness Oriented Recovery Enhancement (MORE)⁶; Substance-free Activity Session SFAS⁶
 - Public policies aimed at increasing substance-free activities for youth (e.g., Iceland model⁷)

¹Acuff et al., 2018; ²Tucker et al 2009; ³McKay, 2016; ⁴Daughters et al. 2008; ⁴Meyers et al., 1999; ⁵Garland et al., 2014; ⁶Murphy et al., 2012, 2019; ⁷Kristjansson et al., 2010, 2016; ⁸Fazzino et al., 2019; ⁹ Acuff et al., 2019

Title of Program: VCBH Monthly Lecture Series FY2021

Title of Talk: *Novel Behavioral Economic Approaches for Measuring Substance Use Severity and Motivating Change*

Speaker/Moderator: James G. Murphy, PhD

Planning Committee Members: Stephen H. Higgins, PhD,
Philip Ades, MD, Diann Gaalema, PhD

Date: September 16, 2020

Workshop #: 21-265-01

Learning Objectives

1.

DISCLOSURE:

Is there anything to disclose? Yes or No

Please list the Potential Conflict of Interest (if applicable): ****

All Potential Conflicts of Interest have been resolved prior to the start of this program.

Yes or No (If no, credit will not be awarded for this activity.)

All VIE staff members do not have any interests to disclose

All recommendations involving clinical medicine made during this talk were based on evidence that is accepted within the profession of medicine as adequate justification for their indications and contraindications in the care of patients. Yes

COMMERCIAL SUPPORT ORGANIZATIONS (if applicable): This activity is free from any commercial support

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