

Investigation of Reward Processing and Habitual Behavior: The Complex Case of Anorexia Nervosa

Abstract to the dissertation submitted by Julius Maximilian Hennig (born Steding), M.Sc.

Altered reward and punishment processing have long been implicated in the development and maintenance of anorexia nervosa (AN), particularly in relation to food-related stimuli, where individuals with AN often report reduced reward sensitivity and heightened anxiety. However, it remains unclear whether these alterations extend beyond disorder-specific contexts and reflect more fundamental cognitive changes in how rewards and punishments are processed. At the same time, recent theories propose that rigid, repetitive behaviors in AN (e.g., as seen in dieting and eating routines) may be underpinned by enhanced habit formation, in which actions become increasingly automated and detached from their original goals. Such mechanisms could contribute to the persistence of maladaptive routines, even in the face of negative consequences or changing motivations. Cognitive control, often found to be altered in AN, may play a dual role in this process, both enabling extreme goal pursuit and potentially accelerating the shift toward habitual responding. Together, these interacting systems may help explain the paradox of persistent, inflexible behavior in a disorder often marked by high levels of control and goal pursuit.

The overarching aim of this thesis was to investigate the role of reward processing and habitual behavior, alongside the influence of cognitive control mechanisms, as potential key psychological and neurobiological factors that may contribute to the development and maintenance of AN. To this end, task-based functional magnetic resonance imaging (fMRI), behavioral measures, questionnaire data, and acute tryptophan depletion (ATD) were used.

Study 1 aimed to investigate reward anticipation and feedback in individuals with acute AN using a monetary instrumental learning task during fMRI. While no significant group-level differences in behavior or brain activation were observed, exploratory analyses identified subgroups within the AN sample who appeared to rely on distinct learning strategies, either more goal-driven or more habit-like. These findings highlight the potential relevance of individual variability in reward learning and suggest that subgroup distinctions may help explain previously inconsistent results.

Building on Study 1, **Study 2** employed the same reward task and additionally applied acute tryptophan depletion (ATD) to investigate the role of serotonin in weight-recovered individuals with AN. ATD modulated reward-related brain activity in recovered patients, “normalizing” it to levels observed in healthy controls. This normalization effect supports the serotonin hypothesis of AN and suggests that altered serotonergic functioning may represent a state-dependent marker or even a premorbid risk factor.

Study 3 focused on avoidance habit learning in acute AN using a habit paradigm during an fMRI session, allowing for the investigation of both behavioral and neural indices of habit formation. Although no clear behavioral alterations were found, patients with acute AN showed increased engagement of frontoparietal control regions during avoidance habit learning. These findings suggest that overcontrol may initially drive maladaptive behaviors in AN.

Together, the studies presented in this thesis contribute new evidence to ongoing debates regarding the domain generalizability of reward processing, the role of serotonergic dysregulation, and the relevance of habitual behavior in AN. They highlight the need for a more nuanced understanding of how altered reward sensitivity, habitual, and top-down control processes interact in shaping maladaptive behaviors. Future research should continue to investigate whether the habit hypothesis holds true in AN, with particular emphasis on methodological refinements and ecologically valid assessments. At the same time, further studies are needed to clarify the conditions under which altered reward processing emerges, across domains and serotonergic states, and when accounting for interindividual differences and subgroups.