# Disentangling Bottom-Up and Top-Down Mechanisms Associated with Social Information Processing in Loneliness Across Behavioral and Neural Levels of Analysis


## Abstract

Loneliness—defined as a subjective sense of insufficient social connection—is associated with substantial risks for physical and mental health problems, as well as premature mortality. Cognitive models propose that loneliness heightens bottom-up vigilance to social cues, functioning as an adaptive mechanism promoting social reconnection. However, this vigilance may lead to hypervigilance to social threats, fostering negative affect and biased interpretations of social environments. These reactions, in turn, exhaust top-down regulatory resources, potentially reinforcing negative social appraisals. Despite strong theoretical underpinnings, empirical support has largely been limited to self-report, with insufficient evidence regarding real-time social stimulus processing.

To address this gap, in this thesis I examine the following hypotheses: (1) whether loneliness is characterized by heightened bottom-up responses to social threats—manifested as increased automatic attentional orienting and heightened physiological affective reactions; and (2) diminished top-down regulatory control during social threat processing—reflected in reduced ability to maintain goal-directed behavior, inhibit prepotent responses, and effectively regulate emotional reactions to socially threatening stimuli. To investigate these cognitive mechanisms, this thesis integrates behavioral and self-report methods with approaches that offer deeper insights into underlying cognitive processes, namely electrophysiological (EEG/ERP) and computational modeling, across three studies. Electrophysiological measures (EEG/ERP) enable tracking neural activity in real time, providing precise temporal insights into separate stages of social stimulus processing. Computational modeling, specifically the Drift Diffusion Model used herein, allows for estimation of latent cognitive processes underlying observable behavioral responses, offering nuanced insights into decision-making and attentional dynamics beyond traditional behavioral measures alone.

To examine processes that may occur when socially salient distractors compete for attentional resources, in the first part of the project (Study 1; N = 52), we employed the dot-probe task, which is considered a gold standard in attentional bias research. Contrary to expectations, lonely individuals did not show increased vigilance to social stimuli during the task. This effect was consistently observed across standard response outcomes (response times), EEG derived markers of neural response to threat (n2pc), and DDM-derived indicators of perceptual engagement with threat distractors ($t_0$). At the same time, DDM analysis of the processes related to the efficiency of the information accumulation revealed difficulties in perceptual decision making among lonely compared to nonlonely individuals.

To assess whether loneliness is associated with increased affective response to social threat and potential difficulties in emotion regulation, Study 2 (N = 150) combined passive viewing and cognitive reappraisal of negative social and nonsocial images, with simultaneous EEG and electrodermal activity recordings. Lonely individuals showed increased P300 amplitude differences in response to negative vs neutral social scenes, indicative of enhanced evaluative engagement. However, none of the ERP components typically associated with early attentional hypervigilance (P1, N1) or sustained affective processing (LPP) showed any differences between lonely and nonlonely individuals. Similarly, no group differences were observed in physiological arousal as indexed by skin conductance. Notably, subjective reports diverged from neural indices: lonely individuals rated negative scenes as less arousing and reported lower reappraisal success, revealing a dissociation between internal affective responses and conscious emotional experience, thus suggesting a possible reduction of emotional self-awareness among lonely individuals. Finally, given the discrepancies between the levels of analysis observed in Study 1 and Study 2, the final part of the project (N = 271) examined how loneliness relates to both biases and abilities in understanding social situations. Participants completed a broad set of tasks measuring explicit social-cognitive capacity (e.g., emotion recognition, mental state inference) and social-cognitive bias (e.g., tendency to interpret ambiguous situations negatively). Outcomes from the explicit measures were combined with DDM-derived indicators of decision-making efficiency and early-stage perceptual processing from a dot-probe task to examine the association between overt and covert markers of social information processing in lonely individuals. Results showed that reduced

decision-making efficiency was associated with objective social isolation, and this relationship was mediated by lower social cognitive capacity. In contrast, loneliness was linked to faster early-stage processing of social information, but this effect was suppressed by a high level of social cognitive bias in lonely individuals when threatening stimuli were present.

Taken together, the results provide no evidence for increased social threat vigilance in loneliness, as none of the main neurophysiological (P1/N1, N2pc, LPP) or computational ($t_0$) markers of vigilance have shown a positive association with loneliness. At the same time, the contrasting, albeit small, effects were found for objective (P300) and subjective (arousal ratings) markers of social threat evaluation. Finally, further investigation of the covert processes associated with attentional engagement with threats has revealed that contrasting effects may be context-dependent and further impacted by high-level social cognitive biases found in lonely individuals. Similarly, despite the theoretical formulations suggesting decreased cognitive control in lonely individuals, we have found no specific association between loneliness and objective markers of decreased inhibitory control or of top-down emotion regulation of affective response. The key conclusion is that loneliness is linked to abnormalities in later stages of social information processing, particularly in interpretive and evaluative mechanisms, which lead to observed discrepancies between objective outcomes and self-reports in lonely individuals. By shifting focus from hypervigilant threat detection to biased meaning-making and reduced emotional self-awareness, the present thesis offers a more nuanced perspective on loneliness and suggests novel targets for intervention.

**Keywords:** Loneliness, Hypervigilance, Affective Response, Inhibitory Control, Emotion Regulation, Social Cognitive Capacity, Social Cognitive Bias