

Cardiac vagal flexibility and accurate personality impressions: Examining a physiological correlate of the good judge

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Abstract

Objective: Research has long sought to identify which individuals are best at accurately perceiving others' personalities or are *good judges*, yet consistent predictors of this ability have been difficult to find. In the current studies, we revisit this question by examining a novel physiological correlate of social sensitivity, cardiac vagal flexibility, which reflects dynamic modulation of cardiac vagal control.

Method: We examined whether greater cardiac vagal flexibility was associated with forming more accurate personality impressions, defined as viewing targets more in line with their distinctive self-reported profile of traits, in two studies, including a thin-slice video perceptions study ($N = 109$) and a dyadic interaction study ($N = 175$).

Results: Across studies, we found that individuals higher in vagal flexibility formed significantly more accurate first impressions of others' more observable personality traits (e.g., extraversion, creativity, warmth). These associations held while including a range of relevant covariates, including cardiac vagal tone, sympathetic activation, and gender.

Conclusion: In sum, social sensitivity as indexed by cardiac vagal flexibility is linked to forming more accurate impressions of others' observable traits, shedding light on a characteristic that may help to identify the elusive good judge and providing insight into its neurobiological underpinnings.

KEYWORDS

accuracy, cardiac vagal flexibility, personality impressions, social sensitivity

1 | INTRODUCTION

Accurately perceiving others' personalities is an adaptive skill that may help individuals navigate their complex social worlds. In particular, forming accurate first impressions may facilitate better decision making about whom to continue interacting with and foster relationship development with those individuals (e.g., Human, Sandstrom, Biesanz, & Dunn, 2013). This raises the question of whether some individuals are more adept at this and, if so, why? Although this is one of the longest-standing questions in personality psychology (e.g., Adams, 1927), identifying consistent predictors of this tendency to be a *good judge* (Funder, 1995) or high in *perceptive accuracy* (Human & Biesanz, 2011) has

proven difficult. Yet individuals are argued to reliably vary in their sensitivity to the social environment, which may be driven by differential neurobiological responses to the environment (e.g., Belsky & Pluess, 2009). Good judges may therefore be identifiable by examining physiological responses to the social environment. In the current studies, we examined whether one proposed physiological indicator of social sensitivity, cardiac vagal flexibility (Muhtadie, Koslov, Akinola, & Mendes, 2015), was associated with forming more accurate impressions of others' stable personality traits in an effort to shed light on who the good judge is and what underlies this ability.

We define accurate impressions as distinctive self-other agreement (Biesanz, 2010; Cronbach, 1955; Furr, 2008),

indicating the extent to which an individual's (perceiver's) impressions correspond to another person's (target's) personality profile across a series of traits, using the target's self-reported personality profile as the accuracy criterion. Though target self-reports are but one, admittedly imperfect, accuracy criterion, they are nevertheless a common and valid criterion, and they correlate highly with other indicators, such as close other reports (Funder & Colvin, 1997).

Thus, in the current studies, a good judge was defined as someone who can determine a target's unique self-reported profile of traits, such as whether he or she is more talkative than creative and more kind than anxious, relative to other people. Such a profile approach to assessing accuracy provides a holistic index of whether the perceiver understands the target by examining the extent to which he or she has developed a valid impression of the target's overall patterning traits (see Borkenau & Leising, 2016, for a review). Further, this indicator of accuracy controls for the normativity of impressions (Biesanz, 2010; Cronbach, 1955; Furr, 2008), the extent to which a perceiver views targets as similar to the average personality profile. Viewing others normatively can reflect a reliance on information about what people generally tend to be like (Rogers & Biesanz, 2015) and also a tendency to view others highly positively, as the normative profile tends to be highly socially desirable in nature (see Wood & Furr, 2016, for a review). For example, most people tend to be more kind than anxious. We therefore control for and examine the role of normativity but focus on distinctive accuracy. As such, when referring to the good judge or accuracy more broadly, we are referring to distinctive accuracy.

What factors predict greater distinctive accuracy? According to the realistic accuracy model (RAM; Funder, 1995), in order for an impression to be accurate, *relevant* cues must be *available* to perceivers, and then both *detected* and appropriately *utilized*. Greater neurobiological sensitivity to the social environment seems particularly likely to enhance a perceiver's ability to detect the cues that targets emit, thereby enhancing the accuracy of personality impressions. Of note, experimental manipulations designed to increase a perceiver's motivation to be accurate, and therefore likely attunement to social stimuli, have been shown to promote accuracy (Biesanz & Human, 2010; Ickes, Gesn, & Graham, 2000; Klein & Hodges, 2001; but see Hall, Blanch, et al., 2009). Further, intranasal administration of oxytocin has been linked to forming more accurate impressions of others' states, perhaps by enhancing the salience of social cues (see Bartz, Zaki, Bolger, & Ochsner, 2011, for a review), suggesting one possible neurobiological underpinning of perceptive accuracy. However, the links between oxytocin administration and accuracy have been inconsistent, especially in healthy samples (Human, Thorson, Woolley, & Mendes, 2017; Radke & De Bruijn, 2015), and effects on the accuracy of personality judgments have not been examined.

There has been more difficulty finding reliable stable predictors of the good judge (see Funder, 1995; Kenny, 1994), perhaps in part because there appear to be small individual differences in this ability (e.g., Biesanz, 2010). Indeed, several characteristics that have been argued to be relevant to perceptive accuracy are more strongly linked to forming normative rather than distinctively accurate personality impressions, including gender (Chan, Rogers, Parisotto, & Biesanz, 2010) and psychosocial well-being (Human & Biesanz, 2011b; Letzring, 2015). However, trait empathy has been linked to forming more accurate impressions of others' traits and states (Colman, Letzring, & Biesanz, 2017; Hall, Andrzejewski, & Yopchick, 2009). Importantly, empathy is a stronger predictor of accuracy for others' emotions when examining more expressive targets (Zaki, Bolger, & Ochsner, 2008), in line with recent findings that good judges of personality are easier to identify when examining their impressions of targets who are easier to perceive (Rogers, 2015)—termed *good targets* (Funder, 1995) or individuals high in *judgability* (Colvin, 1993). This is in line with the multiplicative nature of RAM, whereby successful achievement of the latter stages requires successful achievement of earlier stages (Funder, 1995). That is, in order for a good judge's superior cue detection to enable more accurate impressions, the target must first provide sufficiently relevant cues.

In the current studies, we took a complementary approach: Rather than isolating good targets (thereby limiting our sample of targets), we instead examined perceptive accuracy as a function of *good traits*, another moderator of accurate judgments that may influence cue relevance and availability (Funder, 1995). For example, traits that are high in observability, such as Extraversion and Openness, are considered "good," as they often have clear behavioral manifestations. In contrast, less observable traits, such as Neuroticism and some aspects of Agreeableness (e.g., sympathy, jealousy), are those that tend to be more internal in nature (e.g., Funder & Drobth, 1987), though this can vary as a function of the social context (e.g., Hirschmüller, Egloff, Schmukle, Nestler, & Back, 2015). Thus, focusing on good traits, just like good targets, makes it more likely that relevant cues will be available to the perceiver, thereby enabling differences in perceivers' cue detection to have an impact on accuracy. This should in turn make it easier to identify predictors of this skill. We therefore examined whether a physiological correlate of social sensitivity, cardiac vagal flexibility, emerges as a stronger predictor of perceptive accuracy for high compared with low observability traits.

Cardiac vagal flexibility refers to the dynamic modulation of vagal influence on the heart (Hagan et al., 2016; Muhtadie et al., 2015). The vagus nerve is a core component of the parasympathetic branch of the autonomic nervous system (ANS) and has long been implicated in complex social behavior (e.g., Darwin, 1872; Porges, 2007). Indeed, Porges's polyvagal

theory argues that the vagus nerve plays a key role in a social communication circuit through both somatomotor and autonomic components that benefit interactions and promote flexible responding. The somatomotor component may be beneficial through its regulation of, for example, head gestures, facial expression, responsiveness to others' voices, and vocal production. The autonomic component focuses on the myelinated branch of the vagus nerve, which provides efferent control of the heart. Specifically, during rest, the vagus nerve inhibits the influence of the sympathetic branch of the ANS on the heart, slowing heart rate down during exhalation and promoting a calm resting state, which can facilitate effective communication. Because the sympathetic nervous system maintains its influence on the heart during inhalation, this results in greater heart rate variability (HRV), such that heart rate is faster during inhalation and slower during exhalation. One commonly used index of HRV is respiratory sinus arrhythmia (RSA), which provides an indicator of cardiac vagal tone. Interestingly, greater cardiac vagal tone is associated with a variety of positive social-emotional processes, including greater social competence (Beauchaine, 2001) and psychological well-being, at least at moderate levels (e.g., Kogan, Gruber, Shallcross, Ford, & Mauss, 2013).

Although greater HRV may be generally beneficial at rest, it may be less adaptive during more active tasks. Indeed, when environmental demands increase, the cardiac vagus nerve is likely to withdraw its inhibitory influence, reducing HRV, in order to respond to those demands. Thus, a decrease in RSA may be observed in the shift from more restful to more active tasks, including mentally demanding tasks. For example, attentionally and cognitively demanding tasks reliably elicit greater vagal withdrawal (e.g., Van Roon, Mulder, Althaus, & Mulder, 2004; Walter & Porges, 1976). In turn, greater vagal withdrawal in such tasks tends to predict better cognitive performance and social sensitivity, suggesting an adaptive response (Hagan et al., 2016; Kassam, Koslov, & Mendes, 2009; Muhtadie et al., 2015). As noted above, greater RSA may promote a calm state that should benefit social interactions, but when social contexts shift, it is likely that a decrease in RSA would also be adaptive, as such contextual shifts also tend to be attentionally and cognitively demanding. Thus, the extent of vagal withdrawal in response to a demanding task, whether purely cognitive (Study 1) or more social (Study 2), indexed by a decrease in RSA, is our indicator of cardiac vagal flexibility, reflecting a potentially adaptive responsiveness and sensitivity to situational demands (Friedman, 2007; Muhtadie et al., 2015; Rottenberg, Salomon, Gross, & Gotlib, 2005).

Just as there are individual differences in cardiac vagal tone, there are also stable individual differences in cardiac vagal flexibility—differences that are independent of cardiac vagal tone and with a distinct set of correlates (Muhtadie et al., 2015). For example, compared with vagal tone, vagal

flexibility appears to be uniquely linked to social processes, such as greater behavioral warmth (Diamond & Cribbet, 2013) and lower loneliness (Muhtadie et al., 2015), rather than generally higher well-being. Further, vagal flexibility is not simply related to positive social processes. Supporting its conceptualization as an indicator of social sensitivity, vagal flexibility predicts greater pro-social behavior under positive social conditions but less under adverse conditions (Obrodović, Bush, Stamperdahl, Adler, & Boyce, 2010) and more positive social responses to accepting social feedback but more negative responses to rejecting feedback (Muhtadie et al., 2015). Furthermore, there is preliminary evidence that greater vagal flexibility may foster perceptive accuracy, as it is associated with more accurate detection of emotion from still facial images (Muhtadie et al., 2015).

Overall, we predicted that a physiological indicator of social sensitivity, cardiac vagal flexibility, would be associated with forming more accurate first impressions of personality. We examined this across two studies of dynamic first impressions, based upon brief video clips of targets engaged in a naturalistic interaction (Study 1: $N = 109$) and a longer in-person interaction with a new acquaintance (Study 2: $N = 175$).

2 | STUDY 1

For both studies, we report all data exclusions, conditions, all variables related to the present research questions, and sample size determinations below (see also notes 2–4). All procedures were approved by the ethics board at the University of California, San Francisco.

2.1 | Method

2.1.1 | Participants

Participants between the ages of 18 and 30 who spoke English as their first language were recruited from the community to serve as perceivers. Prior to scheduling a lab appointment, perceivers were prescreened via email and excluded based on criteria that could affect their personality judgments or physiological data in a non-normative manner, including a history of a psychiatric disorder (e.g., depression or anxiety disorder), a physical health condition (e.g., cardiovascular, neurological, or endocrine diseases), or a body mass index (BMI) greater than 30. Perceivers were asked to abstain from caffeine and vigorous exercise for 2 hr prior to the study.

Our goal was to recruit a minimum of 100 participants with complete data or as many as possible between July 2014 and April 2015. A total of 122 perceivers completed the study, of which 13 were excluded due to either lost physiological data ($n = 1$) or video perception data ($n = 12$). The

TABLE 1 Associations between demographic, physiological, and interaction-specific variables and cardiac vagal flexibility

Additional predictors	Descriptive statistics		Correlation with vagal flexibility			
	Study 1	Study 2	Study 1		Study 2	
	<i>M</i> (<i>SD</i>) or %	<i>M</i> (<i>SD</i>) or %	<i>r</i>	95% CI	<i>r</i>	95% CI
Gender	64%	56%	-.11	[-.29, .08]	.15*	[.002, .29]
Age	24.57 (3.66)	24.75 (3.84)	-.05	[-.24, .14]	-.09	[-.24, .06]
BMI	22.69 (3.03)	22.97 (3.00)	-.06	[-.24, .13]	-.10	[-.25, .06]
Respiration rate	17.15 (3.84)	14.82 (2.68)	.03	[-.16, .22]	.07	[-.08, .21]
Cardiac vagal tone	6.54 (1.26)	6.65 (1.06)	.27**	[.09, .44]	.43***	[.31, .55]
Sympathetic reactivity	1.80 (8.79)	6.33 (10.12)	-.16†	[-.35, .02]	-.03	[-.19, .12]
Positive social expectations		4.83 (0.85)			.25**	[.10, .39]
Positive affect		4.71 (0.85)			.02	[-.13, .18]
Negative affect		1.22 (0.48)			.09	[-.06, .23]

Note. *M* = mean; *SD* = standard deviation; *r* = Pearson or point biserial correlation; CI = confidence interval; Gender: 0 = male, 1 = female; BMI = body mass index. Social expectations and affect ratings were made on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

†*p* < .10. **p* < .05. ***p* < .01.

final data set therefore included 109 perceivers (see Table 1 for additional descriptive information). Using an initial effect size estimate from past research on the association between subjective attention and accuracy ($r = .32$; Human et al., 2012), the expected power for the current study with 109 participants, after incorporating the uncertainty of the initial effect size estimate into the analysis, is .82 (see Biesanz & Schrager, 2017; McShane & Bockenholt, 2016; and the faps package for R: `github\jbiesanz\faps`).

2.1.2 | Procedures and measures

Cardiac vagal flexibility

In line with prior research (Muhtadie et al., 2015), to assess vagal flexibility, perceivers' RSA during a baseline period was compared to their RSA during a visual tracking task (Cavanagh & Alvarez, 2005) designed to assess multiple-object tracking capacity in visual cognition studies. This task is ideal for assessing vagal flexibility, as it is mentally demanding and thereby likely to elicit vagal withdrawal, yet it does not require higher-level executive functioning and is free of social and emotional content. As such, the task is less dependent on intelligence and education levels, not emotionally evocative, and distinct from the accuracy task, which is highly social. Specifically, this task involves 16 trials in which 12 black dots are presented against a gray background. At the start of each trial, a subset of dots flashes yellow for 2 s to indicate that they are the target dots to be tracked throughout the trial by the perceiver. The target dots then turn black along with the rest of the dots, and all the dots then move randomly around the screen for 12 s. At the end

of each trial, the dots stop moving and the perceiver must attempt to identify the target dots. Perceivers completed four blocks that each comprised four trials. As perceivers progressed from each block, they were required to track an increasing number of dots (two to five). Thus, the task becomes increasingly difficult as it progresses.

RSA was assessed continuously for the 5-min baseline rest period and during the 4 min of the attention task with impedance cardiography (HIC-2000), which uses a band electrode system and electrocardiography (ECG), in which sensors were placed in a modified lead II configuration (right upper torso, left lower torso) and acquired with an ECG module from Biopac (Goleta, CA). All signals were recorded at a sampling rate of 1000 Hz and integrated with a Biopac MP150. To calculate RSA, we utilized Mindware software's HRV 2.6 module (Lafayette, OH). Trained research assistants visually inspected each minute of the digitized ECG signal and corrected artifacts and incorrectly identified R spikes.

To assess cardiac vagal tone, we averaged across the 5 min of RSA during the baseline period ($M = 6.54$, $SD = 1.26$; range = 3.10–9.12). To assess vagal flexibility, we first calculated RSA reactivity scores by subtracting the last minute of baseline RSA (when perceivers were most relaxed) from the last minute of the attention task RSA (when the attention task was at its most challenging). As expected, RSA significantly declined across these two time points, $t(108) = -4.47$, $p < .0001$ ($M = -0.42$; $SD = 0.99$), although there was substantial variability (range = -2.70–2.96). The RSA reactivity scores were then multiplied by -1 to obtain vagal flexibility scores, whereby higher, positive

values would reflect greater flexibility. We also extracted respiration rate from the z0 signal in order to include respiration rate during the final minute of the attention task as a covariate ($M = 17.15$, $SD = 3.84$; range = 7.37–27.50).

Perceptive accuracy

To assess accuracy, perceivers then viewed a set of four or five 2-min video clips of targets from a pool of 44 targets (24 female, 20 male; $M_{\text{age}} = 24.48$, $SD = 3.53$). This subset of targets was selected from a larger study ($N = 121$) because they (a) consented to having their video viewed by future participants and (b) provided all necessary self-report data to assess accuracy.¹ Targets were video-recorded while engaging in a social interaction, specifically, playing a cooperative game similar to Taboo with a “partner” who was actually a confederate (trained research assistant acting as a fellow participant), matched on gender and ethnicity (when possible). In this game, the target and confederate each took two 1-min turns trying to get their partner to guess words, without being able to use any of five “taboo” words that were listed on their prompt cards (e.g., if the word to be guessed was *birthday*, the clue giver could not say the words *happy*, *anniversary*, *candles*, *cake*, or *presents*). To increase engagement in the task, targets believed they would receive points for every word guessed correctly and lose points for each taboo word accidentally spoken, which would influence a monetary bonus. Confederates’ responses were scripted, thereby creating a similar experience for all targets. Perceivers viewed the middle 2-min block, giving the perceiver the opportunity to view the target as both the guesser and clue giver, and could only see the target, not the confederate. The videos were shortened to these 2-min clips to reduce perceiver time burden, given that accurate judgments can be formed on the basis of very brief amounts of information (e.g., Ambady & Rosenthal, 1993). We selected the middle block because information from the middle segment of a social interaction tends to be of higher quality (Carney, Colvin, & Hall, 2007).

After each video clip, perceivers indicated on the Mini Markers Scale (Saucier, 1994) the extent to which 40 personality traits were characteristic of the target on a scale ranging from 1 (*extremely inaccurate*) to 9 (*extremely accurate*). Each item mapped onto one of the Big Five personality traits: Extraversion (e.g., talkative, bold), Agreeableness (e.g., warm, kind), Neuroticism (e.g., fretful, moody), Conscientiousness (e.g., efficient, organized), and Openness (e.g., creative, intellectual). To examine whether vagal flexibility predicted accuracy for good traits in particular, we categorized each trait as high or low in observability, based on prior research (Human & Biesanz, 2011a) and consideration of the task targets were engaged in (a cooperative and creative game). For example, high observability items included items related to Extraversion (e.g., bold, talkative), Openness (e.g., creative, intellectual), and some facets of

Agreeableness (e.g., warm, cooperative), whereas low observability items included Conscientiousness (e.g., careless, disorganized), Neuroticism (e.g., fretful, moody), and other aspects of Agreeableness (e.g., jealous, sympathetic). All targets completed self-reports on the Mini Markers Scale (Saucier, 1994), using the same rating scale as above, to serve as accuracy validation criteria.²

Covariates

In additional analyses, we also assessed and controlled for several demographic covariates that may play a role in vagal flexibility and/or accuracy, including perceiver gender, age, and BMI. See Table 1 for descriptive statistics and correlations with vagal flexibility. In addition to controlling for cardiac vagal tone and respiration rate, we further assessed the physiological specificity of cardiac vagal flexibility by examining sympathetic activation. Indeed, we contend that vagal flexibility, and specifically the role of the vagus nerve, is uniquely useful to predict accuracy given the vagus nerve’s presumed role in social sensitivity. To buttress this physiological specificity argument, we also assessed changes in pre-ejection period (PEP). PEP reflects the time from the contraction of the left ventricle to the opening of the aorta, a measure of pure sympathetic nervous system activation. Like RSA, PEP was measured with impedance cardiography and electrocardiography. To calculate PEP, we utilized Mindware software’s IMP 2.6 module (Lafayette, OH). Trained research assistants visually inspected the waveforms, corrected artifacts, and adjusted placement of the B and/or X points if needed. PEP reactivity was assessed in parallel to vagal flexibility by subtracting the last minute of baseline PEP from the last minute of the attention task PEP. Lower PEP values indicate greater levels of sympathetic nervous system (SNS) activation. Thus, as expected, PEP significantly decreased across these two time points, $t(106) = -2.12$, $p = .04$ ($M = -1.80$, $SD = 8.79$), although there was substantial range (range = -44.00–35.00). For ease of interpretation, we multiplied change in PEP by -1 so that greater scores would reflect greater SNS activation.

Analytical approach

Accuracy was estimated with a multilevel model utilizing R’s lme4 package (Bates, Maechler, Bolker, & Walker, 2015; R Development Core Team, 2016) following the social accuracy modeling (SAM) procedures (Biesanz, 2010; see Human & Biesanz, 2011a,b, for detailed empirical examples). To assess both distinctive accuracy and normativity, in the within-perceiver part of the model (Level 1), we predicted perceivers’ ratings of each target on each personality item simultaneously from (a) the target’s personality self-report on that item after subtracting the normative mean for that item (*distinctive accuracy*), and (b) the mean target self-report on that item (*normativity*). The normative means were derived from the mean self-report on these measures from the

larger sample ($N = 117$) these targets were drawn from. Items were not reverse coded prior to analysis. Distinctive accuracy and normativity slopes were allowed to vary randomly by perceivers and targets. (The R scripts and data needed to recreate the primary analyses can be found at osf.io/g9tk5/).

To examine the role of trait observability, item observability (0 = low, 1 = high) was included as a predictor of the accuracy and normativity slopes. Similarly, we examined whether vagal flexibility was associated with distinctive accuracy and normativity by including perceiver vagal flexibility as an additional predictor of the accuracy and normativity slopes. A positive interaction between perceiver vagal flexibility and targets' personality self-report predicting perceiver personality ratings would indicate that perceivers with higher vagal flexibility see others more in line with their distinctive self-reported traits.

2.2 | Results

2.2.1 | Levels and variability in accuracy

On average, perceivers viewed targets' personality traits with significant levels of distinctive accuracy ($b = .05$, $z = 2.32$, $p = .02$). This indicates that perceivers were generally able to discern targets' unique, self-reported profile of traits. However, there was a significant interaction with trait observability, such that distinctive accuracy was significantly higher for more observable traits ($b = .03$, $z = 2.13$, $p = .03$). Specifically, distinctive accuracy was significant for high observability traits ($b = .07$, $z = 2.81$, $p = .005$), but not for low observability traits ($b = .04$, $z = 1.61$, $p = .11$). Perceivers also viewed targets in line with the normative profile on average across all personality traits ($b = .50$, $z = 9.25$, $p < .001$), but more so on high observability traits ($b = .52$, $z = 9.59$, $p < .001$) than low observability traits ($b = .45$, $z = 8.22$, $p < .001$; interaction $b = .07$, $z = 4.04$, $p < .001$).

2.2.2 | Vagal flexibility and accuracy

We first examined whether the associations between vagal flexibility and accuracy differed as a function of trait observability. There was a significant three-way interaction between trait observability, vagal flexibility, and distinctive accuracy ($b = .03$, $z = 2.23$, $p = .03$), such that vagal flexibility was associated with greater distinctive accuracy for high observability traits ($b = .02$, $d = 0.62$, $z = 2.24$, $p = .03$; see Figure 1a), but not for low observability traits ($b = -.00$, $d = -0.11$, $z = -.36$, $p = .72$; see Figure 2a).

Specifically, perceivers who exhibited higher vagal flexibility (one standard deviation above the mean) and mean levels of vagal flexibility accurately perceived targets' observable personality traits, such as how talkative, creative, and warm they were (high vagal flexibility: $b = .09$,

$z = 3.44$, $p < .001$; mean vagal flexibility: $b = .07$, $z = 2.92$, $p = .004$). In contrast, perceivers lower in vagal flexibility (one standard deviation below the mean) did not form significantly accurate impressions of targets' more observable traits ($b = .04$, $z = 1.58$, $p = .11$).

Associations between vagal flexibility and normativity did not significantly vary as a function of trait observability ($b = -.01$, $z = -.69$, $p = .49$). Examining all trait items together, vagal flexibility was associated with forming significantly less normative personality impressions ($b = -.06$, $z = -2.01$, $d = -0.39$, $p = .04$). Thus, individuals higher in vagal flexibility were less likely to view others in line with the normative profile on average across traits.

2.2.3 | Covariates

None of the demographic covariates were significantly associated with accuracy, either overall or as a function of trait observability (all $ps > .35$). Further, the associations between cardiac vagal flexibility and accuracy for high observability traits held controlling for each covariate (all $ps < .05$). We also found evidence for physiological specificity. Neither cardiac vagal tone nor respiration rate was significantly associated with forming more accurate impressions, either overall (cardiac vagal tone: $b = -.00$, $z = -0.14$, $p = .89$; respiration rate: $b = -.00$, $z = -.06$, $p = .95$) or as a function of trait observability (cardiac vagal tone: $b = .006$, $z = 1.13$, $p = .26$; respiration rate: $b = -.004$, $z = -1.31$, $p = .19$). Further, sympathetic activation (PEP reactivity) was not significantly associated with greater accuracy either overall ($b = .001$, $z = 0.84$, $p = .40$) or as a function of trait observability ($b = -.001$, $z = -1.47$, $p = .14$). In turn, vagal flexibility remained a significant predictor of accuracy for high observability traits controlling for vagal tone, respiration rate, and sympathetic activation (all $ps < .05$).³

In sum, vagal flexibility was associated with forming more accurate first impressions of others' more observable personality traits based on thin slices of information—2-min video clips of individuals playing a cooperative game. We sought to replicate and extend these findings in Study 2 with a more interactive and in-depth first impressions context involving lengthier face-to-face dyadic interactions.

3 | STUDY 2

3.1 | Method

3.1.1 | Participants

Participants between the ages of 18 and 35 who spoke English as their first language were recruited from the community to serve as perceivers. The same screening procedures and instructions as Study 1 were followed. Participants were

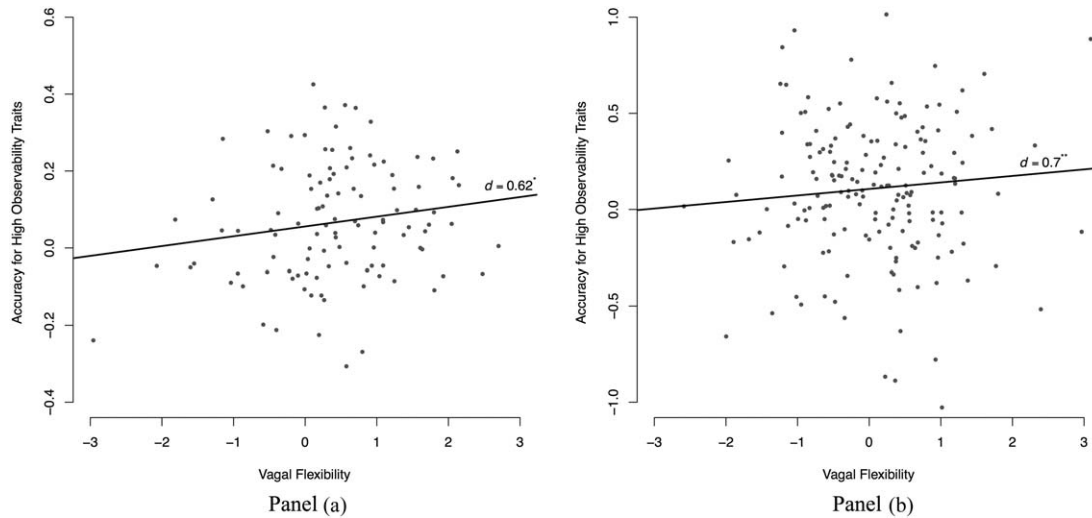


FIGURE 1 Perceiver cardiac vagal flexibility predicting perceiver distinctive accuracy for high observability traits in Study 1 (Panel a) and Study 2 (Panel b). Accuracy values are the ordinary least squares estimates of perceiver distinctive self–other agreement slopes

scheduled for a lab visit at the same time as another participant, matched on gender and age (within 5 years), but were not aware of this during scheduling and arrived at the lab separately. We aimed for a sample of at least 200 participants, intending to collect more to account for inevitable missing data. A total of 204 participants completed the study, of which 29 were excluded from the present analyses due to lost physiological data ($n = 13$) or incomplete questionnaires ($n = 16$), resulting in a final sample for primary analyses of 175 participants (see Table 1 for additional descriptive information). This sample was slightly smaller than planned, but expected power, calculated in parallel to Study 1, was .89.

Upon completion of the study, perceivers were debriefed and compensated \$57 (\$40 as advertised plus \$17 for their

participation in study tasks, described below; all participants received the same amount regardless of performance).

3.1.2 | Procedures and measures

Vagal flexibility

As in Study 1, participants first completed a 5-min rest period during which baseline RSA was assessed. Participants were then told that another participant was in the lab and asked whether they were comfortable engaging in several tasks with them (all said yes). Participants were then brought into the same room and engaged in a series of social interactions, including getting-acquainted conversations (described below), playing the cooperative game Taboo described in Study 1 (without a confederate), and a speech task, in which

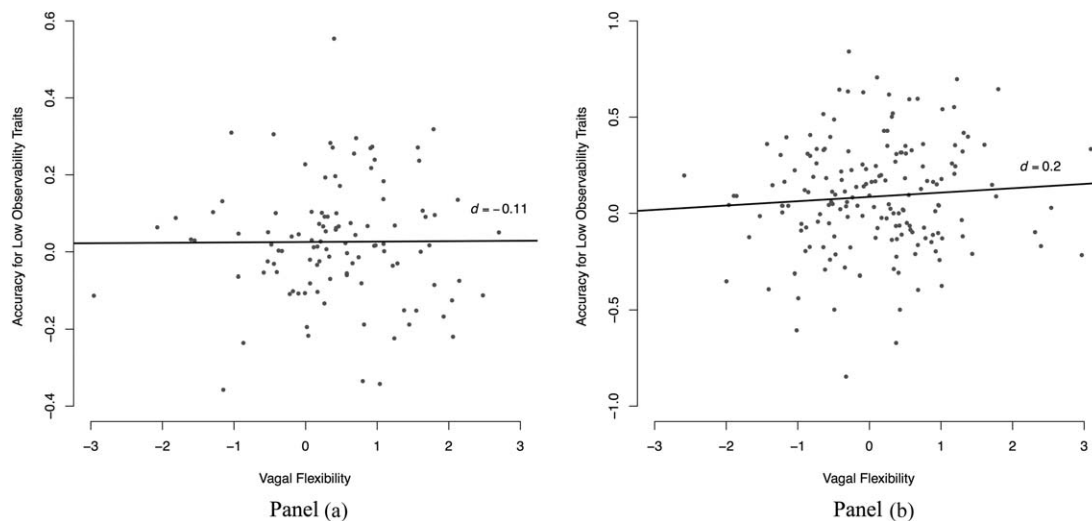


FIGURE 2 Perceiver cardiac vagal flexibility predicting perceiver distinctive accuracy for low observability traits in Study 1 (Panel a) and Study 2 (Panel b). Accuracy values are the ordinary least squares estimates of perceiver distinctive self–other agreement slopes

one of the two participants was randomly assigned to make a 5-min speech about why he or she makes a good friend. Altogether, the interactions lasted a total of 15 min.⁴

In contrast to Study 1, participants did not engage in a purely cognitive, nonsocial task that is optimal for assessing vagal flexibility. Instead, we compared baseline RSA to RSA in the first minute of the social interaction, when participants were first asked to engage in an active task (see Muhtadie et al., 2015, for a similar approach). Specifically, once participants were brought into the room together and briefly introduced, a screen was put up while participants filled out a pre-interaction questionnaire. The screen was then removed, and participants were asked to speak about whatever they wanted for the next 3 min. After 3 min, they were asked to take turns asking and answering questions from a provided list for an additional 3 min. Thus, the first minute of the interaction might be considered the most demanding, as it was completely unstructured and novel. As such, as with the attention task in Study 1, greater vagal withdrawal at the start of a new social interaction should indicate greater attentional focus. However, given that it was more social and affective in nature than the visual tracking task in Study 1, we also controlled for participants' social expectations prior to the interaction and affect directly after the interaction (see Covariates section below).

Cardiac vagal tone, flexibility, and respiration rate were assessed following the same procedures as in Study 1. RSA was again assessed continuously for the 5-min baseline rest period and the social interactions. To assess cardiac vagal tone, we averaged across the 5 min of RSA during the baseline period ($M = 6.65$, $SD = 1.06$; range = 2.99–8.84). To assess vagal flexibility, we calculated RSA reactivity scores by subtracting the last minute of baseline RSA from the first minute of the first social interaction task RSA. The average drop in RSA was smaller than Study 1 and did not significantly decline across these two time points, $t(174) = 1.03$, $p = .31$ ($M = -.07$, $SD = .95$), but there was again substantial variability (range = -3.09–2.59). RSA reactivity scores were then multiplied by -1 to obtain vagal flexibility scores, so that higher, positive values would reflect greater flexibility. We also assessed respiration rate during the first minute of the social interaction ($M = 14.82$, $SD = 2.68$; range = 7.24–23.32) as a covariate.

Perceptive accuracy

To assess accuracy, participants rated their interaction partner's personality traits at the end of the study, as part of a larger questionnaire. Personality impressions of interaction partners were made on the 44-item Big Five Inventory (BFI; Benet-Martínez & John, 1998), plus three items assessing intelligence, on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). We once again examined the role of trait observability, using the same coding scheme as Study 1.

Participants completed self-reports on the same BFI measure in the pre-lab visit questionnaire, using the same rating scale as above, to serve as accuracy validation criteria.

Covariates

In additional analyses, we assessed and controlled for the same demographic characteristics as in Study 1, including perceiver gender, age, and BMI (see Table 1; see Supplementary Online Materials (SOM) for further analyses with psychosocial variables as covariates). We assessed sympathetic activation as change in PEP from the last minute of baseline to the first minute of the first social interaction, parallel to our indicator of vagal flexibility. Participants demonstrated a significant decline in PEP, $t(157) = 7.86$, $p < .0001$ ($M = -6.33$, $SD = 10.12$), indicating increased sympathetic activation at the start of the social interactions, but there was substantial variability (range = -45.67–27.33). As in Study 1, we multiplied these values by -1 so that greater scores would indicate greater activation.

In addition, given that the task in which we assessed vagal flexibility was more social and affective in nature than in Study 1, we also controlled for the positivity of participants' social expectations and their positive and negative affect. For social expectations, after a brief introduction to their interaction partner by the experimenters, participants completed a short questionnaire indicating to what extent they agreed with the following statements: "I am looking forward to talking with this person," "My partner is looking forward to talking to me," "I expect to like this person," and "My partner will like me," all rated on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*; $\alpha = .78$). After the social interaction was complete, participants completed a modified version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), with 12 positive affect items (PA: proud, excited, enthusiastic, warm, interested, happy, alert, determined, attentive, calm, sociable, excited; $\alpha = .90$) and nine negative affect items (NA: distressed, upset, hostile, sad, irritable, ashamed, nervous, jittery, afraid; $\alpha = .76$) on the same 7-point scale as above (see Table 1 for descriptive statistics).

Analytical approach

We again utilized the social accuracy modeling approach to assess accuracy (Biesanz, 2010), modified for dyads. Specifically, rather than modeling perceiver and target random effects, we modeled random effects for each unique perceiver–target pair. The random effects estimates are therefore a combination of perceiver, target, and dyadic variability. Nevertheless, we can still indirectly examine the extent to which perceiver characteristics, such as vagal flexibility, relate to accuracy by introducing these variables as predictors of accuracy slopes, as in Study 1 (see osf.io/g9tk5/ for R scripts and data).

3.2 | Results

3.2.1 | Levels and variability in accuracy

On average, participants viewed their interaction partner's personality traits with significant levels of distinctive accuracy ($b = .09$, $z = 5.50$, $p < .001$), at higher levels than seen in Study 1, as would be expected given the longer and more interactive nature of the tasks. As in Study 1, there was also a significant interaction with trait observability ($b = .04$, $z = 2.14$, $p = .03$), such that distinctive accuracy was significantly higher for more observable traits ($b = .12$, $z = 5.64$, $p < .001$) than less observable traits ($b = .08$, $z = 4.25$, $p < .001$).

Participants also viewed their interaction partners with significant levels of normativity on average across all personality traits ($b = 1.03$, $z = 26.07$, $p < .001$), and this did not significantly differ as a function of trait observability ($b = -.02$, $z = -.68$, $p = .50$). Thus, newly acquainted dyads tend to view one another highly normatively and positively on average across traits.

3.2.2 | Vagal flexibility and accuracy

First, replicating Study 1, there was again a significant three-way interaction between trait observability, vagal flexibility, and distinctive accuracy ($b = .04$, $z = 2.07$, $p = .04$), such that vagal flexibility was associated with greater distinctive accuracy for high observability traits ($b = .06$, $d = 0.70$, $z = 2.74$, $p = .006$; see Figure 1b), but not low observability traits ($b = .02$, $d = 0.20$, $z = .94$, $p = .35$; see Figure 2b).

Specifically, perceivers who exhibited higher vagal flexibility (one standard deviation above the mean) and mean levels of vagal flexibility were able to accurately perceive targets' observable personality traits, such as how talkative, creative, and warm they were (high vagal flexibility: $b = .18$, $z = 5.68$, $p < .001$; mean vagal flexibility: $b = .11$, $z = 5.25$, $p < .001$). In contrast, perceivers lower in vagal flexibility (one standard deviation below the mean) did not form significantly accurate perceptions of targets' more observable traits ($b = .04$, $z = 1.11$, $p = .27$).

The associations between cardiac vagal flexibility and normativity did not significantly vary as a function of trait observability ($b = .01$, $z = .54$, $p = .59$). Looking across trait items together, cardiac vagal flexibility was not significantly associated with the normativity of personality impressions ($b = .04$, $z = .82$, $d = 0.14$, $p = .41$). Thus, individuals higher in vagal flexibility did not necessarily view their interaction partner more or less in line with the normative, socially desirable personality profile.

3.2.3 | Covariates

Several demographic covariates were associated with forming significantly more accurate impressions, although note that because perceivers and targets were matched on gender and age, it is unclear whether any associations with these variables were driven by perceiver, target, or dyadic characteristics. First, there was a significant interaction between gender and trait observability predicting accuracy, such that women tended to form significantly more accurate impressions than men regarding high observability traits ($b = .11$, $z = 2.61$, $p = .009$), but not low observability traits ($b = -.04$, $z = -1.05$, $p = .29$; interaction $b = .13$, $z = 3.56$, $p = .004$). Second, age was also significantly associated with accuracy as a function of trait observability, such that older participants tended to form significantly more accurate impressions than younger participants regarding low observability traits ($b = .01$, $z = 2.89$, $p = .004$), but not high observability traits ($b = -.001$, $z = -1.01$, $p = .31$; interaction $b = -.02$, $z = -4.11$, $p < .001$). Vagal flexibility was also significantly associated with gender (see Table 1), but remained significantly associated with greater accuracy for more observable traits when controlling for each covariate (all $ps < .05$).

As seen in Table 1, vagal flexibility was also significantly associated with positive social expectations prior to the interaction as well as cardiac vagal tone (see Table 1). Neither of these nor the other covariates, including sympathetic activation, were significantly associated with accuracy, as a function of trait observability or independently ($ps > .07$), and vagal flexibility continued to significantly predict greater accuracy for high observability traits controlling for each of these covariates (all $ps < .05$). Although respiration rate was not significantly associated with vagal flexibility, it showed a similar association with forming more accurate personality impressions of high observability traits ($b = .02$, $z = 2.92$, $p = .003$). When examining both together, both vagal flexibility ($b = .06$, $z = 2.61$, $p = .01$) and respiration rate ($b = .02$, $z = 2.65$, $p = .01$) remained significantly associated with forming more accurate impressions of high observability traits, to a similar degree.

4 | GENERAL DISCUSSION

Are some people better able to accurately perceive others' personality traits, leaving them poised to experience better social interactions and relationships? Motivated by arguments that individuals vary in their neurobiological sensitivity to the social environment (Belsky & Pluess, 2009), we examined whether a physiological correlate of social sensitivity predicted forming more accurate first impressions. Across two studies, we found that individuals higher in

cardiac vagal flexibility viewed others more in line with their distinctive, self-reported high observability personality traits based upon thin slices of information observed in a video clip (Study 1) and longer face-to-face interactions across a series of tasks (Study 2). Thus, perceptive accuracy may be indexed by a physiological correlate of social sensitivity, helping to identify the good judge of personality and the neurobiological processes that underlie this tendency.

Of note, vagal flexibility was linked to forming more accurate impressions of traits that were more readily observable within the current social contexts, such as talkativeness, creativity, and warmth, as opposed to traits that were less likely to be expressed, such as moodiness and sympathy. This is in line with past work suggesting that for perceiver characteristics to predict accuracy, targets must provide sufficiently relevant cues (Rogers, 2015; Zaki et al., 2008). Just as good targets may make more relevant cues available to perceivers, good traits should also have clearer, more relevant behavioral manifestations (Funder, 1995; Hirschmüller et al., 2015). Thus, cardiac vagal flexibility, and social sensitivity more broadly, is likely only able to foster accuracy when there are relevant cues available. Methodologically, this suggests that future research must ensure stimuli are of sufficient quality if predictors of perceptive accuracy are to emerge. Even so, of the many plausible predictors of perceptive accuracy assessed in this study, such as gender and psychosocial functioning (see SOM), only vagal flexibility was consistently associated with greater accuracy across studies, indicating that examining physiological correlates is a fruitful approach for identifying good judges. Indeed, in addition to the importance of high-quality stimuli, another reason past work may have had difficulty identifying predictors of the good judge could be due to the heavy reliance on self-reports and broad demographic categories.

These findings are consistent with and contribute to the growing body of research on cardiac vagal flexibility as an indicator of social sensitivity, distinct from other physiological processes, including cardiac vagal tone and sympathetic activation. In particular, these findings extend past work linking cardiac vagal flexibility to forming more accurate perceptions of emotions based on nonverbal, static cues (Muhtadie et al., 2015) to impressions of stable traits based on dynamic social stimuli. This is notable because perceptive accuracy in different domains is not always strongly related (see Hall, Gunnery, Letzring, Carney, & Colvin, 2016). Thus, vagal flexibility may be indicative of a social sensitivity that broadly predicts accuracy across impression formation domains, though future work that examines multiple domains simultaneously is needed. Further, it remains unclear why vagal flexibility may enhance accuracy. We argue that vagal flexibility should facilitate cue detection, but it is not clear how much of this tendency is motivational or skill based. Future research could experimentally manipulate motivation

(e.g., Biesanz & Human, 2010) or use pharmacological interventions to alter vagal flexibility to more precisely identify to what extent this association is motivationally or physiologically mediated.

Importantly, cardiac vagal flexibility predicted more accurate impressions above and beyond the tendency to view others normatively and therefore positively. Thus, even though in Study 2 we saw links with vagal flexibility and positive social experiences, such as positive social expectations, in line with past work (Muhtadie et al., 2015), vagal flexibility did not simply foster viewing others more positively. In fact, in Study 1, vagal flexibility was associated with viewing others in a less normative, socially desirable fashion. This may be because a greater responsiveness to the changing social environment would reduce reliance on general information or heuristics in impression formation. This may have the unintended consequence of also resulting in less positive personality impressions, suggesting a potential downside, as there are benefits to viewing others in a positive light (e.g., Human et al., 2013; Murray, Holmes, & Griffin, 1996). It is unclear to what extent forming less positive impressions would offset the benefits of forming accurate impressions (cf. Swann, 1983).

Although the results of the current studies are very consistent with each other and with prior work on vagal flexibility, there were several limitations. One limitation is that vagal flexibility in Study 2 was assessed at the start of the dyadic interactions and therefore involved social and affective content that overlapped with the accuracy task. Consequently, it is harder to conclude that vagal flexibility generally, outside of social tasks with the target of impressions, is linked to accuracy. Yet it is reassuring that the results held controlling for social expectations and affect and were highly consistent with Study 1, in which vagal flexibility was assessed in a nonsocial, nonaffective task. Another limitation is that both studies utilized self-reports as the accuracy criterion measure, which, although a valid and common accuracy criterion, is nevertheless imperfect. Future work should examine whether vagal flexibility is similarly associated with other criteria, such as close other and behavioral reports, ideally in combination. It is also unclear whether cardiac vagal flexibility would be associated with accuracy in different social contexts, such as longer-term relationships.

5 | CONCLUSION

Although individual differences in perceptive accuracy may be subtle, making the good judge difficult to find, neurobiological processes that foster greater sensitivity to the social environment may be one factor that underlies this tendency. Indeed, across two studies, we found that cardiac vagal flexibility, one physiological correlate of social sensitivity, was

associated with forming more accurate first impressions of others' observable personality traits, such as their talkativeness, warmth, and creativity. These findings may help to shed light on who good judges are as well as provide insight into the neurobiological underpinnings of this ability.

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CONFLICT OF INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ENDNOTES

¹ Targets were also randomly assigned to two orthogonal conditions involving (a) help manipulation from a confederate (vs. a control) and (b) oxytocin administration (vs. placebo). The effects of these manipulations with the full sample are reported elsewhere (Human, Woolley, & Mendes, 2017; see also Human, Thorson, & Mendes, 2016) and did not influence or overlap with the results presented here.

² Perceiver ratings and target self-reports were also available for depressive symptoms (Radloff, 1977), self-esteem (Rosenberg, 1965), and positive and negative affect (Watson, Clark, & Tellegen, 1988) in both studies. Vagal flexibility was significantly associated with forming more accurate impressions of depressive symptoms in Study 1, but this was not replicated in Study 2, nor found with self-esteem or state affect in either study.

³ We also conducted exploratory analyses to examine the role of a target characteristic that could also enhance the availability of cues: Extraversion. In Study 1, target Extraversion did significantly interact with perceiver vagal flexibility in predicting accuracy for high observability traits ($b = .02, z = 2.47, p = .01$), such that vagal flexibility was associated with greater accuracy for high observability traits for targets at mean and high levels of Extraversion (all $ps < .05$), but not for targets at low levels of Extraversion ($b = -.02, z = -1.00, p = .32$). However, we did not replicate this interaction in Study 2 ($b = .02, z = 0.75, p = .45$), despite the larger number of targets available for those analyses (157 vs. 44).

⁴ There was also an experimental manipulation aimed to increase accuracy that did not influence the results presented here (Human, West, & Mendes, 2018). Specifically, all results held controlling for condition, and none of the key results were moderated by condition.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

Appendix S1

Table S1

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