Neural Mechanisms of Adolescent Social Decision-Making: Insights from Computational Modeling

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Abstract

Adolescents often prefer immediate rewards for themselves over delayed rewards for others, but the underlying motivations: impulsivity or selfishness remain unclear. We applied a novel computational model to disentangle these factors by independently estimating discounting rates for self and other and the relative weight of others' rewards. Using behavioral and fMRI data from 88 adolescents, we found that participants discounted delayed rewards more steeply for others and prioritized self-rewards. Age was associated with reduced impulsivity for others but not for self. fMRI results revealed that value-based decisions involving self and other recruited the right temporoparietal junction (TPJ), while decision difficulty engaged the cingulate cortex, insula, and amygdala. These findings highlight age-related improvements in social decision-making and suggest distinct neural mechanisms for evaluating rewards for self vs. others during adolescence.

Keywords: adolescence; temporal discounting; social decision-making; computational modelling;

Instructions

Younger adolescents tend to prioritize immediate rewards for themselves over delayed rewards for others (van de Groep et al., 2023). To disentangle motivations of impulsivity and selfishness, we introduce a new computational choice model that separately accounts for, and quantifies, the effect of delays and the relative weight attributed to rewards for self and others. Using existing data, this model allows us to separately quantify the effect of age on impulsivity and selfishness and to localize brain functions involved in value computations and choices. By combining behavioral, computational, and neuroimaging approaches, this study provides new insights into the mechanisms driving social decision-making in adolescence.

Methods

The data were from van de Groep et al. (2023), involving 88 adolescents (aged 10–20 years) who completed a delayed reward task. Participants chose between smaller immediate rewards and larger delayed rewards for either themselves or a friend (Fig1a). Depending on the reward recipient, the task included within-subject decisions (Self now vs Self later, SS; Other now vs Other later, OO) and between-subject comparisons (Self now vs Other later and Other now vs Self later, SO).

We developed a modified hyperbolic discounting model (Mazur, J. E. (1987), Fig1b) to compute the expected value (EV) of each option, capturing individual differences in impulsivity (self and other discount rates: ks, ko) and selfishness (weighting of others' rewards: w). A family of hierarchical Bayesian models was tested in RStan, with LOO comparison to identify the best-fitting model.

FMRI analyses focused on contrasts between conditions (e.g., SO vs. SS/OO) to disentangle domain-general value-based decisions from those specific to contrasting values for self and other. Individual parameters were regressed against decision-related brain activity to explore developmental effects.

Trial-by-trial decision difficulty (EV unchosen option − EV chosen option) was modelled as a parametric modulator to localize brain regions with activity associated with choice-relevant trial-by-trail

valuation. Region-of-interest (ROI) analyses further explored condition-specific activation patterns.

Results

Behaviorally, participants prioritized their own rewards (w<1) and discounted delayed rewards more steeply for others (ko>ks, Fig1c). Age was negatively correlated with ko but not ks (Fig1d) indicating greater patience in decisions for others amongst older adolescents.

Neuroimaging revealed that compared to SS and OO, the SO condition elicited stronger activation in the right temporoparietal junction (TPJ, Fig2a).

Age-related increases were found in the posterior cingulate cortex (PCC).

Under the SO-OO contrast, left superior parietal lobule (SPL) activation was negatively correlated with w.

Decision difficulty was linked to greater activation in regions associated with cognitive control and emotional regulation, including the cingulate cortex, insula, and amygdala (Fig2b). Of these, ROI analyses revealed three regions with signals depending on the condition: the MCC, PCC, and amygdala (Fig2c).

Conclusions

Our computational model showed adolescents displayed steeper discounting of delayed rewards for others and a stronger preference for self-rewards, with older adolescents demonstrating reduced impulsivity for others' rewards. Neural activation patterns suggest a role for the TPJ when having to simultaneously entertain value for self and other, and the cingulate cortex, insula, and amygdala in arbitrating options closer in value. These findings advance our understanding of the developmental trajectories underlying social cognition and self-other trade-offs, with implications for fostering prosocial behaviour and emotional regulation during adolescence.

Figures

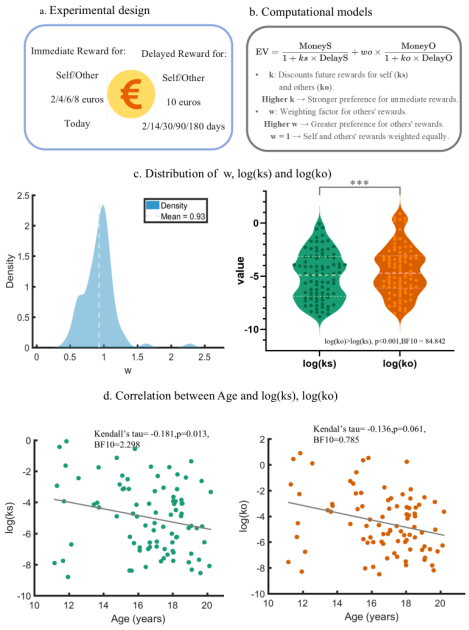

Figure 1: Experimental design and model parameters

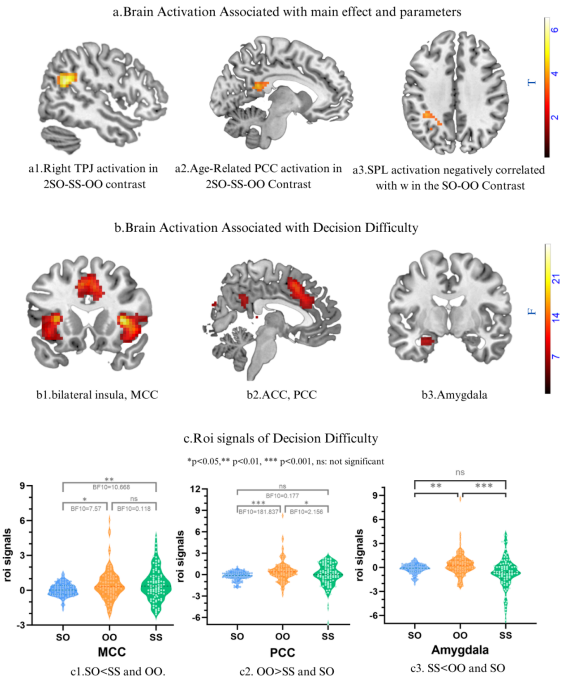

Figure 2: fMRI results

Acknowledgments

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