The Behavioral Economics of Social Anxiety Disorder Reveal a Robust Effect for Interpersonal Traits

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Abstract

Recent evidence suggests that reduced generosity among individuals with social anxiety disorder (SAD) in behavioral economic tasks may result from constraint in changing behavior according to interpersonal contingencies. That is, people with SAD may be slower to be more generous when the situation warrants. Conversely, more global effects on generosity may be related to interpersonal vindictiveness, a dimension only somewhat related to SAD. A total of 133 participants, 73 with the generalized form of SAD, completed self-report instruments and a behavioral economic task with simulated interpersonal (friend, romantic partner, stranger) interactions. In a separate visit, friends (n = 88) also came to the lab and rated participants on vindictiveness. Interpersonal vindictiveness was associated with reduced initial and overall giving to simulated friends. SAD predicted a lack of increased giving to a simulated friend, and attenuated an increase in giving to simulated known versus unknown players compared to participants without SAD. Friend-reported vindictiveness predicted in the same direction as diagnosis. However, the findings for SAD were less robust than those for vindictiveness. SAD is perhaps weakly related to behavioral constraint in economic tasks that simulate interpersonal interactions, whereas vindictiveness is strongly related to lower overall generosity as well as (via friend report) behavioral constraint. Further study is needed to better characterize the construct of vindictiveness. Our findings dovetail with the suggestion that SAD is related to impairment in the proposed affiliation and attachment system, but further suggest that direct study of that system may be more fruitful than focusing on disorders.

Keywords: social anxiety disorder, behavioral economics, interpersonal processes, RDoC

The Behavioral Economics of Social Anxiety Disorder Reveal a Strong Role for Interpersonal Traits

Social anxiety disorder (SAD) has been described as an essentially interpersonal disorder (Alden & Taylor, 2010), and much recent work has investigated behavioral economic tasks as a potential means to better understand the disruption of social behavior and its underlying neural sources (see, e.g., Carter, 2012, for a review). Accordingly, researchers have turned to a variety of economic tasks to understand the disrupted interpersonal behavior typical of SAD in particular (e.g., Sripada et al., 2009; Sripada, Angstadt, Liberzon, McCabe, & Phan, 2013). These investigators are part of a larger group that has expressed optimism that behavioral economic tasks may detect differences between disorders or be helpful in generating new biomarkers for disorders (Carter, 2012; Kishida, King-Casas, & Montague, 2010; Sharp, Monterosso, & Montague, 2012).

Initial observations that SAD is associated with reduced giving behavior on behavioral economic tasks led to hypotheses that the disorder itself may cause reductions in generosity (Rodebaugh, Heimberg, Taylor, & Lenze, 2016; Rodebaugh et al., 2013). However, recent work has challenged these hypotheses and instead suggests that common *correlates* of SAD might better account for the associations observed in the initial study. More specifically, interpersonal vindictiveness was associated with overall reduced giving, yet neither social anxiety symptoms nor a diagnosis of SAD were (Rodebaugh et al., 2016). Interpersonal vindictiveness was measured using the Inventory of Interpersonal Problems (Horowitz, Alden, Wiggins, & Pincus, 2000), and its name could be argued to be misleading. Rather than referring to vengefulness per se, the scale refers to a combination of interpersonal coldness and dominance (Horowitz et al.,

2000). That is, the items seem to refer to experiencing problems due to a tendency to put oneself first and be detached from others rather than be hurtful or angry per se.

Thus, Rodebaugh and colleagues (2016) found that effects expected to be due to SAD were instead due to an interpersonal correlate of SAD. In contrast, higher SAD severity was related to a *slow rate of increased* giving. Thus, in accordance with findings involving live interpersonal interactions, Rodebaugh and colleagues (2016) found evidence that SAD involves more constrained responses to interpersonal interactions, possibly representing an attempt at self-protection, and not a lack of generosity per se (cf., e.g., Meleshko & Alden, 1993). In other words, SAD plausibly involves a subdued reaction to interpersonal cues related to signals of friendliness. A similar constrained *neural* responsiveness to trustworthy versus untrustworthy strangers has been reported in an imaging study (Sripada et al., 2013). In that study, although behavior did not differ between diagnostic groups, people with SAD showed constrained response to the potential rewards of interacting with trustworthy versus untrustworthy strangers.

The recent findings of Rodebaugh and colleagues (2016) suggest that additional constructs or factors might predict behavior on economic tasks, with implications for our understanding of SAD and how it influences interpersonal behavior. The assumption that behavior on economic tasks parallels interpersonal behavior is nearly ubiquitous (see, e.g., Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005, among many others). However, few studies demonstrate a consistent relationship between giving on economic tasks and individual differences thought to be related to interpersonal behavior. The findings of Rodebaugh and colleagues regarding vindictiveness, as described above, are unusual in that they have support from multiple studies (i.e., Study 2 and reanalysis of a previous study, both reported in Rodebaugh et al. 2016). However, even this finding can easily be questioned: It is unclear to

what extent self-report of vindictiveness can be expected to translate to interpersonal behavior. Such findings would be far more convincing as evidence of interpersonal functioning relating to economic behavior if the measure of interpersonal functioning was not restricted to self-report. For example, if informant-report predicted in a similar manner, it would be more convincing that the observed effect is due to interpersonal behavior rather than factors purely associated with self-report.

In the current study, we examined which aspects of interpersonal economic behavior are related to social anxiety and SAD, versus correlates of the disorder. To this end, we asked participants with and without SAD to complete a behavioral economic task as well as interviews and self-report measures. Further, we asked informants to provide ratings of participants to better assess interpersonal traits. Our hypotheses, as suggested by the results of Rodebaugh et al. (2016), were as follows: First (Hypothesis 1), we expected that diagnosis alone would *not* predict overall giving to simulated friends. Second (Hypothesis 2), we expected that interpersonal vindictiveness would predict overall and baseline tendencies toward giving to simulated friends (i.e., total giving and intercept of giving), whereas social anxiety severity would predict more gradual increases (i.e., shallower slope) in giving in the SAD group. In addition (Hypothesis 3), extending the previous findings, we hypothesized that informant-reported (i.e., friend-reported) vindictiveness would predict in the same manner as self-reported vindictiveness, consistent with the effect being due to interpersonal tendencies, as opposed to merely a tendency toward rating oneself in a negative manner (which is common in SAD; Moscovitch, Orr, Rowa, Reimer, & Antony, 2009).

The above hypotheses involve replications or extensions of previous results and thus focus on giving to simulated friends only (i.e., because giving to simulated friends only was the

focus of the previous studies by Rodebaugh and colleagues, 2013, 2016). However, in this study we collected data on responses to simulated strangers and simulated romantic partners as well. Thus, following speculations of Rodebaugh et al. (2016) and the imaging findings of Sripada et al. (2013), we also hypothesized (Hypothesis 4) that SAD (versus absence of the disorder) would be related to lack of responsiveness to different simulated partner types (known versus unknown). Finally, in exploratory analyses we tested whether any effects for diagnosis were better explained by social anxiety symptom severity or depression, which is a common comorbidity of social anxiety disorder (Kessler, Chiu, Demler, Merikangas, & Walters, 2005).

Further, we tested whether attachment style, both in terms of attachment anxiety and attachment avoidance, might better explain any diagnosis effects. We considered both attachment anxiety and avoidance to be interpersonal traits rather than symptoms of mental disorders (e.g., in the same way that vindictiveness is interpersonal). We examined attachment because it represents the Research Domain Criteria (RDoC; Cuthbert & Kozak, 2013) construct most clearly associated with cooperative behavior: *affiliation/attachment*. Notably, the RDoC matrix suggests that a preference for certain individuals is a crucial behavioral dimension for the affiliation/attachment construct. Because we tested preferential giving to simulated known versus unknown individuals, our behavioral economic tasks are arguably a plausible behavioral indicator of the affiliation/attachment dimension. Thus, although our study was not designed to evaluate RDoC constructs, the behavioral task used is plausible as a measure of this RDoC construct.

Method

Participants

Participants (N = 133) with generalized SAD (GSAD; n = 73) and without the disorder (NOSAD; n = 60) completed a behavioral economic task, clinical interviews, and self-report measures.[1] The GSAD group was recruited through community advertising and the NOSAD group was recruited through a participant registry to match groups on demographic features. Participants meeting diagnostic criteria were included if they were 18 years or older and willing to bring a friend or romantic partner to a later part of the study; participants were excluded if they were currently psychotic, manic, or actively suicidal, or if they had abused or been dependent on any substances in the past two months. A portion of the present sample was included within several prior publications that did not report on the behavioral economics task, the testing of which was one of the primary goals of the study. The most notable previous study was a study assessing friendship-related variables (Sample 2 in Rodebaugh et al., 2014) that reported the diagnostic procedure in detail. A full list of studies using these participants is available from the first author.

Table 1 details demographic data comparisons across groups. Groups did not significantly differ on age, ethnicity, race, or gender, although there was a trend (p = .090) toward a difference in age. Further, GSAD participants received relatively less education and were less likely to be married; these differences are expected given epidemiological data (Ruscio et al., 2008). We included age and interactions with age in all analyses including group as a predictor; these are not reported because no effect achieved statistical significance (i.e., all ps

[1] Two additional participants who were unable to complete the study due to sickness and a lack of task understanding are not included.

were > .05). Participants who brought a friend did not differ from those who did not in terms of diagnosis, self-rating of vindictiveness, attachment anxiety, or attachment avoidance (*p*s > .11).

Measures

Self- and other-report questionnaires. The *Inventory of Interpersonal Problems* (IIP-32; Horowitz et al., 2000), is a subset of items from the original 64-item self-report measure describing common interpersonal difficulties. Participants and a friend (see **Study Procedure**) independently rated each item about the participant on a Likert-type scale from 0 (*Not at all*) to 4 (*Extremely*). A factor analytic comparison of the 64- and 32-item Dutch versions yielded superior fit for the IIP-32 (Vanheule, Desmet, & Rosseel, 2006). Internal consistency estimates for self- and friend-reported IIP-32 scores on vindictiveness (e.g., "It is hard for me to really care about another person's problems") were excellent for the present study (αs of .93 and .94, respectively).

The *Beck Depression Inventory-II* (BDI-II; Beck, Steer, & Brown, 1996) is a frequently-used measure of depressive symptoms that was used here to rule out the possibility that any diagnosis effects were due to depression alone. The internal consistency of the BDI-II was excellent (α = .93).

The *Experiences in Close Relationships Scale Revised* (ECR-R; Fraley, Waller, & Brennan, 2000) was generated using an item response theory analysis of multiple scales designed to assess adult attachment. The ECR-R consists of those items that best provided the information captured across these scales, and assesses two factors: attachment anxiety ("I worry a lot about my relationships.") and attachment avoidance ("I prefer not to be too close to romantic partners."). Subsequent research has supported the reliability, stability, factor validity, and construct validity of the measure (Sibley, Fischer, & Liu, 2005; Sibley & Liu, 2004). Notably,

because this measure uses a dimensional approach, it does not render attachment styles in a categorical fashion. Instead, a relative lack of attachment anxiety and avoidance can be construed as indicating secure attachment, whereas presence of higher levels of either attachment anxiety or attachment avoidance can be construed as suggesting various insecure attachment styles (Fraley et al., 2000). In the current sample, internal consistency was excellent for both subscales (αs > .92).

Diagnostic measures. The *Liebowitz Social Anxiety Scale* (LSAS; Liebowitz, 1987) is a 24-item, clinician-administered interview measuring anxiety and avoidance related to various social situations on a Likert-type scale. The LSAS has excellent convergent and divergent validity (Heimberg et al., 1999) and is able to distinguish between patients meeting criteria for GSAD, non-generalized SAD, and controls without SAD (Mennin et al., 2002). In addition to being used for diagnosis, it was also used as a measure of social anxiety symptom severity for follow-up tests. Internal consistency for this instrument in the present study was excellent (α = .99).

The *Structured Clinical Interview for DSM-IV* (SCID-IV-TR; First, Spitzer, Gibbon, & Williams, 1995) is a semi-structured interview with adequate to excellent inter-rater reliability used to assess current and lifetime DSM-IV-TR disorders (Zanarini et al., 2000). In the present study, the interview was abridged to assess current mood-and anxiety-related psychopathology, with past symptoms assessed as needed to render current diagnoses (e.g., past mood episodes).

Participants meeting criteria for GSAD on the SCID and having an LSAS score of 60 or higher were included in the GSAD group. Participants who both did not meet criteria for SAD and had an LSAS score less than 30 were included in the NOSAD group. Inter-rater reliability,

rated based on 10% of the interviews from this sample and an additional sample (including screen failures), was 100% for assignment to diagnostic group.

Behavioral Economic Task. The same general flexible iterated prisoner's dilemma (FIPD) program used by Rodebaugh and colleagues across several studies (Rodebaugh et al., 2016; Rodebaugh, Klein, Yarkoni, & Langer, 2011; Rodebaugh et al., 2013) was used. Figure 1 depicts the task procedure (see also a more detailed description in **Supplementary Material**). Notably, the computer responded in a more friendly way for known participant rounds than stranger rounds (i.e., during the latter it responded randomly). This design choice was made to provide face validity for the different players and prevent participants from assuming the computer would always respond the same way; however, as a design choice it has consequences for interpretation, as noted in the **Discussion**. Giving across the first 15 turns of the friend round was used as an index of overall giving; this index has shown good internal consistency and stability and convergent validity with ratings of friend relationships (Rodebaugh et al., 2016; Rodebaugh et al., 2013). In addition, giving across the first 10 friend round turns and first 15 turns of all rounds were analyzed below, as explained further in the **Data Analytic Procedure**; all of these sets of turns showed excellent internal consistency in the current data (αs > .87).

Study Procedure. After providing informed written consent and meeting diagnostic inclusion criteria, participants provided several ratings and a genetic sample not reported on here. Participants were then oriented to the FIPD task, which was described as a social dilemma game. Details of how the task was introduced and implemented are included in **Supplementary Material**. Participants were intermittently asked to provide ratings, not used here, associated with the task. Lastly, participants were provided with a packet of questionnaires including demographic items and the IIP-32 that they were asked to return completed at their next study

visit. All participants were invited to bring a friend to Visit 2, which occurred one week after the initial session whenever possible. Friends were defined as someone who was not a current romantic partner or family member. At this visit, friends completed the IIP-32 in reference to the primary participant, as well as additional tasks not reported on here.

Analytic Procedure

Primary analyses were conducted in Mplus 7.4 using the MLR estimator (Muthén & Muthén, 1998-2015). Hypothesis 1 was tested as a simple regression model in which diagnosis predicted giving across the first 15 friend turns; self- and friend-reported vindictiveness were then added to the model to test portions of Hypotheses 2 and 3. The remainder of Hypotheses 2 and 3, concerning giving to friends across time, was examined using a latent trajectory model of initial turns on the FIPD in the friend round. Differences in slope and intercept across diagnostic group were examined in initial models, followed by tests of how LSAS, self-, and friend-reported vindictiveness predicted slope and intercept. Hypothesis 4 was tested using a latent trajectory model in which giving to strangers across each round of stranger turns, giving to friends across the first 15 turns, and giving to romantic partners across the first 15 turns were included to estimate intercept and slope. The first 15 turns were used for each because only 15 stranger turns were included on each stranger round, and latent trajectory results are dependent on the scale of the variables included. The slope parameter was estimated such that stranger rounds had a loading of 0 and friend and romantic partner rounds had a loading of 1, which meant that the slope parameter represented the difference between giving to known versus unknown players. A latent trajectory approach was used to allow the estimate of latent variables representing initial giving (intercept) and rate of giving increase (slope) using all available

information. Diagnosis was included as an initial predictor to test Hypothesis 4. In exploratory analyses, dimensional measures were tested as alternative predictors to diagnosis.

We report fully standardized estimates (STDYX in Mplus, reported as *b**) except when the raw estimates have a clearer interpretation than standardized estimates (e.g., when diagnosis predicts slope of giving, the *standardized* estimates have no clear interpretation, whereas the raw estimates clearly depict how presence of diagnosis impacts the slope of giving). We consulted the following fit indices to determine global model fit for latent trajectory analyses: (a) Tucker-Lewis incremental fit index (TLI) (Tucker & Lewis, 1973), (b) comparative fit index (CFI) (Bentler, 1990), (c) root mean square error of approximation (RMSEA) (Steiger & Lind, 1980), and (d) the standardized root mean square residual (SRMR) (Bentler, 1995; Jöreskog & Sörbom, 1981). To determine a good fit of the model to the data, the following values were used: TLI and CFI ranging from .95 to 1, RMSEA below 0.6, and SRMR below .08 (Hu & Bentler, 1999).

Age and its interaction with diagnosis, as well as gender (of primary participant) and its interaction with diagnosis were ruled out as potential alterative explanations of effects in tests not shown here because none of these predictors were statistically significant. (Age and gender were tested in separate models to avoid depletion of power to detect any effects.) Order of known players (i.e., simulated friend or romantic partner first) was also examined for interactions with predictors other than diagnosis; these tests essentially involve smaller sample sizes (e.g., because order of known players is a between-participants factor), so we report departures from the primary results based on interactions with order in separate sections following the main tests, which are emphasized.

Bayesian analyses were also conducted to supplement standard (i.e., frequentist) analyses, because Bayesian methods are not vulnerable to problems due to multiple tests

(Kruschke, 2014). We report these results in the **Supplementary Material**; when frequentist tests are not conclusive, we report the Bayesian results in brief in this paper. Most missing data were due to the 45 participants who did not bring a friend to Visit 2 (35% of NOSAD; 33% of GSAD). In addition, fewer than 10 participants failed to provide data regarding IIP-32, ECR-R, and BDI-II. There were no missing data for behavioral economic tasks, diagnosis, and LSAS scores. The estimators used handle missing data, allowing the use of all participants. When necessary, predictors that had more missing data were regressed upon related predictors that had fewer missing data (e.g., diagnosis) to permit the use of the full sample.

Results

Sample Characteristics

Overall sample characteristics and basic FIPD task metrics are presented in Table 1 by diagnostic group. Notably, there were no differences in total giving across diagnosis for any of the FIPD conditions. However, the diagnostic groups did differ on self-reported (but not friend-reported) vindictiveness, with participants with GSAD reporting more vindictiveness. Also notably, level of giving was similar within each group within each type of player (i.e., known: friend and romantic partner; unknown: strangers). We also examined the correlation of self-report and friend-report of vindictiveness; these variables correlated moderately (r = .35, p = .001).

Prediction of Giving to Friend by Diagnosis

Generally consistent with hypothesis (Hypothesis 1, that diagnosis would not predict), diagnosis showed only a trend to predict giving to simulated friends across the first 15 turns (partially standardized coefficient = -0.33, p = .062). GSAD participants tended to give a third of a standard deviation less than NOSAD participants. When self- and friend-reported

vindictiveness were added as predictors, diagnosis no longer showed a trend to predict giving (p = .206), but self-reported vindictiveness showed a trend effect (b^* = -0.15, p = .058) and friend-reported vindictiveness showed a significant effect (b^* = -0.23, p = .010). Each parameter was in the direction of increasing vindictiveness predicting decreased giving. As described in **Supplementary Material**, the Bayesian estimate suggested that *both* friend- and self-reported vindictiveness had a meaningful effect on giving behavior. Thus, in support of Hypotheses 2 and 3, there was evidence that both self- and friend-reported vindictiveness predicted in the same manner as vindictiveness did in Rodebaugh et al. (2016).

Prediction of Trajectory of Giving to Friend

Overall trajectory model. We first attempted to fit the same four-turn model used in our previous (Rodebaugh et al., 2016) investigation, but we could find no reasonable version of this model with good fit. Examination of the data suggested a more gradual slope across the initial turns of the task, resulting in no ability to estimate the slope from the first four turns. Notably, the inclusion of stranger turns (during which the computer responded randomly) was a new addition to our procedure. We speculate, but cannot test, that the stranger turns could impact how quickly participants increased giving. We thus investigated a latent trajectory model of the first ten turns (i.e., the interval during which the task correlated most strongly with interpersonal variables in previous work, cf. Rodebaugh et al., 2013; we did not use 15 turns because of concerns that such a model would be too complex given the sample size). This model fit reasonably well (CFI = .94, TLI = .95, RMSEA = .06, SRMR = .06) and showed a significant mean (M = 0.05, p = .021) and variance (Variance = 0.02, p = .019) for the slope parameter, indicating that participants overall tended to increase giving over time but there was significant

variation in this increase. We therefore investigated a multiple-group model focusing on the trajectory for the first ten turns of the simulated friend round.

Multiple group trajectory model. In this model, the GSAD and NOSAD groups were permitted to have different average trajectories. This model had marginal fit (CFI = .87, TLI = .88, RMSEA = .10), but this appeared to be due to a lack of significant mean or variance for slope in the GSAD group (*p*s > .58). The GSAD group appeared to be adequately characterized by an intercept alone (M = 5.06, Variance = 2.52, *p*s < .003). That is, participants in the GSAD group tended to give about 5 tokens on the first turn (with significant variation between individuals) and showed no tendency to systematically increase or decrease their giving over time. In contrast, the NOSAD group tended to start with a similar amount of giving (M = 5.15, Variance = 3.97, *p*s < .001), but also tended to give systematically more over time (slope mean = 0.10, slope variance = 0.04, *p*s < .008), such that most NOSAD participants gave about 6 tokens on the tenth turn. Consistent with these findings, a nested chi-square test for a model in which the mean and variance of the slope were constrained across diagnostic group revealed that this resulted in worse model fit, $\Delta\chi^2(2) = 6.25$, $p = .044$. This finding was unexpected, but was consistent with Hypothesis 2, which stated that social anxiety would limit increases in giving.

Prediction in multiple group trajectory model. To complete the planned tests of Hypothesis 2, we examined whether social anxiety severity (measured by the LSAS), as well as self- and friend-reported vindictiveness, predicted the slope and intercept of giving. The only significant prediction in either group was for the intercept. In the GSAD group, self-reported vindictiveness predicted the intercept such that higher self-reported vindictiveness was associated with lower initial giving (b^* = -0.29, p = .03). In the NOSAD group, in contrast, *friend-reported* vindictiveness predicted the intercept such that higher friend-reported

vindictiveness was associated with lower initial giving (b^* = -0.41, p = .03); the same finding was supported by Bayesian analysis. That is, in the NOSAD group, the self-report of vindictiveness had a credible interval that contained zero, whereas the friend-report of vindictiveness had a credible interval that did not contain zero; the pattern was reversed for the GSAD group (see **Supplementary Material**). The LSAS did not predict slope or intercept in any instance (ps > .28). Thus, partial support was found for Hypothesis 2, in that vindictiveness, but not social anxiety severity, predicted as expected.

Order effects. To test potential differences in prediction based on order of playing, the prediction model was run in each order subsample. Attempts to handle these tests through interactions with order in a single model resulted in improper solutions, which suggests caution in interpreting findings for order in general in these models. Effects were substantively similar, with the following differences. When participants completed the romantic partner condition before the friend condition, self-report vindictiveness no longer predicted for the GSAD group. However, the LSAS predicted slope (higher LSAS predicted *more* of an increase in giving, b^* = .86, p = .005), as did friend-reported vindictiveness (higher vindictiveness predicted less of an increase in giving, b^* = -.99, p < .001). Similarly, in the NOSAD group, friend-reported vindictiveness predicted slope (b^* = -.38, p < .001). NOSAD effects could not be tested in the participants who completed the friend condition first because there were too few participants for the parameters used; the GSAD effects for that order condition were substantively identical to those reported in the primary analysis.

Prediction of Difference between Giving to Simulated Known and Unknown Players

In an initial test of Hypothesis 4, diagnosis was used to predict the intercept and slope of the trajectory representing difference in giving between simulated stranger and known player

rounds. Thus, the intercept represented the tendency to give to simulated strangers and the slope represented the degree of change between giving to simulated strangers and known players. Diagnosis did not predict the intercept (p = .998), but did predict the slope (estimate = -9.86, p = .014). Participants with GSAD only gave an average of 1.12 tokens more per turn to known than unknown players. (That is, because the slope's intercept was 26.66, those who had GSAD had a slope of 16.80, indicating a 16.80 increase in giving to known versus unknown players over the course of 15 turns). In contrast, NOSAD participants gave an average of 1.78 tokens (i.e., 26.66 divided by 15) more per turn to known than unknown players. Results were essentially identical in Bayesian analyses.

Adding self-reported and friend-reported vindictiveness to the model did not eliminate the diagnosis effect. Further, friend-reported vindictiveness strongly predicted the slope (estimate = -1.24, p = .008), such that participants who were higher in friend-reported vindictiveness showed less of an increase in giving to simulated known versus unknown players. Notably, because vindictiveness varied from 0 to 16 whereas diagnosis varied from 0 to 1, this means that friend-reported vindictiveness could have a much bigger impact on slope (reducing slope by up to 19.84) than would diagnosis (reducing slope by 9.86), if it is the case that all values of vindictiveness were represented in the data.

Because the apparently stronger effect for vindictiveness would also depend on what values can actually be observed in the dataset, we examined this issue more closely. The predicted giving to a known versus unknown player is depicted in Figure 2 based on the knowledge that a participant was in a given diagnostic group and the lowest and highest friend-rated vindictiveness actually observed in that group. Importantly, Figure 2 presents the predicted effects for participants observed in the data, given multiple predictors: No interaction effect is

depicted. That is, both diagnostic groups had participants for whom both self- and friend-reported vindictiveness was zero, but only in the NOSAD group was there a participant for whom both friend- and self-reported vindictiveness was at the maximum (16). In the GSAD group, the maximum friend-report of vindictiveness was 14, with the self-report for that participant being 0. As a result, the figure seems as if it might depict an interaction effect, yet the predictors were only additive in the model. The figure makes it clear that the significant diagnostic effect on slope is far outweighed by the effect of vindictiveness. Bayesian analyses supported the role of friend-reported vindictiveness, but indicated less confidence in the diagnosis effect, such that its 95% credible interval contained zero. Hypothesis 4, which specified a diagnosis effect for change in giving between known and unknown players, was thus only partially supported, whereas the unexpected effect for friend-rated vindictiveness appeared more robust.

Order effects. In an initial test including interaction of order with all three predictors, interactions with diagnosis and self-reported vindictiveness showed trend-level interactions (the former for slope and the latter for intercept), but friend-reported vindictiveness did not interact significantly for either ($p > .10$). When the nonsignificant interactions were eliminated in predicting both slope and intercept, the remaining interactions were statistically significant: Order interacted with self-reported vindictiveness to predict the intercept ($b^* = .32$, $p = .001$) and with diagnosis to predict slope ($b^* = .71$, $p = .02$). The effect of friend-report of vindictiveness on the slope was substantively unchanged. Probing the interaction revealed that when participants completed the friend condition first, diagnosis had no effect on slope ($p = .943$) and self-reported vindictiveness showed a trend effect in predicting intercept (estimate = -1.13, $p = .056$). In contrast, diagnosis had a large effect on slope when participants completed the romantic

partner condition first (estimate = 15.75, p = .007). Self-reported vindictiveness, however, did not predict intercept in that order (p = .275).

Exploratory Follow-up Tests

Two possible diagnosis effects were noted above: For diagnosis to affect slope in giving to friend, and for diagnosis to affect giving to known versus unknown players. We conducted follow-up tests in which social anxiety symptom severity (measured by the LSAS), depression, attachment avoidance, and attachment anxiety were tested as alternatives to diagnosis as a predictor. Notably, the estimator used accounts for any nonnormality created by the presence of the diagnostic groups.

When all predictors were included as predictors of intercept and slope of giving to simulated friends, only attachment avoidance significantly predicted slope (b* = -.32, p = .045) such that participants with higher attachment avoidance tended not to increase their giving over time. None of the other predictors approached statistical significance (ps > .58). In the Bayesian version of the analysis, the credible interval for attachment avoidance contained zero at its upper limit (with an upper bound of 0.000), suggesting limited confidence in this result.

For the moderated effect of diagnosis in predicting giving to known versus unknown players, we tested each potential predictor against the LSAS in separate models to avoid excessive complexity. The LSAS significantly predicted slope when attachment anxiety was also included in the model (b* = -.19, p = .041), but not when depression or attachment avoidance was included (for the latter, the LSAS showed a trend effect, p = .055). In contrast, none of the other predictors showed a significant effect (ps > .14). Thus, overall, social anxiety severity showed some, albeit inconsistent effects similar to diagnostic group. As with the diagnostic

group finding, the Bayesian version of these analyses did not support confidence in the LSAS as a predictor.[2]

Discussion

Emerging research suggests that SAD is characterized by a lack of sensitivity to interpersonal context that may contribute to observed reductions in prosocial behavior on economic tasks. Here, we tested whether SAD is associated with reduced giving when a situation warrants such behavior (e.g., to a simulated known versus unknown person), as opposed to overall reductions in generosity on a prisoner's dilemma task. We also explored whether self- and informant-reported interpersonal vindictiveness may more generally contribute to reduced overall generosity. Finally, we assessed whether any effects for SAD might be better explained by alternative constructs, such as depression and attachment style.

Three primary findings emerged. First, participants with SAD were slower to give more to a simulated friend. Second, consistent with our prior research (Rodebaugh et al., 2016) interpersonal vindictiveness was negatively associated with giving behavior according to self- and informant-report. Follow-up tests revealed that no effects found for SAD were better explained by depression, but that attachment avoidance better explained slower giving to a friend than did SAD diagnosis or symptom severity. The effect for SAD was additionally found to be inconsistent relative to task order. Third, an inconsistent diagnosis effect was found for predicting the degree to which participants gave more to simulated known versus unknown players. An effect for friend-report of vindictiveness predicting the same outcome proved more robust. We discuss these findings further below.

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[2]In the interest of transparency, we acknowledge that we also tested a candidate gene effect (*AVPR1A* RS3 repeat length), specified a priori, in this sample. Although results were positive, we recognize that our study is underpowered for a candidate gene investigation and therefore we do not report these tests. The first author can provide details on these analyses.

SAD and Interpersonal Context Insensitivity

Our findings were that limited effects on the FIPD are primarily associated with a SAD diagnosis, whereas others are primarily attributable to interpersonal tendencies that are moderately associated with SAD. These findings should be instructive to the future studies in behavioral economics (or neuroeconomics) in individuals with mental disorders that have been called for by multiple researchers (Hasler, 2012; Sharp et al., 2012).

The mere fact that diagnostic groups differ on an economic construct, as was initially reported by Rodebaugh et al. (2013), does not necessarily mean that the diagnosis or even the dimensional construct central to the diagnosis is the primary correlate of the economic behavior. Notably, many of the researchers who have expressed optimism regarding behavioral economics have focused on the neural level, but focusing on this level of analysis does not obviate the more general observation that a difference between diagnostic groups is no guarantee that the difference is due to diagnosis alone. As shown subsequently by Rodebaugh and colleagues (2016) and further supported here, a detailed examination of both the task behavior and competing predictors can reveal more complex relationships between diagnoses, associated conditions, and economic behavior. Both individual differences in vindictiveness (as hypothesized) and attachment avoidance (as found in exploratory tests) demonstrated stronger or more consistent predictions of economic behavior than either SAD or SAD severity in this study. That said, however, our results regarding simulated known versus unknown players add indirect support to findings that participants with SAD show less reward sensitivity to the trustworthiness of players (i.e., based on their previous behavior) in a trust task (Sripada et al., 2013). Overall, the evidence suggests that the primary effect of SAD on economic tasks concerns lack of flexible responding, which could very well be due to constrained reward sensitivity to social stimuli

(although we did not assess such reward sensitivity here). However, such effects do not appear to be robust and may be dependent on what other predictors are in the model, in what order tasks are administered, and whether frequentist or Bayesian analyses are preferred. Ratings of vindictiveness were more stable in their prediction across these factors.

Vindictiveness and Overall Reductions in Giving

For overall giving, vindictiveness showed the clearest effect: Participants who were more vindictive gave less initially and less overall. We examined friend-reported vindictiveness under the assumption that if the effects of vindictiveness and generosity shown on the FIPD are *interpersonal*, then friend-reported vindictiveness should also predict giving. Although the relative contribution of self- and friend-reported vindictiveness varied, the effects were always in the same direction. Further, *friend-reported* vindictiveness showed more consistent effects overall. The effect of vindictiveness is clearly not just a matter of self-report bias, but instead plausibly represents an association between interpersonal behavior and task behavior.

Given the consistency of findings for vindictiveness, the construct bears closer examination. We have found relatively few studies in the existing literature that help characterize this subscale. One study found that vindictiveness (among other IIP subscales) was associated with self-report of narcissism, although vindictiveness did not show the strongest relationships with this variety of personality pathology (Ogrodniczuck, Piper, Joyce, Steinberg, & Duggal, 2009). A second study suggested that vindictiveness may correlate with self-report of aggression, but that it may also decline with age (Weinryb et al., 1996). None of these results may be particularly surprising when it is remembered that the items on the subscale focus on finding it hard to care about others or put their needs before one's own. Overall, however, these items appear to have little to do with the dictionary definition of vindictiveness (e.g., being spiteful or

revenge-seeking), but rather suggest a difficulty making interpersonal connections and experiencing empathy. Seen this way, it should be no surprise that this scale is related both to SAD (in self-report) and to behavior on the FIPD. It may be of particular interest that, in terms of initial giving to simulated friends, friend-reported vindictiveness predicted better for NOSAD participants, whereas *self-reported* vindictiveness predicted better for GSAD participants. It may be that participants with SAD who experience lack of empathy for others may be reluctant to share this personal information with friends.

The consistency of the findings for vindictiveness are also suggestive of a potential reframing of the broader implicit research question that drove both this research and that of previous studies examining the FIPD. That question is: How does social anxiety disorder lead to relationship impairment? It is quite clear that SAD is related to *self-report* of relationship impairment (Aderka et al., 2012; Rodebaugh, 2009; Schneier et al., 1994). However, more recent findings (drawn partially from the sample used here) shed doubt on whether relationship partners see negative effects of SAD (Rodebaugh et al., 2014). Further, the available prospective findings in adults suggests that interpersonal variables (e.g., loneliness, friendship quality) prospectively predict social anxiety severity far more so than social anxiety severity predicts interpersonal variables (Lim, Rodebaugh, Zyphur, & Gleeson, 2016; Rapee, Peters, Carpenter, & Gaston, 2015; Rodebaugh, Lim, Shumaker, Levinson, & Thompson, 2015). Further, although interpersonal therapy modified from treatments with depression showed somewhat limited effects for SAD (Lipsitz et al., 2008), recent tests of combining exposure-like exercises with either intimacy-building (Alden & Taylor, 2011) or practicing kindness (Trew & Alden, 2015) may have promise in treating SAD. We believe it would be premature to conclude that SAD has no effect on interpersonal functioning beyond self-perception, but it now seems clear that

interpersonal functioning has a much stronger effect on SAD than vice versa. In sum, these findings suggest a renewed focus on such constructs as loneliness, attachment, and quality of relationships in the treatment of SAD.

Reframing research questions currently posed as "How does SAD cause relationship impairment?" into questions more related to the originating and maintaining factors for relationship impairment itself (which may then exacerbate social anxiety, among many other symptoms) is consistent with the RDoC framework (Cuthbert & Kozak, 2013). The RDoC framework emphasizes a shift from a focus on diagnoses to underlying dimensional constructs that may contribute to the problems identified by those processes (Cuthbert & Kozak, 2013). Taken together with other recent prospective studies of social anxiety and interpersonal functioning, our findings suggest that a focus on systems underlying interpersonal behavior might benefit not only those suffering from SAD, but potentially also other internalizing disorders. Specifically the affiliation/attachment dimension defined by RDoC (Cuthbert & Kozak, 2013), focusing as it does on such issues as preference for individuals and attachment to caregivers and romantic partners, seems plausible as a system that may underlie our findings on the FIPD, vindictiveness, and attachment. Future research designed at the outset to focus on this dimension and its contribution to economic behavior, social anxiety, and interpersonal relationships is called for.

Limitations and Future Directions

It is important to interpret this study in the context of its limitations. Because known and unknown players responded based on different strategies (with known players responding in a more friendly way; see **Supplementary Material**), it is not possible to determine whether differences between player type were due to who the participants imagined playing with, the

computer's responses, or both. There would be virtues to a follow-up study in which these factors were varied independently. Although the study is moderately large in size for a behavioral study stratified by clinical diagnosis, sample size was more limited when examining task order. Our findings in this regard may serve as a caution to multiple-task studies of behavioral economics, in which we have rarely seen order considered, let alone tested. Second, our sample was primarily comprised of women, with limited diversity in ethnicity and race; larger, more diverse samples would clearly be useful. Third, our task was a simulation, and we did not attempt to deceive participants; a similar task in which participants believe they are playing with real people would arguably have higher ecological validity.

After accounting for the limitations of this study, it remains the case that the findings are broadly consistent with previous literature and suggest future directions. Our results indicate that SAD is related to behavioral economic indices in regard to simulated known players, as was indicated by early results (Rodebaugh et al., 2011; Rodebaugh et al., 2013). However, our results also indicate, in line with more recent findings (Rodebaugh et al., 2016), that the specific effect of SAD is more likely to be detected in regard to flexibility of giving behavior, primarily across players (e.g., known versus unknown). Even these effects, however, may be weak and inconsistent compared to the effect of interpersonal variables. Interpersonal vindictiveness, which might be better conceptualized as lack of empathy, was a clear driver of economic behavior. Further, friend-report of this construct was, if anything, more related to economic behavior, increasing our confidence that an interpersonal behavioral pattern is responsible (i.e., rather than mere self-report bias). Further examination of how vindictiveness (or lack of empathy) might affect interpersonal functioning in the context of internalizing disorders seems warranted.

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Table 1
Frequencies and Descriptive Statistics for GSAD and NOSAD Participants

	NOSAD (n = 60)	GSAD (n = 73)
Age	36.46 (13.33)	40.48 (13.57)
Number of (%) Women	43 (71.67%)	53 (72.60%)
Race		
White	36 (60.00%)	38 (52.05%)
Asian	3 (5.00%)	2 (2.73%)
Black	20 (33.33%)	27 (36.99%)
Multiracial	1 (1.67%)	5 (6.84%)
American Indian	-	1 (1.36%)
Pacific Islander	-	-
Ethnicity (Non-Hispanic)	57 (95.00%)	72 (98.63%)
Marital status*		
Never married	35 (58.33%)	47 (64.38%)
Currently married	16 (26.67%)	7 (9.58%)
Previously married	9 (15%)	19 (26.02%)
Education*	15.58 (2.64)	14.05 (2.90)
Liebowitz Social Anxiety Scale**	11.13 (7.45)	92.88 (18.29)
Self-Reported Vindictiveness**	2.54 (3.52)	5.06 (4.42)
Friend-Reported Vindictiveness	3.71 (4.20)	3.46 (4.44)
Total Giving - Stranger 1st turn	59.42 (23.22)	60.12 (21.82)
Total Giving - Stranger 2nd turn	62.45 (24.85)	61.44 (26.56)
Total Giving - Romantic Partner	87.38 (37.47)	79.97 (33.91)
Total Giving - Friend	87.27 (36.75)	76.21 (30.98)

Note. GSAD = Participants with generalized social anxiety disorder; NOSAD = Participants without social anxiety disorder
*SAD and NOSAD differ significantly at $p < .05$
**SAD and NOSAD differ significantly at $p < .001$

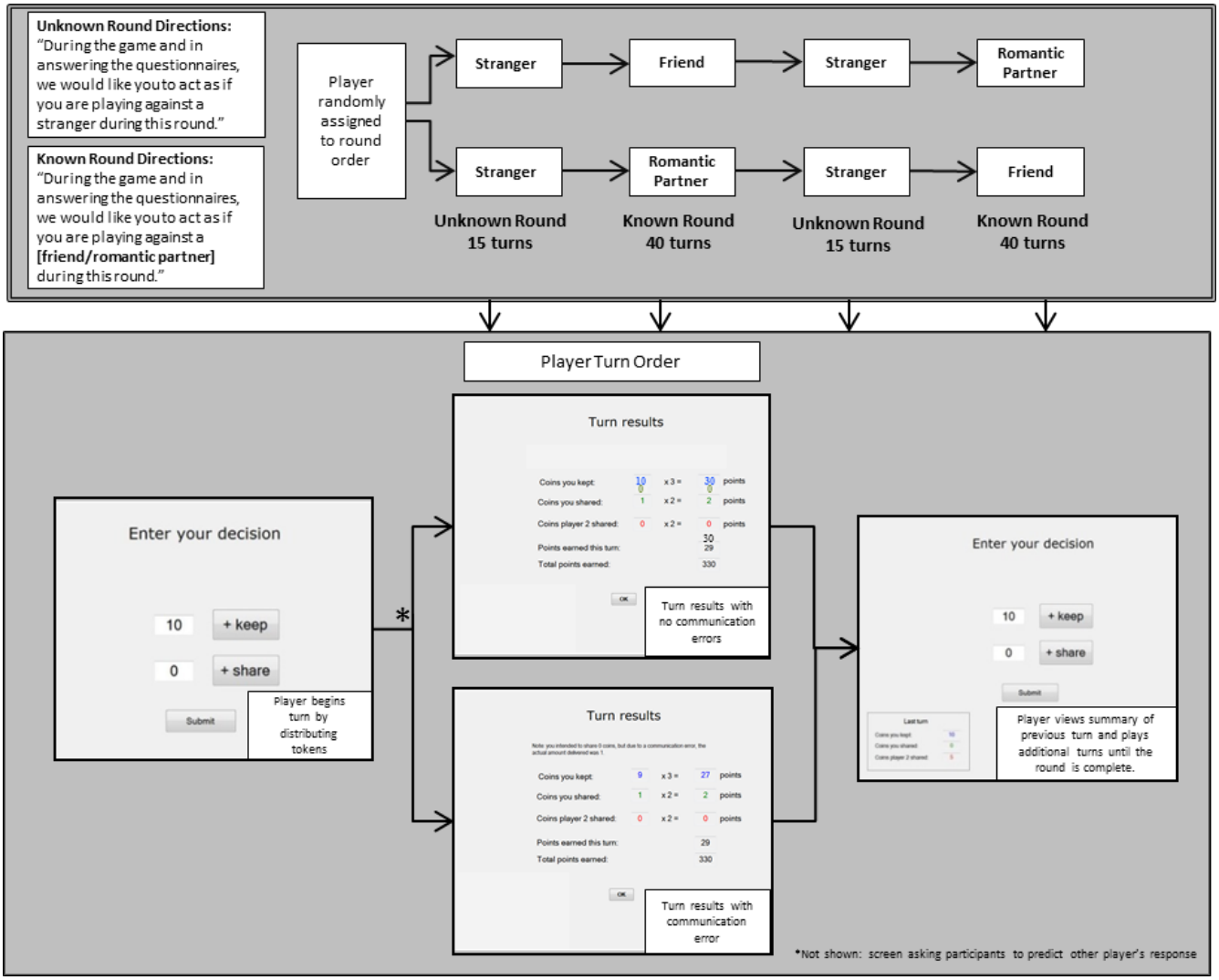

Figure 1. A graphical depiction of turn orders and round orders. All players follow the same round order (unknown player round, known player round, unknown player round, known player round); however, whether the directions for the known player round instruct the participant to first play against a friend or a romantic partner was determined by a randomization procedure. Turn order was identical for all rounds. Note that participants were randomly assigned to have the computer systematically defect (versus not) for the final five turns, but these data are not analyzed in this paper. More information is available in the **Supplementary Material**.

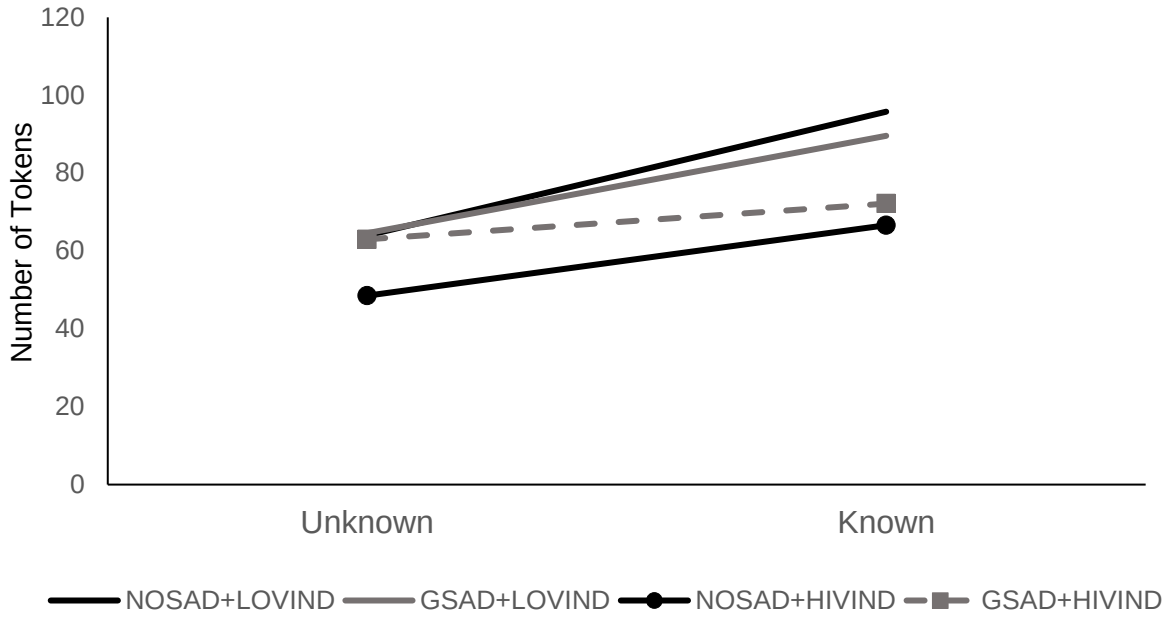

Figure 2. Predicted giving to simulated known and unknown players based on the latent trajectory model. The lines show the predicted amount given to a player of that type by a participant with the specified characteristics. NOSAD = Participant with no social anxiety disorder; GSAD = Participant with social anxiety disorder; LOVIND = The participant with the lowest vindictiveness values in that group (0 for both self-report and friend-report of vindictiveness); HIVIND = The participant with the highest friend-rated vindictiveness in that group (for NOSAD, ratings of 16 for self- and friend-report, for GSAD, friend-report of 14 and self-report of 0). Participants could have given between 0 and 150 tokens to each simulated known and unknown player. Note that there were no significant interactions in the model; the appearance of an interaction is due to the fact that there were different observations for actual highest vindictiveness ratings in each group.

Supplementary Material

Additional Procedural Notes

The overall nature of the Flexible Iterated Prisoner's Dilemma (FIPD) is noted in the main text, primarily in the visual depiction in the main text Figure 1. Some additional details are as follows. On each turn, participants were asked to divide 10 tokens between their partner and themselves. Decisions were made simultaneously (e.g., by both the participant and computer). Reaction time (in seconds) was recorded for each turn. Feedback screens (e.g., tokens given by each player) were then displayed. During decisions, participants were shown the results of the prior trial. Tokens given to the other player were worth 2 points to each player and tokens kept were worth 3 points to the individual player only.

When the computer responded in a friendly way (friend and romantic partner rounds) it used the modified Raise the Stakes strategy described by Rodebaugh and colleagues (MRTS; Rodebaugh, Klein, Yarkoni, & Langer, 2011, based on Roberts & Sherratt, 1998). Essentially, the MRTS was more generous than a strict tit-for-tat strategy. The computer responded randomly during stranger rounds.

Participants' choices as well as computer responses were affected by simulated communication errors on 10% of trials causing an up to 3 token change (in either direction) in giving. Errors were not added to computer responses during rounds with players described as strangers because those responses were already random. Participants were informed that communication errors could occur before they began play, but they were not told how often such errors would occur. The purpose of the errors was to improve ecological validity (cf. Van Lange, Ouwerkerk, & Tazelaar, 2002). Information about errors affecting participant (but not computer) decisions was presented on the feedback screen. The errors were randomly generated at the time

of playing; an error in programming present in previous studies was corrected for this study (see, e.g., Rodebaugh et al. 2011).

The initial instructions given for the task were as follows:

Now we are going to start the computer task. Today you will be playing a social dilemma game. In the first part, you will play with a computerized stranger—someone you don't know. Each turn you will have 10 tokens. You can give any number of these tokens to the other player, and the other player can choose to give anywhere between 0 and 10 tokens to you. Both you and the other player earn 3 points for every token kept, and 2 points for every token that the two of you share.

So, if you each keep 5 and share 5, you will each get 15 points for the ones you keep, and 20 points for the ones that you share [show example table in the questionnaire packet].

At each turn you will be asked to decide how many tokens to give to the other player, and then you will be asked to estimate how much you think they will give you this turn. This will help us know how well you can predict the other player's actions. You and the other player will each make your decision at the same time. So, each of you will not be sure about what the other is going to do. Any questions so far? [answer any]

You have two tasks. One is to do as well as possible in the game by earning the most points you can. At the same time, please imagine that you are playing with a stranger. Does that make sense? [answer any questions]

All right. One more thing. There will also be communication errors on some trials of this game. Say you meant to give five tokens. The communication error means you might end up giving 2 tokens, which would be less than you meant, or, for example, 8, which is more than you meant. You will be informed of the error when it causes you to give fewer or more tokens than

intended. The other player will also be affected by noise, but you won't know when this is happening. Does that make sense?

After each turn, you will see a screen that summarizes what happened on that turn. At the end of playing a series of turns, we will ask you to rate how you feel in regard to the other player you just played. Then you will move on to the next player.

Any questions about any of that?

OK. Finally, please remember that during the game and in answering the questionnaires, we would like you to act as if you are playing against a stranger during this round.

Go ahead and start, and let me know when the screen comes up that says to talk to me.

The experimenter script for the known player rounds were as follows:

If it is friend: Say: Now you will play the next player, who will be a close friend. Everything will be the same about the game, but the player you are working with is different: it is a friend of yours [if necessary: what you imagine a friend would be like]. This will be the same person you are filling out your packet about.

Determine who they are filling out the packet about. For the next portion, feel free to use the friend's actual name.

Say: Please close your eyes for a moment and bring your friend to mind. [Wait for them to close their eyes; encourage this as needed.] Please imagine your friend's face [if imagined friend: what you imagine your friend would look like] and think about your relationship with them. Please keep in mind that this is the person you will be playing next.

If it is romantic, say: Now you will play the next player, who will be a romantic partner. Everything will be the same about the game, but the player you are working with is different: it is

your romantic partner [if necessary: a previous romantic partner/what you imagine a romantic partner would be like].This will be the same person you are filling out your packet about.

Bayesian Analyses

The analyses reported in the manuscript were also examined using Bayesian analyses conducted in the same software. We used previously-reported data as priors. For example, for diagnosis effect on giving, the data used in three previous tests across two manuscripts (Rodebaugh, Heimberg, Taylor, & Lenze, 2016; Rodebaugh et al., 2013) were available. We therefore conducted Bayesian versions of those three tests, starting with a flat, diffuse prior, and with each subsequent test taking the posterior distribution of the diagnosis effect as the prior for the next analysis after multiplying the variance by four (Yuan & MacKinnon, 2009). For effects of vindictiveness, two previous data sets were available for self-report, and none were available for friend-report. We therefore developed a self-report vindictiveness effect prior based on the available data (including diagnosis and self-reported vindictiveness as predictors) and multiplied the variance of that prior by an additional factor of four for a friend-report prior (representing the additional uncertainty represented in using a different form of report). Because the previous tests used the 64-item version of the IIP, whereas we used the 32-item version, we also multiplied the estimate by two in each case (because the same effect size mapped onto half the number of items should result in a parameter estimate that is twice as large). Because the trajectory model that was used was not hypothesized, we report Bayesian estimates using uninformative priors (i.e., which reflect a situation of starting with no clear hypothesis). One exception was for vindictiveness predicting the intercept, because the intercept prediction was expected to be similar even if, for example, the slope parameter differed across studies. Intercept and slope variances are not reported in this case because they could not be estimated separately by group in

this analysis. Finally, for the exploratory tests we also used uninformative priors because of the exploratory nature of the tests. We report the 95% credible interval, mean, and standard deviation for Bayesian effects as a supplement to frequentist information.

Prediction of giving to friend by diagnosis. Similarly to the frequentist analysis, the Bayesian estimate indicated that although NOSAD participants gave about ten more tokens over the first 15 turns (M = 10.08 SD = 5.40), the 95% credible interval included zero (-0.61 to 20.46). When vindictiveness scores were added to prediction, the Bayesian estimate indicated that each point increase in friend-rating of vindictiveness was related to giving nearly two fewer tokens over the first 15 turns (M = -1.71 SD = 0.72), with the 95% credible interval not including zero (-3.12 to -0.31). The estimate for the effect of self-reported vindictiveness was only slightly smaller (M = -1.48 SD = 0.58), with the 95% credible interval also not including zero (-2.63 to -0.34).

Prediction of trajectory of giving to friend

Overall trajectory model. This model was not conducted because there were no crucial predictor tests.

Multiple group trajectory model. Compared to the frequentist findings, the Bayesian estimates suggested similar conclusions regarding the GSAD slope, with the credible interval for the mean of the slope including zero. The GSAD intercept was also similar to that found for the frequentist tests (Bayesian estimated M = 5.07, SD = 0.25, credible interval = 4.66 - 5.81). The NOSAD intercept (Bayesian estimated M = 5.16, SD = 0.30, credible interval 4.59 - 5.75) and slope (Bayesian estimated slope M = 0.10, SD = 0.04, credible interval 0.03 - 0.17) were also similar to the frequentist estimates.

Prediction in multiple group trajectory model. As in the frequentist analysis, self-reported vindictiveness predicted the intercept of giving in the GSAD group (Bayesian *b** = -0.19, *SD* = 0.09, credible interval -0.36 - -0.02), whereas friend-reported vindictiveness predicted in the NOSAD group (Bayesian *b** = -0.26, *SD* = 0.10, credible interval -0.46 - -0.06). The other predictor had a credible interval that included zero in each case.

Prediction of difference between giving to known and unknown players. As in the frequentist tests, there was an effect of diagnosis on slope (estimate = -9.82, credible interval 1.79 17.96). This was despite the fact that, notably, uninformative priors were used because no empirical evidence clearly applying to this test was available (i.e., no priors were generated based on theory, resulting in a quite strict test). However, when vindictiveness ratings were added as predictors, the diagnosis effect had a credible interval that contained zero between the 5% and 2.5% lower bound (estimate = -7.96, credible interval -0.43, 16.43). In other words, adding the vindictiveness ratings increased the credibility of the diagnosis effect actually being null. In contrast, the effect for friend-report of vindictiveness had a credible interval that did not contain zero (estimate = -1.20, credible interval -2.35 -0.01).

Exploratory tests. The prediction of the slope of giving to a friend by attachment avoidance included zero in the credible interval in that the upper bound was 0.000. Thus, Bayesian analysis did not indicate sufficient confidence that the effect was not zero, but did indicate that most of the credible interval was negative in sign. (Bayesian *b** = -0.19, *SD* = 0.24, credible interval = -.65 - .29). Tests for the LSAS and other predictors focusing on difference in giving to known versus unknown players never produced a credible interval that excluded zero.

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