# Influence of interpersonal personality traits on cooperative and competitive behavior in transparent dyadic interactions

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# Abstract

Social decision-making requires individuals to balance self-interest with mutual benefit, continuously adapting their behavior to the intentions and actions of others. While classical economic games have provided important insights into cooperation and competition, they typically rely on discrete, turn-based decisions that fail to capture the fluid and reciprocal nature of real-world social interactions. The present study used a novel transparent Dyadic Interaction Platform and a novel Cooperation–Competition Foraging task to examine how the interpersonal personality traits agency and communion shape dynamic, real-time social behavior. In this task, pairs of participants (dyads) jointly or individually collected targets with variable payoffs, allowing cooperative and competitive strategies to emerge naturally as both partners continuously observed each other's gaze, actions, and outcomes. Using a round-robin design, we assessed how interpersonal traits and partner-specific adaptations jointly predicted dyadic strategic outcomes. Within each session, dyads gradually converged toward stable interaction modes, with increasing cooperation across sessions. Higher mean communion within dyads predicted enhanced cooperation, indicating that shared affiliative tendencies promote jointly oriented behavior. Additionally, behavior in each session was significantly influenced by prior dyadic history, indicating experience-dependent adaptation. These findings demonstrate that continuous, transparent interaction paradigms reveal how stable personality traits and dynamic partner feedback jointly shape social strategies. By linking personality traits from the Interpersonal Circumplex to behavioral adaptations, this study contributes to bridging the gap between traditional game-theory approaches and ecologically valid models of real-world social decision-making.

# Introduction

Imagine two team members working on a shared task where success depends on joint effort but rewards are distributed individually. At the same time, there is a possibility to obtain all the reward for oneself, provided that the other member does not get the same idea first. Each must decide whether to invest effort for the group's benefit or prioritize personal recognition or gain, carefully monitoring how the other person behaves in turn. Such social decision-making often involves varying degrees of cooperation and competition between interacting individuals, requiring them to adjust their own goals with the intentions and actions of others. Expected utilities, and hence value-based decisions, are not only modulated by the costs and benefits of different options and the uncertainty about the environment, but also by the presence, actions, and gains or losses of others (Rilling & Sanfey, 2011; Ruff & Fehr, 2014; Sanfey, 2007; Schultz, 2015; van Dijk & De Dreu, 2021). Classical work in psychology further demonstrated that even the mere presence or visibility of others can alter behavioral responses (Diener et al., 1976; Latané & Darley, 1970). Thus, beyond environment-related factors such as expected utilities and outcome uncertainties, social decision-making also depends on the ability to infer and adapt to others' mental states and intentions within a dynamically changing environment.

Research on social decision-making has traditionally relied on discrete, trial-based paradigms, most notably classical economic games such as the Prisoner's Dilemma, Ultimatum Game, Battle of the Sexes, or Stag Hunt (e.g., Camerer, 2003). These paradigms have yielded fundamental insights into when, why and how cooperation or competition emerge. However, since decisions in these paradigms occur in isolation and without continuous feedback, they provide only limited insight into the dynamic and reciprocal adjustments that underpin continuous and temporally unfolding nature of real-world social interactions. Consequently, such tasks capture only static snapshots of interaction behaviors based on the history of previous choices and outcomes. Moreover, social decision-making has often been studied in the absence of a real interaction partner as choices are revealed on computer screens or simulated computationally (e.g., Schilbach et al., 2013). In everyday life, social encounters are inherently continuous and transparent, where individuals have ongoing access to their partner's gaze, expressions, and body movements, and decisions evolve dynamically through mutual monitoring, coordination, and socio-emotional signaling. Here, transparency refers to the mutual visibility of actions and intentions that allows each individual to observe and adjust to the other in real time. These features underscore the need for experimental paradigms that move beyond static, isolated decisions to capture the dynamic, cue-rich nature of real-world social interaction.

Emerging work on transparent social interaction games (Moeller et al., 2023; Ong et al., 2021; Unakafov et al., 2020; Vaziri-Pashkam et al., 2017; Yoo et al., 2021) has underscored the importance of these continuous and reciprocal processes. Additionally, these transparent and dynamic settings highlight not only the mutual adaptation between partners but also the pronounced variability in how individuals perceive, interpret, and respond to others' actions. While previous research has acknowledged the role of individual factors in social behavior (Edelson et al., 2018; Faure et al., 2022; Proto et al., 2019; Zhao & Smillie, 2015), most studies have relied on group-level averages, with insufficient attention to individual variability. Given the multitude of perceptual, cognitive, and affective operations required in social settings, substantial individual differences are expected but remain poorly understood.

A central dimension along which individual differences unfold concerns individuals' motivational orientation toward others, ranging from purely self-interested to prosocial. The interdependence of one's own and others' behavior inherent to social interactions, where one's choices affect both personal and others' outcomes, enables the study of graded prosocial behavior, defined as a tendency to enhance joint outcomes and promote equality (Murphy et al., 2011). Classical game theory, grounded in the assumption of economic rationality (Von Neumann & Morgenstern, 1944), posits that individuals act competitively to maximize self-gain. However, behavioral economics and social neuroscience have consistently shown that people often deviate from this model, displaying prosocial and empathic tendencies even at personal cost (Fehr & Fischbacher, 2002; de Vignemont & Singer, 2006). Understanding which individual characteristics account for such deviations remains a central question in social decision-making research.

Personality factors have been identified as key drivers of these differences, predisposing individuals toward distinct strategies in social contexts along the continuum of cooperation and competition (Kenny et al., 2020; Ugazio et al., 2014). These tendencies can be systematically represented within the Interpersonal Circumplex (IPC; Wiggins, 1996), which organizes personality variation along two orthogonal dimensions: agency (dominance–submission) and communion (warmth–coldness). Traits such as agreeableness, honesty–humility, and empathy are typically associated with prosocial orientations, whereas narcissism, Machiavellianism, and psychopathy (the Dark Triad) favor self-serving or competitive strategies, and extraversion lies in between, and these map accordingly onto the IPC (Fong et al., 2021; Thielmann et al., 2020; Wertag & Bratko, 2019). While the IPC dimensions of agency and communion have been successfully linked to behavioral patterns in social decision-making, such associations have largely emerged from discrete, turn-based paradigms that lack the real-time interaction of everyday social encounters (Fernández-Berrocal et al., 2014; Locke, 2014; McCarty et al., 2014; Zhao & Smillie, 2015).

In dynamic, transparent social interactions the personalities of both partners jointly shape the expression and perception of socio-emotional cues, facilitating the subsequent strategic decision-making (Back et al., 2011; Kenny et al., 2020). Empathy, for example, facilitates cooperative behavior by enhancing sensitivity to others' emotional states (Decety & Yoder, 2016) and by motivating adherence to moral norms (Ugazio et al., 2014). Thus, cooperative or competitive outcomes in dynamic settings likely reflect an interplay between individual personality traits and partner-specific behavioral adaptations.

To examine such processes, we used the novel transparent Dyadic Interaction Platform (DIP; Isbaner et al., 2025; Moeller et al., 2023) which addresses these concerns of classic economic games. It enables real-time, face-to-face interaction between participants within a shared workspace. This setup allows continuous monitoring of a partner's gaze, facial expressions, and actions, as well as joint manipulation of shared objects while maintaining precise experimental control. Building on this platform, a Cooperation–Competition Foraging (CCF) task was developed (Lewen et al., 2025) to study cooperative and competitive behavior under transparent and dynamic conditions. In this task, dyads continuously collect targets with different payoffs, individually or jointly, allowing cooperation and competition to emerge naturally. Lewen and colleagues (2025) observed that dyads spontaneously converged toward distinct strategies along the cooperation–competition continuum. While several stable game-related strategies were identified, the underlying causes of this strategic diversity remain to be investigated. Addressing this gap, the present study using the DIP and the CCF task aims to investigate the role of personality traits, particularly agency and communion, in addition to the mutual adaptation between the interaction partners (dyads) as the game unfolds, in shaping cooperative and competitive strategies. To capture the reciprocal and interdependent nature of these interactions, we employed a round robin design, in which each participant interacted with every other member of a group. This design provides a powerful framework to quantify mutual influences between partners (Kenny, 1994; Schönbrodt et al., 2012), which allows researchers to disentangle within- and between-dyad variability and model how individual personality traits and partner-specific adaptations jointly shape interaction outcomes. We hypothesized that agentic traits would predict more self-oriented, competitive strategies, whereas communal traits would predict more other-oriented, cooperative strategies. This integrative approach allows us to begin disentangling the relative contributions of personality traits to strategic convergence in dyadic social interaction.

# Methods

## Participants

The study was approved by the Ethics Committee of the Institute of Psychology at the University of Göttingen (Ethics Application No. 375, 2024-03-18) and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to participation.

A total of $N$ = 125 male participants (age range: 18–35 years; $M$ = 23.6 , $SD$ = 3.6) were recruited through university mailing lists, flyers, social media, and a local job portal. Inclusion criteria (some of which not relevant for the current article) required participants to be male, native German speakers or fluent in German, with no history of neurological, endocrinological, or psychiatric disorders, no current use of psychotropic medication, and no psychotherapeutic treatment within the past six months.

Participants were assigned to groups of five (25 groups in total) and interacted sequentially with each of the four other members in their group, following a round robin design. Each interaction was termed one session of the game, which led to ten sessions within a group. Due to participant dropouts, we collected data from a total of 245 unique dyadic sessions.

Compensation was based on earnings from the CCF game. To maintain fairness, a random session out of the four played was selected for payment, with participants receiving a minimum of 45 euros.

## Procedure

Before the laboratory sessions, participants completed an online battery of personality questionnaires including a measure for the interpersonal circumplex (Interpersonal Adjective List, German version by Jacobs & Scholl, 2005) among other personality questionnaires not relevant to the current study. The online survey was implemented on the *formr* survey framework (Arslan et al., 2020).

In the laboratory, each participant completed four sessions, approximately lasting twenty minutes, interacting with a different partner each time. Depending on participant availability, sessions were scheduled either on separate days or at different times within the same day. The first session began with consent and data privacy forms, followed by a Choice Reaction Time (CRT) task to measure information processing speed using the Deary-Liewald method (Deary et al., 2011). In the CRT task, participants responded as quickly as possible to visual stimuli appearing in one of four on-screen locations. Each stimulus remained visible until a response was made. The mean response time was calculated as a  measure of information processing speed based on the task performance.

Additional measures were collected but are beyond the scope of the present study and therefore not reported here. The second and third sessions followed the same structure, excluding the initial forms. The fourth session included an additional solo skill task, in which participants collected as many competitive targets as possible within one minute to assess individual performance development. At the end of the fourth session, participants rolled a die to determine from which session their payment would be drawn.

## Personality Measures

For the purpose of this study, we focused on participants' interpersonal personality traits as conceptualized within the Interpersonal Circumplex (IPC) model (Gurtman, 1997; Horowitz et al., 2006; Wiggins, 1979, 1996). The IPC (***Fig. 1***) represents interpersonal behavior within a two-dimensional space defined by the orthogonal dimensions of Agency (dominance–submission) and Communion (warmth–coldness). From the 64 individual items of the IAL questionnaire, we derived the eight octant scales that constitute the circumplex: Assured–Dominant, Arrogant–Calculating, Coldhearted, Aloof–Introverted, Unassured–Submissive, Unassuming–Ingenuous, Warm–Agreeable, and Gregarious–Extraverted. Each octant score represented the average of its eight constituent items. Responses were given on an 8-point Likert-type scale (1 = *extremely inaccurate*, 8 = *extremely accurate*), with higher scores indicating stronger endorsement of the respective trait descriptors. Internal consistency for each octant scale was evaluated using Cronbach's alpha. All octant scales of the IPC met the criterion for acceptable reliability ($\alpha \geq .67$), indicating adequate internal consistency for subsequent analyses (Nunnally & Bernstein, 1994). Of the the octant scales, the Cronbach's alpha was >.80 for the dimensions Assured–Dominant, Aloof–Introverted and Coldhearted and >.70 for the dimensions Arrogant–Calculating, Unassured–Submissive, Gregarious–Extraverted, Warm–Agreeable. The lowest internal consistency was for the dimension Unassuming–Ingenuous (.67).

To derive the theoretical dimensions of Agency and Communion, we employed the standard vector-based scoring approach (Gurtman, 1997; Locke, 2011; Wiggins, 1996). The eight octant scores were arranged in a circular order around the circumplex, corresponding to equally spaced angular positions (0° to 315° in 45° increments). Each participant's Agency and Communion scores were computed as the vector projections of these octant scores onto the horizontal (cosine) and vertical (sine) axes of the circumplex, respectively. Mathematically, this involved multiplying each octant score by the cosine (for Agency) or sine (for Communion) of its corresponding angle in radians and summing across all eight octants. The resulting continuous values represent each participant's standing on the two fundamental interpersonal dimensions, with higher Agency reflecting assertive, dominant, and self-confident tendencies, and higher Communion reflecting warm, agreeable, and prosocial tendencies.

In addition to these theoretically derived scores, we conducted an Exploratory Factor Analysis (EFA) to empirically validate the latent structure of the IPC data and examine whether the observed response patterns aligned with the theoretical Agency–Communion framework. In the IAL items, and cases containing missing values were excluded. The suitability of the data for factor analysis was assessed using Bartlett's test of sphericity (Bartlett, 1954) and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (Kaiser, 1974). Items with individual Measures of Sampling Adequacy (MSA) values below .60 were excluded to ensure factorability and reliability (Field, 2024). A parallel analysis (Horn, 1965) was performed to determine the optimal number of factors to retain. Based on these diagnostics, a two-factor solution was extracted using maximum likelihood estimation with promax (oblique) rotation, which allows for correlated factors — consistent with the known interdependence between Agency and Communion (Gurtman, 1997). The resulting factor pattern matrix revealed two interpretable dimensions corresponding to Agency and Communion, thereby confirming the theoretical circumplex structure. Factor scores were calculated for each participant using the regression method and reverse coded for interpretability.

Together, these procedures provided both theoretical and data-driven quantifications of interpersonal personality dimensions, ensuring robust estimation of Agency and Communion for use in subsequent behavioral and modeling analyses. The correlations between the theoretically derived and empirically extracted dimensions were high (Agency: $r = 0.93$, $p < .001$; Communion: $r = 0.91$, $p < .001$), indicating strong convergence between the two approaches. The exploratory factor analyses revealed two interpretable dimensions consistent with Agency and Communion. However, the extracted factors were not perfectly orthogonal, with axes oriented approximately along 135°–315° and 45°–225°, rather than the theoretically defined 0°–180° and 90°–270° axes. To preserve the canonical orthogonal configuration of the interpersonal circumplex (Wiggins, 1996) and maintain comparability with prior research, the theoretically derived (vector-based) Agency and Communion scores were used for all subsequent analyses. This choice ensures that the dimensions reflect established interpersonal theory rather than sample-specific rotational artifacts, thereby facilitating interpretability across studies.

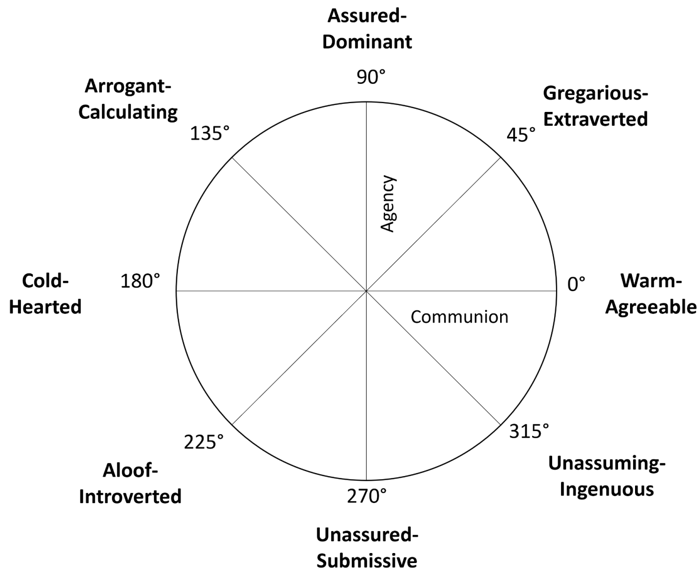


**Figure 1.** The Interpersonal Circumplex.

## CCF Game Procedure

Pairs of participants (dyads) played the Cooperation–Competition Foraging (CCF) task in the Dyadic Interaction Platform (DIP; Isbaner et al., 2025; Moeller et al., 2023), sitting face-to-face across the table (120-140 cm inter-subject distance) with a large transparent screen in between (Eyevis 55 inch OLED, 1920x1080 pixels, 60 Hz refresh rate. The visual stimuli presented on the screen were visible from both sides. The task was implemented in Python 3.10 and run on Ubuntu 20.04 LTS. In the CCF task, each player can collect single, winner-take-all targets individually (worth 7 cents) or joint targets cooperatively, which require both players to hover over the target simultaneously. The joint targets vary in payoff distribution: one favors the self (5 cents to self, 2 cents to the other), and the other favors the partner (2 cents to self, 5 cents to the other) (***Fig. 2***).  The payoff structure was designed to be "flat" such that, under balanced conditions—where both joint targets were collected equally often and both players achieved comparable competitive success—the expected value for collecting either single or joint targets was the same at 3.5 cents. Each session ended once the players had collected 600 targets (including single and joint targets) which lasted approximately 20 minutes.

To collect a target, participants had to hover their mouse-controlled cursors (blue and orange circles, 2 cm diameter, about 1.9° visual angle at a 60 cm viewing distance) over the chosen target (a larger circle, 5 cm diameter, about 4.8°) for one second. The game field was a visible square (51 cm side, 56° visual angle) containing three targets at all times—one single target and two joint targets. All targets and agents were visible to both participants, and initial target positions were randomized using a 2D uniform distribution. After each target was collected, a new target of the same type appeared immediately at a random position, without overlapping the remaining targets. Agent positions and uncollected targets were not reset, creating a continuous flow between collection cycles. For the detailed experimental procedure, please refer to Lewen et al. (2025).

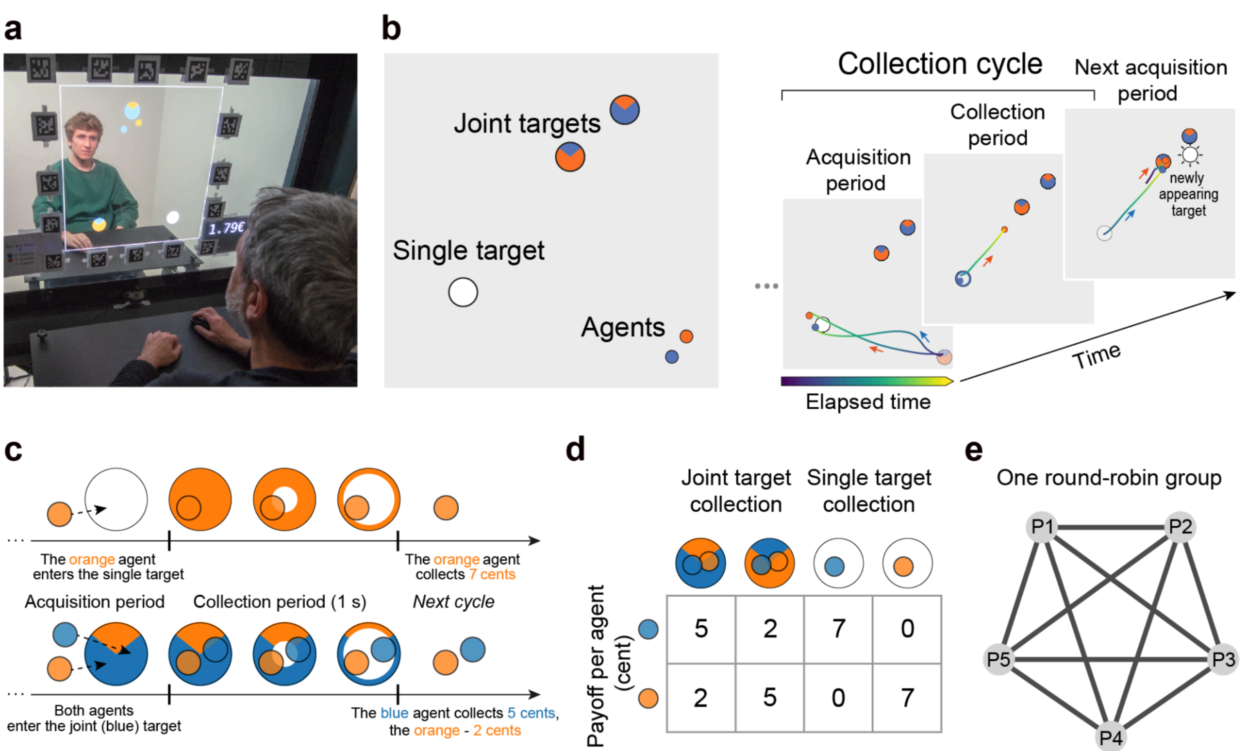


**Figure 2. Cooperation-Competitive Foraging (CCF) game experimental setup. (a)** Two participants playing the Cooperation--Competition Foraging (CCF) game on a transparent OLED screen, in front of each other. *Note: the people depicted here are an author and a lab member who provided explicit consent for the publication of the photograph.* **(b)** Left: Game depiction. Small blue and orange circles are the two

cursors ("virtual agents") controlled by the participants with a computer mouse. Agents collect targets (larger circles) by hovering over them. Each agent can collect the white target ("single target") on their own, while the colored targets ("joint targets") can only be collected cooperatively – when both agents hover over it simultaneously. If both agents arrive at a single target, the agent who first reaches the target wins. Right: Game progression. Each collection cycle begins with an acquisition period that lasts until one or both agents select a target. During the subsequent collection period, if a single target is collected as in this example, the free agent can move around. Immediately after the target's disappearance at the end of the collection, the target reappears at a random position, and the next cycle begins. The color of trajectories represents elapsed time from the start of the period (visualizing the relative timing of the two agents: e.g., in the third frame the blue agent begins moving after the orange agent). **(c)** An agent (or both agents) enter the target and hover over it for 1 s to collect it. Once the collection of the white single target starts, it changes to the color of the collecting agent. The expanding transparent circle from the target's center indicates the collection progress. At the end of each collection cycle, the sound is played and the display of total earnings in Euro is incremented. **(d)** Payoff matrix. The payoffs of the two participants in each cycle depend on the type of target collection. **(e)** A round-robin design in one group of 5 players, resulting in 10 dyads per group.

## Correlation between Personality and Game Behavior

Correlations between FST and composite scores derived from the Interpersonal Circumplex (IPC) were computed. For each of the four primary IPC axes, opposing octants were reverse-coded and averaged to create bipolar dimensions: Aloof–Introverted - Gregarious–Extraverted, Arrogant–Calculating - Unassuming–Ingenuous, Assured–Dominant - Unassured–Submissive, and Coldhearted - Warm–Agreeable. This approach provides a parsimonious representation of the major interpersonal traits while maintaining theoretical alignment with the circumplex structure. In addition, we used the vector-based Agency and Communion scores for the two theoretically derived main dimensions.

## Generalized Linear Mixed Model (GLMM)

Fraction of Single Target (FST) collected is the number of single targets collected in the game out of the total targets collected. FST is a dyadic measure which captures cooperative and competitive tendencies (Lewen et al., 2025). To predict the FST collected by each dyad, we fitted a GLM with a beta error distribution and logit link function (Baayen et al., 2008; McCullagh & Nelder, 1989). The model included as fixed effects the mean personality traits of both the players (Agency and Communion), the mean FST of both players from their respective immediately preceding sessions, the mean session number across both players, and the mean information processing speed obtained from the CRT task. Prior to fitting the model we transformed the response to avoid values being exactly zero or one (Smithson & Verkuilen, 2006). We also z-transformed all the predictors to achieve an easier interpretation of model estimates (Schielzeth, 2010) and ease model convergence.

We fitted the model in R (version 4.3.2; R Core Team 2022), using the function betareg of the equally named package (version 3.2-0; (Zeileis et al., 2016)). We assessed whether collinearity was an issue by means of Variance Inflation Factors (VIF; Field 2024) using the car package in R (version 3.1-2; Fox & Weisberg, 2018). We obtained 95% confidence intervals for model estimates via nonparametric bootstrapping (R = 1,000 resamples) using the boot package in R (version 1.3-28.1; (Canty & Ripley, 2017)). On each bootstrap iteration we resampled dyads with replacement, refit the beta regression ( betareg with logit link), and derived percentile 95% CIs from the empirical sampling distribution of coefficients.

# Results

## Game Behavior

Due to the continuous and dynamic interaction and a flat payoff formulation that was afforded by the CCF game  (see Methods), a range of strategic behaviors emerged. Most dyads, after an initial period of exploration, settled into a characteristic mode of interaction along the cooperation–competition axis. This was evident in the stabilization of FST, calculated as the proportion of single targets collected relative to all targets collected within a given time frame. Replicating Lewen et al. (2025), FST divided the dyads into the sub-groups of cooperation, intermediate and competition (FST ≤ 0.1: cooperative; FST > 0.1 and < 0.9: intermediate; FST ≥ 0.9: competitive) (***Fig. 3a***). 36 dyads only collected joint targets, while 33 dyads only collected single targets throughout the game. The rest of the dyads (176 dyads) opted for a mixed strategy of collecting both joint and single targets. Deviation from the stable FST, across a moving average time window, showed that players converged to a stable (usually, but not always, more cooperative) strategy within the first 5-7 minutes of the game. Further, this convergence is relatively slower for the first session played (***Fig. 3b***). This is also seen as decreasing FST across subsequent sessions (***Fig. 3c***), that is, players played more cooperatively as they gained more experience with the game.

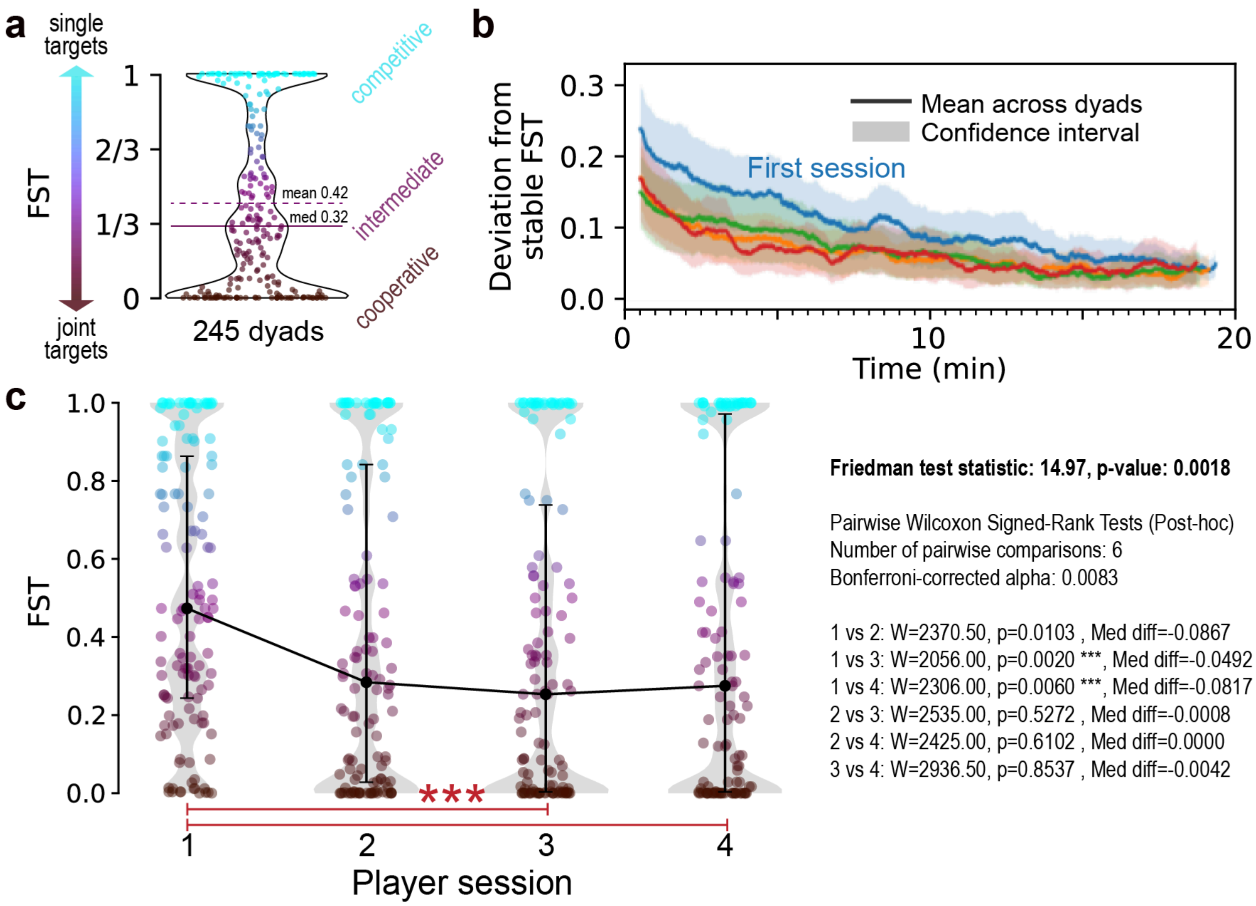


**Figure 3. Descriptive statistics of CCF game behavior using Fraction of Single Targets (FST). (a)** Violin plot of FST across all 245 dyads. **(b)** Mean deviation from stable FST as a function of time in the session. The curves indicate different sessions played by the players, with shaded regions as the confidence intervals. **(c)** FST as a function of session order for each player (N=490; each dyadic session contributes two data points, once for player 1 and once for player 2). Median and IQR [25th to 75th percentiles] are plotted for each of the four sessions. On average, the behavior becomes more cooperative (see Friedman ANOVA and post-hoc Wilcoxon Signed-Rank test statistics in the inset on the right).

## Stability of FST behavior

To assess the temporal stability of FST behavior within a session, we computed the Intraclass Correlation Coefficient (ICC) using the psych package in R (version 2.4.6.26;

Revelle, 2025). Specifically, we applied the single-rater, absolute-agreement model which quantifies the consistency of FST values across multiple time blocks within the same session. Each session lasted approximately 20 minutes (until a total of 600 targets were collected) and was divided into four 5-minute time blocks. According to the guidelines proposed by Koo and Li (2016), ICC values below 0.50 indicate poor reliability, between 0.50 and 0.75 moderate reliability, between 0.75 and 0.90 good reliability, and above 0.90 excellent reliability. The FST showed excellent reliability across time blocks within each experimental session (ICC = .91, 95% CI [.89, .93]), indicating strong temporal consistency of behavioral patterns. For the first session, ICC values were slightly lower (ICC = .87, 95% CI [.83, .91]), reflecting good reliability and supporting the observation that strategy convergence was slowest during the initial session.

## Associations of FST and IPC

Correlation between the two theoretically-derived dimensions of IPC and FST indicated negative correlation with Communion ($r = -0.15$, $p < .001$) and a positive correlation with the corresponding bipolar octants score (which was scored in the opposite direction), Coldhearted - Warm–Agreeable ($r = 0.14$, $p < .002$), suggesting that smaller FST values reflected more cooperative behavior, with more joint targets collected. Although FST was not significantly correlated with Agency, the direction of correlation was positive ($r = .04$, $p = .378$) and the corresponding bipolar octants score, Assured–Dominant - Unassured–Submissive showed a stronger correlation in the expected direction that reached statistical significance ( $r = .09$, $p = .048$). An even stronger correlation was found between FST and the bipolar octants score Arrogant–Calculating - Unassuming–Ingenuous ($r = .13$, $p = .004$), indicating that competitive game behavior was best predicted by high Agency combined with low Communion (***see Table 1***).

| IPC dimension | r | p-value |
|---|---|---|
| Aloof-Introverted – Gregarious-Extraverted | .08 | .081 |
| Arrogant-Calculating – Unassuming-Ingenuous | .13 | .004 |
| Assured-Dominant – Unassured Submissive | .09 | .048 |
| Coldhearted – Warm Agreeable | .14 | .002 |
| Agency (vector-based) | .04 | .378 |
| Communion (vector-based) | -.15 | .001 |

**Table 1.** Correlations of IPC dimensions with FST.

To examine whether dyadic behavior was better explained by overall personality composition or by the most extreme trait expressions within the pair, we compared two beta regression models. The first (mean-predictor) model included the mean trait values of both partners in each dyad—specifically, mean Agency, mean Communion, and the mean FST of both partners from their respective preceding sessions—along with the mean session number and the mean reaction time derived from the CRT task as a measure of information processing speed. The second (max/min-predictor) model included the maximum Agency, minimum Communion, and maximum prior FST values across the dyad, in addition to the same control variables (mean session number and mean CRT reaction time). The mean-predictor model tested whether average dyadic characteristics predicted interaction outcomes, whereas the max/min-predictor model assessed whether behavior was primarily driven by the more agentic or less communal member of the pair.

Model comparison based on information criteria indicated that the mean-predictor model provided a better fit (AIC = –382.48, LogLik = 198.24) relative to the max/min-predictor model (AIC = –374.86, LogLik = 194.43). Accordingly, subsequent interpretations are based on the mean-predictor model, suggesting that overall dyadic personality composition, rather than the specific traits of a single partner, best explains cooperative and competitive strategies in the CCF task across dyads. The GLM beta model was not overdispersed (dispersion parameter: 0.99) and there was no collinearity between the fixed effects (maximum VIF: 1).

Overall, the mean-predictor model revealed a significant effect of dyadic personality composition and prior interaction history on cooperative–competitive behavior. Specifically, mean Communion was a significant negative predictor of FST (β = -0.23, SE = 0.09, z = -2.56, p = .011), indicating that dyads with higher average Communion values displayed lower FST values, consistent with more cooperative strategies (***Fig. 4a***). In contrast, mean Agency was not a significant predictor (β = 0.06, SE = 0.09, z = 0.73, p = .464), suggesting that average dominance or assertiveness within the dyad did not systematically influence cooperative–competitive outcomes (***Fig. 4b***). Mean FST of the previous session showed a strong positive association with current FST (β = 0.36, SE = 0.09, z = 4.15, p <.001), indicating that dyads tended to maintain their prior behavioral tendencies: more competitive dyads remaining competitive and more cooperative dyads remaining cooperative across sessions (***Fig. 4c***). Neither mean session number (β = -0.06, SE = 0.09, z = -0.71, p = .477) nor mean CRT response time (β = -0.04, SE = 0.09, z = -0.42, p = .675) significantly predicted FST.

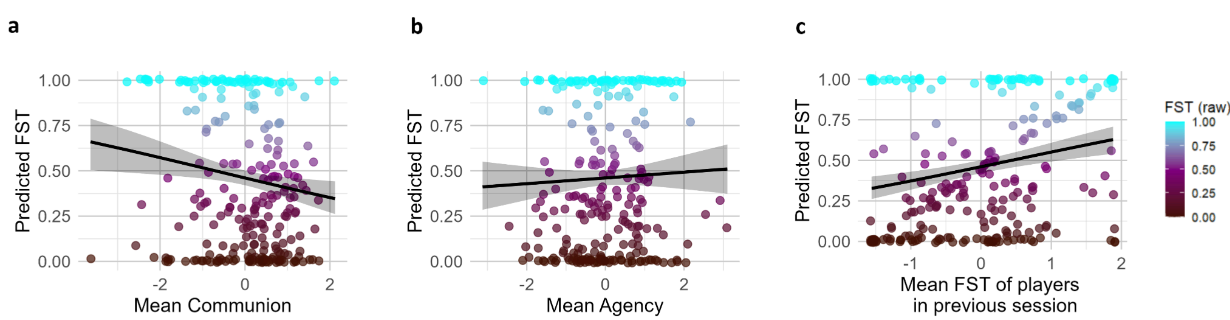


**Figure 4. GLM beta model predicting Fraction of Single Target (FST). (a)** Effect of Communion. **(b)** Effect of Agency. **(c)** Effect of mean FST players from their respective immediately preceding sessions. The solid line represents model-based predictions with shaded regions indicating their 95% confidence intervals. Raw FST data overlayed as dots.

| | estimate | std. error | z-value | p-value | ci_lower | ci_upper |
|---|---|---|---|---|---|---|
| **Intercept** | 0.16 | 0.08 | -1.89 | - | -0.32 | -0.02 |
| **Mean Agency** | 0.06 | 0.09 | 0.73 | .464 | -0.07 | 0.22 |
| **Mean Communion** | -0.23 | 0.09 | -2.56 | .011 | -0.41 | -0.05 |
| **Mean FST of players in previous session** | 0.36 | 0.09 | 4.15 | <.001 | 0.19 | 0.54 |
| **Mean number of sessions played by players** | -0.06 | 0.09 | -0.71 | .477 | -0.20 | 0.07 |
| **Mean RT of players** | -0.04 | 0.09 | -0.42 | .675 | -0.19 | 0.13 |

**Table 2.** Results of GLM beta model predicting Fraction of Single Target (FST). *Note.* p-values are not reported for the intercept due to lack of interpretability; all values except p-values are rounded to two decimals. ci_lower = lower bootstrapped 95% confidence interval; ci_upper = upper bootstrapped 95% confidence interval. RT = Reaction time based on the Choice Reaction Time (CRT) task.

# Discussion

The present study investigated how interpersonal personality traits shape cooperative and competitive behavior in continuous, transparent dyadic social interactions. Using the novel DIP and the CCF task (Moeller et al., 2023; Lewen et al., 2025), we examined how dyads navigate varying degrees of cooperation and competition in real-time, dynamic contexts. Our main findings demonstrate that social strategies are flexible and shaped by both personality traits of the individuals and game-related dynamics. Specifically, (i) dyads gradually converged toward stable cooperative or competitive modes of interaction; (ii) this convergence accelerated with repeated sessions, indicating experience-dependent adaptation; (iii) mean higher communion of the players was associated with reduced FST, indicating cooperation; and (iv) prior behavior significantly influenced current strategy selection, reflecting a history-dependent component in social decision-making. Together, these findings highlight that continuous, transparent interactions reveal both the stability of personality-driven tendencies and the plasticity of behavior in response to partner feedback and prior experience.

The finding that dyads did not immediately settle into a single mode of interaction but instead explored a range of strategies before converging on stable patterns supports the notion that social decision-making involves a dynamic exploration–exploitation process (Rilling & Sanfey, 2011; Ruff & Fehr, 2014; van Dijk & De Dreu, 2021). Such dynamic adjustment likely reflects the ongoing monitoring of partner behavior, gaze, and actions afforded by the transparent setup (Schilbach et al., 2013). The initial variability in the FST collection suggests that participants first engage in exploratory behavior to infer the partner's goals and responsiveness before establishing a mutually beneficial cooperative equilibrium (Unakafov et al., 2020; Ong et al., 2021). The subsequent convergence toward stable (often cooperative) strategies is consistent with findings that transparency and repeated interaction facilitate prosocial behavior (F. Behrens & Kret, 2019; Jahng et al., 2017; Moeller et al., 2023; Tang et al., 2016). Moreover, the slower convergence observed during the first session likely reflects the joint effects of task learning, trust calibration, and mutual adaptation—processes that are well documented in dynamic social exchange (Camerer, 2003; Fudenberg & Levine, 1998).

Across sessions, dyads became increasingly cooperative, as indicated by decreasing FST values. This experience-dependent shift suggests that mutual visibility and repeated interaction may enhance coordination and trust, promoting prosocial outcomes (Fehr & Fischbacher, 2002; de Vignemont & Singer, 2006). Such learning may arise from reinforcement of positive joint outcomes (Schultz, 2015) or from the gradual alignment of internal models of the partner's intentions (Frith & Frith, 2006). Importantly, these findings extend previous research that relied on discrete, trial-based paradigms (Fernández-Berrocal et al., 2014; Locke, 2014; McCarty et al., 2014; Zhao & Smillie, 2015) by demonstrating that cooperation emerges naturally even in continuous, real-time interactions where participants have full access to the partner's actions.

A key contribution of this study is linking personality traits captured by the Interpersonal Circumplex (Gurtman 2009; Wiggins 1996) to behavior in a dynamic, continuous social task. As predicted, higher mean communion of the players of the dyad predicted reduced FST, consistent with greater cooperativeness. This pattern parallels previous work showing communal individuals emphasize affiliation, empathy, and mutual benefit

(Ugazio et al., 2014; Zhao & Smillie, 2015; Thielmann et al., 2020; Fong et al., 2021). Notably, these relationships emerged in a setting where both participants continuously could observe and respond to one another, suggesting that trait-level personalities are expressed even under dynamic, reciprocal conditions.

These results expand on findings from turn-based or simulated paradigms (Guilfoos & Kurtz, 2017; Proto et al., 2019), showing that personality exerts measurable influences on real-time coordination. The negative correlation between communion and FST aligns with evidence that empathic concern and moral sensitivity enhance cooperative responding (Decety & Yoder, 2016). Together, these data provide converging evidence that enduring interpersonal tendencies guide social decision-making, even when decisions unfold spontaneously and continuously.

Importantly, in the present study, Communion represents the overall affiliative orientation of the dyad, emerging from both partners' warmth, empathy, and cooperativeness. This suggests that cooperative outcomes arise from the combined affiliative tendencies of both partners. In such pairs, both individuals appear to contribute to and sustain a mutually supportive dynamic, promoting cooperative alignment even in potentially competitive contexts. Although dyads gradually converged toward cooperative strategies over the course of the game, this convergence occurred on a foundation shaped by their underlying interpersonal dispositions, indicating that personality traits exerted an independent influence on cooperation beyond dynamic adaptations afforded by the game. Thus, the results emphasize that social strategies in transparent, temporally extended interactions are shaped by both stable personality traits and moment-to-moment mutual adjustments in the course of the game.

The significant predictive effect of prior-session FST on current behavior indicates that dyads carry over learned strategies across interactions, supporting models of history-dependent adaptation in social decision-making (Behrens et al., 2008; Delgado et al., 2005). This persistence may reflect reinforcement learning mechanisms, where prior cooperative experiences increase expectations of reciprocity and trust (Fehr &

Camerer, 2007), or social norm internalization processes that stabilize prosocial strategies over time (Bicchieri, 2006).

## Limitations

Although the CCF task captures dynamic, unconstrained behavior in salient face-to-face social context, the sample comprised dyads interacting under specific laboratory conditions, which may limit ecological generalizability. In addition, while the current analyses focus on interpersonal personality traits and prior behavior, other factors specific to the game dynamics or state-level measures of personality may also contribute to strategic variation in game behavior. In particular, we observed that some participants appeared to impose a characteristic level of cooperation or competition, resulting in remarkably consistent FST values across all dyads that included them, regardless of their partners. Further analyses are required to understand the underlying factors driving these stable individual influences—such as personality traits, strategic preferences, or sensorimotor dominance—that shape the overall cooperative or competitive dynamics within the dyad.

We limited our sample to only male participants since we also studied effects of testosterone in this sample, which will be reported in a separate article. Also, so far we sampled only young adults with above-average education levels from a Western society. Our current results cannot speak on whether or not they generalize to other genders, age groups, socioeconomic groups, or populations. In addition it is an open research question if these results generalize to mixed-gender dyads. All this should be studied in future research.

## Implications and future directions

Overall, the present findings demonstrate that dynamic, transparent paradigms such as the CCF task provide a powerful tool to study the emergence of cooperative and competitive behavior under ecologically valid conditions. By integrating personality assessment within such frameworks, this work bridges the gap between trait-level and state-level approaches to social decision-making. Future research should aim at identifying individual-level behavioral indices to fully make use of the round-robin structure (Back & Kenny, 2010) to disentangle actor, partner, and relationship variance components and to model the dyad-specific contingencies that shape strategic convergence. Moreover, combining behavioral measures with physiological or neural indices (e.g., endocrine measures, heart rate, EEG hyperscanning, eye-tracking) could illuminate the affective and cognitive mechanisms that mediate personality–behavior interactions in real time.


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# Competing interests

The authors declare no competing interests.

# References


Arslan, R. C., Walther, M. P., & Tata, C. S. (2020). formr: A study framework allowing for automated feedback generation and complex longitudinal experience-sampling studies using R. *Behavior Research Methods*, *52*(1), 376–387. https://doi.org/10.3758/s13428-019-01236-y

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Back, M. D., Schmukle, S. C., & Egloff, B. (2011). A closer look at first sight: Social relations lens model analysis of personality and interpersonal attraction at zero acquaintance. *European Journal of Personality*, *25*(3), 225–238. https://doi.org/10.1002/per.790

Bartlett, M. S. (1954). A Note on the Multiplying Factors for Various χ2 Approximations. *Journal of the Royal Statistical Society. Series B (Methodological)*, *16*(2), 296–298.

Behrens, F., & Kret, M. E. (2019). The Interplay Between Face-to-Face Contact and Feedback on Cooperation During Real-Life Interactions. *Journal of Nonverbal Behavior*, *43*(4), 513–528. https://doi.org/10.1007/s10919-019-00314-1

Behrens, T. E. J., Hunt, L. T., Woolrich, M. W., & Rushworth, M. F. S. (2008). Associative learning of social value. *Nature*, *456*(7219), Article 7219. https://doi.org/10.1038/nature07538

Bicchieri, C. (2006). *The grammar of society: The nature and dynamics of social norms* (pp. xvi, 260). Cambridge University Press.

Brooks, M. E., Kristensen, K., Benthem, K. J. van, Magnusson, A., Berg, C. W., Nielsen, A., Skaug, H. J., Mächler, M., & Bolker, B. M. (2017). GlmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling. *The R Journal*, *9*(2), 378–400. https://doi.org/10.32614/RJ-2017-066

Camerer, C. F. (2003). *Behavioral game theory: Experiments in strategic interaction* (pp. xv, 550). Russell Sage Foundation.

Canty, A., & Ripley, B. (2017). Package 'boot'. *Bootstrap Functions. CRAN R Proj.*

de Vignemont, F., & Singer, T. (2006). The empathic brain: How, when and why? *Trends in Cognitive Sciences*, *10*(10), 435–441. https://doi.org/10.1016/j.tics.2006.08.008

Deary, I. J., Liewald, D., & Nissan, J. (2011). A free, easy-to-use, computer-based simple and four-choice reaction time programme: the Deary-Liewald reaction time task. *Behavior research methods*, *43*(1), 258-268.

Decety, J., & Yoder, K. J. (2016). Empathy and motivation for justice: Cognitive empathy and concern, but not emotional empathy, predict sensitivity to injustice for others. *Social Neuroscience*, *11*(1), 1–14. https://doi.org/10.1080/17470919.2015.1029593

Delgado, M. R., Frank, R. H., & Phelps, E. A. (2005). Perceptions of moral character modulate the neural systems of reward during the trust game. *Nature Neuroscience*, *8*(11), 1611–1618. https://doi.org/10.1038/nn1575

Diener, E., Fraser, S. C., Beaman, A. L., & Kelem, R. T. (1976). Effects of deindividuation variables on stealing among Halloween trick-or-treaters. *Journal of Personality and Social Psychology*, *33*(2), 178–183. https://doi.org/10.1037/0022-3514.33.2.178

Dobson, A. J., & Barnett, A. G. (2018). *An Introduction to Generalized Linear Models*. CRC Press.

Edelson, M. G., Polania, R., Ruff, C. C., Fehr, E., & Hare, T. A. (2018). Computational and neurobiological foundations of leadership decisions. *Science*, *361*(6401), eaat0036. https://doi.org/10.1126/science.aat0036

Faure, P., Fayad, S. L., Solié, C., & Reynolds, L. M. (2022). Social Determinants of Inter-Individual Variability and Vulnerability: The Role of Dopamine. *Frontiers in Behavioral Neuroscience*, *16*. https://doi.org/10.3389/fnbeh.2022.836343

Fehr, E., & Camerer, C. F. (2007). Social neuroeconomics: The neural circuitry of social preferences. *Trends in Cognitive Sciences*, *11*(10), 419–427. https://doi.org/10.1016/j.tics.2007.09.002

Fehr, E., & Fischbacher, U. (2002). Why Social Preferences Matter – the Impact of Non-Selfish Motives on Competition, Cooperation and Incentives. *The Economic Journal*, *112*(478), C1–C33. https://doi.org/10.1111/1468-0297.00027

Fernández-Berrocal, P., Extremera, N., Lopes, P. N., & Ruiz-Aranda, D. (2014). When to cooperate and when to compete: Emotional intelligence in interpersonal decision-making. *Journal of Research in Personality*, *49*, 21–24. https://doi.org/10.1016/j.jrp.2013.12.005

Field, A. (2024). *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications.

Fong, M., Zhao, K., & Smillie, L. D. (2021). Personality and competitiveness: Extraversion, agreeableness, and their aspects, predict self-reported competitiveness and competitive bidding in experimental auctions. *Personality and Individual Differences*, *169*, 109907. https://doi.org/10.1016/j.paid.2020.109907

Forstmeier, W., & Schielzeth, H. (2011). Cryptic multiple hypotheses testing in linear models: Overestimated effect sizes and the winner's curse. *Behavioral Ecology and Sociobiology*, *65*(1), 47–55. https://doi.org/10.1007/s00265-010-1038-5

Fox, J., & Weisberg, S. (2018). An R companion to applied regression. *Sage publications*.

Frith, C. D., & Frith, U. (2006). The neural basis of mentalizing. *Neuron*, *50*(4), 531–534. https://doi.org/10.1016/j.neuron.2006.05.001

Fudenberg, D., & Levine, D. K. (1998). *The Theory of Learning in Games*. MIT Press.

Guilfoos, T., & Kurtz, K. J. (2017). Evaluating the role of personality trait information in social dilemmas. *Journal of Behavioral and Experimental Economics*, *68*, 119–129. https://doi.org/10.1016/j.socec.2017.04.006

Gurtman, M. B. (1997). Studying personality traits: The circular way. In *Circumplex models of personality and emotions* (pp. 81–102). American Psychological Association. https://doi.org/10.1037/10261-004

Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika*, *30*(2), 179–185. https://doi.org/10.1007/BF02289447

Horowitz, L. M., Wilson, K. R., Turan, B., Zolotsev, P., Constantino, M. J., & Henderson, L. (2006). How interpersonal motives clarify the meaning of interpersonal behavior: A revised circumplex model. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc*, *10*(1), 67–86. https://doi.org/10.1207/s15327957pspr1001_4

Isbaner, S., Báez-Mendoza, R., Bothe, R., Eiteljoerge, S., Fischer, A., Gail, A., Gläscher, J., Lüschen, H., Möller, S., Penke, L., Priesemann, V., Ruß, J., Schacht, A., Schneider, F., Shahidi, N., Treue, S., Wibral, M., Ziereis, A., Fischer, J., … Mani, N. (2025). Dyadic Interaction Platform: A novel tool to study transparent social interactions. *ELife*, *14*. https://doi.org/10.7554/eLife.106757.1

Jacobs, I., & Scholl, W. (2005). Interpersonale Adjektivliste (IAL): Die empirische Umsetzung theoretischer Circumplex-Eigenschaften für die Messung interpersonaler Stile. [Interpersonal Adjective List (IAL): An empirical realization of theoretical circumplex concepts for the assessment of interpersonal style.]. *Diagnostica*, *51*(3), 145–155. https://doi.org/10.1026/0012-1924.51.3.145

Jahng, J., Kralik, J. D., Hwang, D.-U., & Jeong, J. (2017). Neural dynamics of two players when using nonverbal cues to gauge intentions to cooperate during the Prisoner's Dilemma Game. *NeuroImage*, *157*, 263–274. https://doi.org/10.1016/j.neuroimage.2017.06.024

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31–36. https://doi.org/10.1007/BF02291575

Kenny, D. A. (1994). *Interpersonal perception: A social relations analysis* (pp. xvii, 270). Guilford Press.

Kenny, D. A., Kashy, D. A., & Cook, W. L. (2020). *Dyadic Data Analysis*. Guilford Publications.

Latané, B., & Darley, J. M. (1970). Social determinants of bystander intervention in emergencies. *Altruism and helping behavior*, 13-27.

Lewen, D., Ivanov, V., Dehning, J., Ruß, J., Fischer, A., Penke, L., Schacht, A., Gail, A., Priesemann, V., & Kagan, I. (2025). *Continuous dynamics of cooperation and competition in social decision-making. Commun Psychol in press*. doi: 10.1038/s44271-025-00348-w

Locke, K. D. (2011). Circumplex measures of interpersonal constructs. In *Handbook of interpersonal psychology: Theory, research, assessment, and therapeutic interventions* (pp. 313–324). John Wiley & Sons, Inc.

Locke, K. D. (2014). Circumplex Scales of Intergroup Goals: An interpersonal circle model of goals for interactions between groups. *Personality & Social Psychology Bulletin*, *40*(4), 433–449. https://doi.org/10.1177/0146167213514280

McCarty, M. K., Monteith, M. J., & Kaiser, C. R. (2014). Communally constrained decisions in workplace contexts. *Journal of Experimental Social Psychology*, *55*, 175–187. https://doi.org/10.1016/j.jesp.2014.07.007

McCullagh, P., & Nelder, J. A. (1989). *Generalized Linear Models*. Springer US. https://doi.org/10.1007/978-1-4899-3242-6

Moeller, S., Unakafov, A. M., Fischer, J., Gail, A., Treue, S., & Kagan, I. (2023). Human and macaque pairs employ different coordination strategies in a transparent decision game. *ELife*, *12*, e81641. https://doi.org/10.7554/eLife.81641

Murphy, R. O., Ackermann, K. A., & Handgraaf, M. (2011). *Measuring Social Value Orientation* (SSRN Scholarly Paper 1804189). Social Science Research Network. https://doi.org/10.2139/ssrn.1804189

Nunnally, J., & Bernstein, I. (1994). The Assessment of Reliability. Psychometric Theory, 3, 248–292. Nyhan, RC, and HA Marlowe.(1997). Development And Psychometric Properties Of The Organizational Trust Inventory. *Eval Rev*, *21*, 614-35.

Ong, W. S., Madlon-Kay, S., & Platt, M. L. (2021). Neuronal correlates of strategic cooperation in monkeys. *Nature Neuroscience*, *24*(1), 116–128. https://doi.org/10.1038/s41593-020-00746-9

Proto, E., Rustichini, A., & Sofianos, A. (2019). Intelligence, Personality, and Gains from Cooperation in Repeated Interactions. *Journal of Political Economy*, *127*(3), 1351–1390.

Revelle, W. (2025). *psych: Procedures for Psychological, Psychometric, and Personality Research* (Version 2.5.6) [Computer software]. https://cran.r-project.org/web/packages/psych/index.html

Rilling, J. K., & Sanfey, A. G. (2011). The neuroscience of social decision-making. *Annual Review of Psychology*, *62*, 23–48. https://doi.org/10.1146/annurev.psych.121208.131647

Ruff, C. C., & Fehr, E. (2014). The neurobiology of rewards and values in social decision making. *Nature Reviews. Neuroscience*, *15*(8), 549–562. https://doi.org/10.1038/nrn3776

Sanfey, A. G. (2007). Social decision-making: Insights from game theory and neuroscience. *Science (New York, N.Y.)*, *318*(5850), 598–602. https://doi.org/10.1126/science.1142996

Schielzeth, H. (2010). Simple means to improve the interpretability of regression coefficients. *Methods in Ecology and Evolution*, *1*(2), 103–113. https://doi.org/10.1111/j.2041-210X.2010.00012.x

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience. *The Behavioral and Brain Sciences*, *36*(4), 393–414. https://doi.org/10.1017/S0140525X12000660

Schönbrodt, F. D., Back, M. D., & Schmukle, S. C. (2012). TripleR: An R package for social relations analyses based on round-robin designs. *Behavior Research Methods*, *44*(2), 455–470. https://doi.org/10.3758/s13428-011-0150-4

Schultz, W. (2015). Neuronal Reward and Decision Signals: From Theories to Data. *Physiological Reviews*, *95*(3), 853–951. https://doi.org/10.1152/physrev.00023.2014

Smithson, M., & Verkuilen, J. (2006). A better lemon squeezer? Maximum-likelihood regression with beta-distributed dependent variables. *Psychological Methods*, *11*(1), 54–71. https://doi.org/10.1037/1082-989X.11.1.54

Tang, H., Mai, X., Wang, S., Zhu, C., Krueger, F., & Liu, C. (2016). Interpersonal brain synchronization in the right temporo-parietal junction during face-to-face economic exchange. *Social Cognitive and Affective Neuroscience*, *11*(1), 23–32. https://doi.org/10.1093/scan/nsv092

Thielmann, I., Spadaro, G., & Balliet, D. (2020). Personality and prosocial behavior: A theoretical framework and meta-analysis. *Psychological Bulletin*, *146*(1), 30–90. https://doi.org/10.1037/bul0000217

Ugazio, G., Majdandzic, J., & Lamm, C. (2014). Are empathy and morality linked?: Insights from Moral Psychology, Social and Decision Neuroscience, and Philosophy. In H. L. Maibom (Ed.), *Empathy and Morality* (pp. 155–171). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199969470.003.0008

Unakafov, A. M., Schultze, T., Gail, A., Moeller, S., Kagan, I., Eule, S., & Wolf, F. (2020). Emergence and suppression of cooperation by action visibility in transparent games. *PLOS Computational Biology*, *16*(1), e1007588. https://doi.org/10.1371/journal.pcbi.1007588

van Dijk, E., & De Dreu, C. K. W. (2021). Experimental Games and Social Decision Making. *Annual Review of Psychology*, *72*, 415–438. https://doi.org/10.1146/annurev-psych-081420-110718

Vaziri-Pashkam, M., Cormiea, S., & Nakayama, K. (2017). Predicting actions from subtle preparatory movements. *Cognition*, *168*, 65–75. https://doi.org/10.1016/j.cognition.2017.06.014

von Neumann, J., & Morgenstern, O. (1944). *Theory of games and economic behavior* (pp. xviii, 625). Princeton University Press.

Wertag, A., & Bratko, D. (2019). In search of the prosocial personality: Personality traits as predictors of prosociality and prosocial behavior. *Journal of Individual Differences*, *40*(1), 55–62. https://doi.org/10.1027/1614-0001/a000276

Wiggins, J. S. (1979). A psychological taxonomy of trait-descriptive terms: The interpersonal domain. *Journal of Personality and Social Psychology*, *37*(3), 395–412. https://doi.org/10.1037/0022-3514.37.3.395

Wiggins, J. S. (1996). An informal history of the interpersonal circumplex tradition. *Journal of Personality Assessment*, *66*(2), 217–233. https://doi.org/10.1207/s15327752jpa6602_2

Yoo, S. B. M., Tu, J. C., & Hayden, B. Y. (2021). Multicentric tracking of multiple agents by anterior cingulate cortex during pursuit and evasion. *Nature Communications*, *12*(1), 1985. https://doi.org/10.1038/s41467-021-22195-z

Zeileis, A., Cribari-Neto, F., Gruen, B., Kosmidis, I., Simas, A. B., Rocha, A. V., & Zeileis, M. A. (2016). *Package 'betareg'. R package, 3(2), 51*.

Zhao, K., & Smillie, L. D. (2015). The role of interpersonal traits in social decision making: Exploring sources of behavioral heterogeneity in economic games. *Personality and Social Psychology Review*, *19*(3), 277–302. https://doi.org/10.1177/1088868314553709