

Abstract

Alcohol use is often intentional and goal-directed in the short term. People drink to relax, to feel more socially at ease or to cope with stress. At the same time, alcohol-related harms typically accumulate across repeated episodes and unfold through chains of consequences. This creates a central puzzle in alcohol use disorder (AUD): why does drinking remain compelling even when long-term costs are known or repeatedly experienced?

Prominent theories of addiction approach this question with alterations in goal-directed control processes, especially when decisions require anticipating future consequences rather than reacting to immediate rewards. However, much of the empirical evidence has come from paradigms that are either single choice tasks or very shallow sequential tasks, making it difficult to specify which components of goal-directed decision-making are actually affected in more realistic multi-step scenarios.

This dissertation addresses this gap by focusing on forward planning, a form of goal-directed control that evaluates actions by mentally simulating future states and outcomes. This is computationally demanding, especially in probabilistic environments where the decision tree grows quickly. As a result, human planning is expected to rely on resource-rational approximation strategies that keep costs within bounds. The overarching aim of the thesis is to characterize forward planning strategies in probabilistic multi-step environments and to test whether individuals with AUD show systematic differences in key planning parameters with an emphasis on planning depth and additional strategy components that can reduce planning costs under uncertainty.

To accomplish this, three experimental studies were conducted using a probabilistic three-step decision-making task. In each trial of the task, participants navigated through small planetary environments by performing sequences of two or three actions to maximize cumulative reward. Participants were required to plan ahead as simple repetition strategies brought no advantage. Computational modelling approaches from model-based reinforcement learning were used to infer individual planning parameters and compare different planning strategies.

The first study established the task and modelling approach in healthy younger (age < 40 years; n = 25) and older (age > 60 years; n = 27) adults. Behavior was well captured by a model that assumes limited planning depth. Forward planning was clearly present in both groups but older adults showed lower planning depth and higher response noise than younger adults. These differences were partly linked to general cognitive capacities. This supported the sensitivity of the task and modelling approach to meaningful variation in goal-directed decision processes.

The second study applied the same task and model to a general-population sample with mainly mild-to-moderate AUD (n = 30) and healthy controls (n = 32). Planning depth did

not differ between groups. Participants with AUD even showed higher task performance. This pattern was explained by longer planning time and general cognitive measures. Post-hoc analyses suggested higher effort and stronger reward sensitivity in the AUD group. These results argue against a general planning impairment in mild-to-moderate AUD and they highlight the role of motivation and sampling in case-control comparisons.

The third study focused on moderate-to-severe AUD cases and explicitly controlled for tobacco use disorder (TUD) using a matched multi-group design with an AUD group (n = 45), a TUD group (n = 49) and a comorbid AUD+TUD group (n = 45). The computational model was extended by two strategies for dealing with the probabilistic nature of the task: ignoring unlikely branches of the decision tree (low-probability pruning) and a general bias to devalue outcomes the more uncertain they are (probability discounting). Model comparison showed that a combination of planning depth limitation, low-probability pruning and probability discounting best explained behavior. All substance use disorder groups showed reduced planning depth compared to matched healthy controls. Probability discounting tended to be stronger in the substance use disorder groups and it was clearly elevated in the comorbid AUD+TUD group.

Taken together, the findings suggest that forward planning via resource-rational strategies remains available across groups, even in individuals with substance use disorders, when tasks are neutral and incentives are explicit. Rather than treating AUD as a global loss of goal-directed control, the results show that strategies are reweighted toward shallower planning horizons and altered treatment of uncertainty. Planning alterations were not uniform across AUD. They emerged most clearly in more severe and comorbid cases. Reduced planning depth offers a mechanistic route by which immediate and reliable effects of substances can dominate over longer-term consequences. Stronger discounting of probabilistic outcomes may further weaken the impact of uncertain harms and make alternative rewards less competitive. Methodologically, this work contributes a validated task and computational model which can isolate planning mechanisms beyond previous single measures of planning performance or model-basedness.

Some important constraints should be considered when interpreting the present findings. Neutral experimental tasks remove many contextual drivers of drinking including cues, stress or fluctuating goals. Loss of control is likely to be state- and context-dependent so preserved planning in a neutral task does not contradict real-world loss of goal-directed control. Future research should move planning tasks closer to the moments and contexts of consumption and should link computational parameters to real-life behavior with longitudinal and high-resolution methods. Integrating further computational mechanisms into more holistic models of goal-directed control may help explain heterogeneity in AUD trajectories and may also suggest intervention targets, for example by training computationally defined aspects of forward planning.