Reproducibility Studies of From the Viscera to First Impressions:Phase-Dependent Cardio-Visual Signals Bias the Perceived Trustworthiness of Faces

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Author Note

Author Note: This is for demonstration only.

The authors made the following contributions. Shen Tong: Reproducibility Study1, Introduction; Xi Yue: Reproducibility Study2, Presentation; Yao Menghan: Reproducibility Study3, Dissucion.

Abstract

When we see new people, we rapidly form first impressions. Whereas past research has focused on the role of morphological or emotional cues, we asked whether transient visceral states bias the impressions we form. Across three studies (N = 94 university students), we investigated how fluctuations of bodily states, driven by the interoceptive impact of cardiac signals, influence the perceived trustworthiness of faces. Participants less often chose faces presented in synchrony with their own cardiac systole as more trustworthy than faces presented out of synchrony. Participants also explicitly judged faces presented in synchrony with their cardiac systole as less trustworthy. Finally, the presentation of faces in synchrony with participants' cardiac diastole did not modulate participants' perceptions of the faces' trustworthiness, suggesting that the systolic phase is necessary for such interoceptive effects. These findings highlight the role of phasic interoceptive information in the processing of social information and provide a mechanistic account of the role of visceroception for social perception.

Keywords: interoception, gut feelings, social perception, cardiac cycle, trustworthiness, first impressions, open data

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Introduction

The formation of first impressions when we see new faces shapes our social interactions as we appraise others on the basis of their facial appearance. An important aspect of such appraisals relates to perceived trustworthiness(Kapfer, Seidl, Schweizer, & Grothe, 2002).One way to study the impact of visceral signals on cognition is to synchronize the presentation of stimuli with the participants' physiological rhythms(Azevedo, Von Mohr, & Tsakiris, 2023).

Past research has mainly focused on morphological or emotional cues of facial appearance, researchers here turned their attention to how visceral states that are interoceptively perceived can bias our first impressions, focused on whether and how cardiac afferent signals can influence the first impressions of trustworthiness, with the aim of providing a mechanistic account of the role of visceroception for face and social perception.

Researchers implemented a cardio-visual stimulation paradigm to study the influence of transient interoceptive states on the perceived trustworthiness of new faces across three studies.

In Studies 1(35 volunteers) and 2(30 volunteers),Participants judged the perceived trustworthiness of faces flashing either in frequency and phase synchrony (i.e., at systole) with their own heartbeats (systole-self condition) or following someone else's previously recorded heart rhythms (other-hearts conditions).In Study 3(29 volunteers),followed the same paradigm but with a constant phase shift in the cardio-visual synchrony to coincide with cardiac diastole (diastole-self condition), rather than systole, to test whether the cardiac influence is dependent on the phase of the cardiac cycle.

Following the known cardiac cycle modulation of saliency networks in the brain and the increased sensitivity to motivationally salient and threat-signaling stimuli (Garfinkel et al., 2014), researches predicted reduced trustworthiness during synchronous cardio-visual stimulation. Moreover, we predicted that this effect would be cardiac-phase specific (i.e., synchronous with systole) rather than simply frequency dependent (i.e., synchronous with either systole or diastole). They expected the bodily signals of arousal conveyed at systole to selectively increase vigilance or sensitivity to salient social stimuli, which in this context of threat-related judgments would lead to increased perceptions of untrustworthiness.

Finally, face presentation synchronized with participants' cardiac diastole was found not to moderate subjects' perception of face credibility, suggesting that systole is necessary for this entrainment effect.

In this paper we will follow the authors' research ideas and intentions to replicate and supplement the data according to three experiments, mainly using descriptive statistics, regression and analysis of variance.

Study 1

Methods

Participants

A total of 35 volunteers (age: *M* = 22.6 years, *SD* = 3.4; 27 females) were recruited via the departmental subject pool. Calculations in G*Power (Version3.1; Faul et al., 2007), based on a previous study of cardiac gating on emotional valence (Garfinkel et al., 2014),indicated that a sample size of 35 would be needed to obtain an effect size (f^2) of .40 at a power of 85%, which is consistent with other studies in the field (Azevedo et al., 2018; Li et al., 2020).

Material and Procedure

Stimuli consisted of images (400 × 477 pixels) of computer-generated Caucasian male faces with neutral facial expressions against a black background (Oosterhof & Todorov, 2008). The faces were created using FaceGen (Version 3.1; http://facegen.com) by the Social Perception Lab at Princeton University (https://tlab.uchicago .edu/databases/) to vary along the dimension of trustworthiness. The selected stimuli set comprised a total of 150 different images consisting of 25 different face identities, each of them with six versions that varied in trustworthiness by increments of 1 standard deviation. The face masks were created by maintaining the shape of the faces but replacing them with pixel-size black-and-white random noise.

Three disposable ECelectrodes were placed in a modified lead I chest configuration: Two electrodes were positioned underneath the left and right collarbone, and another was placed on the participant's lower back on the left side. The ECG signal was recorded at 1000 HZ (band-pass filtered between 0.3 and 1000 Hz) with a PowerLab 8/35 data acquisition device using LabChart 8 Pro software (ADInstruments). Heartbeats were detected on-line with a hardwarebased function (fast output response; ADInstruments), which identifies the ECG's R-wave with a delay smaller than 1 ms when the amplitude exceeds an individually defined threshold. In the systole-self condition, pictures were presented at R + 200 ms (Azevedo et al., 2015; Sel et al., 2017) to coincide with the cardiac systole and the period of maximal representation of arterial baroreceptors in the brain. Other heart rhythms consisted of prerecorded interbeat intervals of previous participants performing a similar task (Azevedo et al., 2015) and were adjusted on each trial to be 8% faster or slower than the participant's heart, as estimated during the preceding trial. In otherslow versus other-fast trials, the average heart rhythms were 4% slower and faster, respectively, than the participants' own heart to maintain the 8% relative difference between the two rhythms. The other-hearts database contained several different heartbeat samples from distinct participants, and each trial presented a random portion of one of these samples. Thus, no other-heart trials had exactly the same heart rate variability.

Result

People less often chose faces synchronized with their own heart as more trustworthy (M = 28.26, SD = 3.66, 95% confidence interval [CI] = [27.00, 29.51]) than faces synchronized with other-slow (M = 30.66, SD = 3.72, 95% CI = [29.38, 31.93]), $t(34)$ = -2.40, p = .022, Cohen's d = 0.40, and other-fast (M = 31.08, SD = 4.39, 95% CI = [29.58, 32.60]), $t(34)$ = -2.33, p = .026, Cohen's d = 0.39 (see Fig. 1).

No difference between other-fast and other-slow trials was observed, $t(34)$ = -0.35, p = .73, Cohen's d = 0.059. Using multilevel mixed log-linear regression analysis to control for the possible picture-specific effects and to understand whether the effect of rhythm varied according to the "objective" level of trustworthiness of each face pair.

Study 2

Methods

We presented only one face at a time and asked participants to judge the perceived trustworthiness of each face . Lower ratings to faces synchronized with the participants' heartbeats would provide a conceptual replication of Study 1 and rule out the possibility that the previously observed effects were driven by attention competition between the two faces.

Participants

The effect size obtained in Study 1 suggested that at least 27 participants were needed to obtain a power of 95% (power analysis run in G*Power Version 3.1; Faul et al.,2007). Thus, a similar sample size was selected for this study. Specifically, 30 volunteers (age: M = 24.17 years, SD = 4.90; 21 females) were recruited from the departmental subject pool in Royal Holloway University of London. Data from one additional participant were excluded because of technical problems during the session. The study was approved by the Royal Holloway University of London Department of Psychology ethics committee, and written informed consent was obtained from all participants.

The stimuli, task, and procedures were identical to those of Study 1 with the exception that in this study, only one face was presented at a time in the center of the screen. The trial ended with participant's answer to the question, "How trustworthy is this face?" on a visual analogue scale (1–100) anchored with the labels low trustworthiness and high trustworthiness. Each face was presented three times, once with each rhythm type: systole-self, otherslow, and other-fast. As in Study 1, in the systole-self condition, pictures were presented during cardiac systole (R +200 ms). Cases with scores 2 standard deviations above or below the mean were excluded from the main analyses. One participant was excluded on this basis (note that we obtained the exact same pattern of results when including this participant in the main analyses).

Result

Lower trustworthiness ratings for faces in the systole-self compared with those in the other-slow, and other-fast . No difference in the ratings given to faces in the other-slow and other-fast conditions (see Fig. 2).

linear mixed model regression analysis : only the main effect of rhythm, and not its interaction with trustworthiness, levels, was found to be significant.

Study 3

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

To maximize comparability between studies, we set target sample size to be equivalent to that of Study 2. Specifically, a new group of 53 volunteers was needed for this study, but in the article, they recruited 29 volunteers (age: M = 25.03 years, SD = 5.27; 20 females) via the departmental participant pool. The study was approved by the Royal Holloway University of London Department of Psychology ethics committee, and written informed consent was obtained from all participants.

Material and Procedure

The stimuli, task, and procedures were identical to those of Study 2 with the exception that in this study, stimuli in the synchronous condition were presented during cardiac diastole (R + 500 ms; diastole-self condition). This procedure preserved the frequency and heart dynamics of the previous cardio-visual stimulation procedure but introduced a phase shift (i.e., consistent delay) of the visual presentation in relation to the cardiac cycle (cf. Salomon et al., 2016). In other words, the exteroceptive and interoceptive information were still coupled, but synchrony was now achieved by presenting stimuli during the quiescent phase of the cardiac cycle. Cases with scores 2 standard deviations above or below the mean were excluded from the main analyses. One participant was excluded on this basis (note that we obtained the exact same pattern of results when including this participant in the main analyses). We used R for all our analyses. The results from Frequentist hypothesis testing (i.e., ANOVA) will be reported below.

Results

A repeated measures ANOVA with rhythm (diastole-self, other-slow, other-fast) as a within-subjects factor was used to test for differences in average trustworthiness ratings in each condition. Contrary to Study 2, results showed no significant effect of rhythm, $F(2, 54) = 0.93$, $p = .40$ (see Fig. 3), with BF analysis ($BF_{10} = 0.21$) indicating moderate (Quintana & Williams, 2018) or substantial (Dienes, 2014; Jeffreys, 1939/1961) evidence in favor of the null hypothesis. These results were further confirmed by a linear mixed model regression analysis (see the Supplemental Material) that also showed a lack of a significant interaction between rhythm and "objective" trustworthiness levels on subjective ratings. The contrast with Study 2 was further qualified by an additional analysis merging the two data sets in a single ANOVA with study (Study 2, Study 3) as a between-subjects factor. Although we found a significant Rhythm × Study interaction, $F(2, 110) = 7.32$, $p = .001$, $BF_{10} = 7.74$, neither the main effect of rhythm, $F(2, 110) = 1.86$, $p = .16$, $BF_{10} = 0.27$, nor the main effect of study, $F(1, 55) = 2.10$, $p = .15$, $BF_{10} = 0.81$, were significant. Critically, even though the significant Rhythm × Study interaction merely suggests that the rhythm effect was smaller in Study 3 relative to Study 2, our BF analyses indicated that the data supported the null hypothesis of no effect of rhythm for Study 3. As in the previous studies, we found no correlation between interoceptive accuracy ($M = 50.80$, $SD = 8.4$) and the difference in trustworthiness ratings in the diastole-self and the average of the other-hearts conditions ($r = -.25$, $p = .20$). Thus, contrary to Studies 1 and 2, Study 3 did not show a modulation in participants' judgments as a function of the presentation rhythm, suggesting that the phase (i.e., systole) of the cardiac cycle in which synchronization occurs is crucial for the effects to take place.

Discussion

The role of cardio-visual stimulation on trustworthiness judgments. Faces presented in synchrony with the participant's heart rhythm (at systole) were chosen less often as more trustworthy (Study 1) and were explicitly judged as less trustworthy (Study 2) than those presented asynchronously. These patterns suggest an influence of ongoing interoceptive information when people make social inferences from others' faces. Presenting faces synchronized with the participant's heart rhythm at diastole (Study 3) does not have an effect on participants' judgments, indicating that the cardiac cycle phase is critical. A crucial role for the transient phasic cardiac afferent signals conveyed to the brain during systole in the modulation of social judgments.

Heightened arousal has been associated with reduced perceived trustworthiness of other people. At systole, one's own cardiac physiological information is accentuated, when faces are presented when one is in a state of heightened physiological arousal, they are more likely to be perceived as less trustworthy. People tend to judge faces presented during systole (vs. diastole) as less trustworthy in conditions of high attentional load(Li, Chiu, Swallow, De Rosa, & Anderson, 2020)."Diastolic states" are associated with increased trust or "systolic states" are associated with decreased trust. These effects are indeed driven by phasic activity taking place during systole alone.

The specific cardio-visual effects observed on perceived trustworthiness reported here go beyond the multisensory integration process. The observed selective cardio-visual effect on trustworthiness judgments at systole is likely to go beyond simple interoceptive-exteroceptive integration and may reflect a neuromodulation of saliency and orienting systems driven by the cardiac cycle. Amygdala, an area known to mediate cardiac cycle modulations of threat processing(Garfinkel et al., 2014).

Limitations and future directions

The role of cardio-visual stimulation on the processing of other types of social inferences from faces remains unknown.

Interoceptive accuracy did not seem to relate to the observed effects. Future studies should examine whether other interoceptive dimensions, such as interoceptive sensibility or awareness(Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015), play a role on perceived trustworthiness or whether they interact with the phase of cardio-visual synchrony.

Cannot fully discard the possibility that other bodily changes covarying with the cardiac cycle (e.g., muscle spindle activity due to cardioballistic fluctuations) (Birznieks, Boonstra, & Macefield, 2012).

Conclusion

People less often chose faces presented in synchrony with their own cardiac systole as more trustworthy than faces presented out of synchrony. People also explicitly judged faces presented in synchrony with their cardiac systole as less trustworthy. The presentation of faces in synchrony with participants' cardiac diastole did not modulate participants' perceptions of the faces' trustworthiness, suggesting that the systolic phase is necessary for such interoceptive effects.

These findings highlight the role of phasic interoceptive information in the processing of social information and provide a mechanistic account of the role of visceroception for social perception.

This study analyzes the trustworthiness of human face from the perspective of interperception, which opens a new idea for our future research.

Division of labor

It was agreed that we would each be responsible for one, Shen Tong for study 1 and introduction, Xi Yue for study 2 and presentation, and Yao Menghan for study 3 and discussion.

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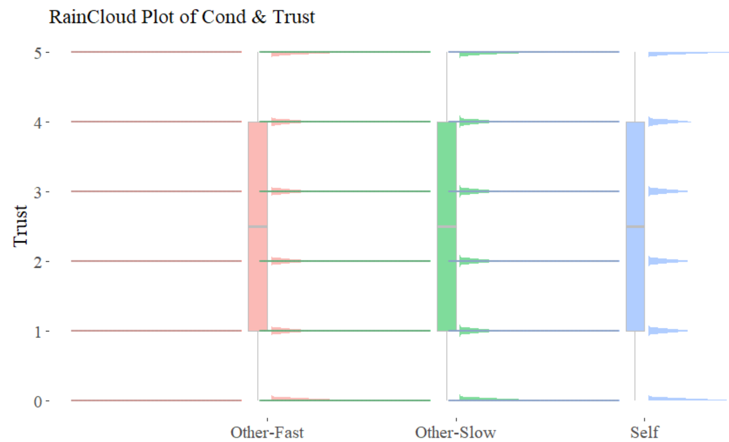

Fig. 1 Trustworthiness judgments for Study 1

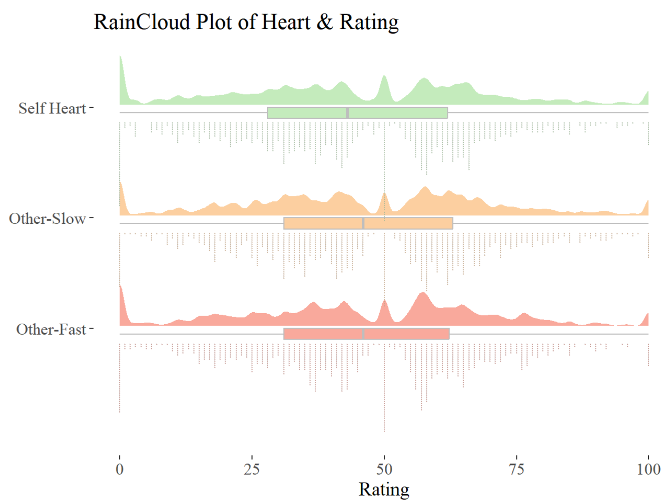

Fig. 2 Trustworthiness judgments for Study 2

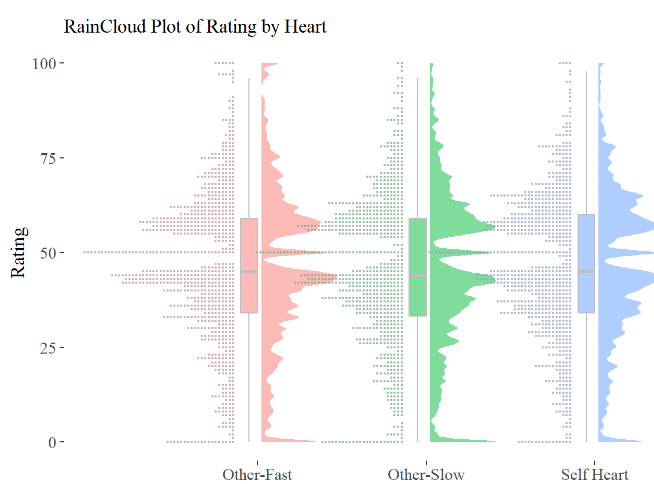

Fig. 3 Trustworthiness judgments for Study 3