The Heartbeat Counting Task Largely Involves non-Interoceptive Processes: Evidence from both the Original and an Adapted Counting Task

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3 authors:


Olivier Desmedt
University of Lausanne


Olivier Luminet
Catholic University of Louvain


Olivier Corneille
Catholic University of Louvain

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The heartbeat counting task largely involves non-interoceptive processes: Evidence from both the original and an adapted counting task

Olivier Desmedt[a,*], Olivier Luminet[a,b], Olivier Corneille[a]

[a] Psychological Science Research Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium
[b] Fund for Scientific Research – Belgium (FRS-FNRS), Belgium

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ABSTRACT

The heartbeat counting task (HCT) is among the most frequently used measures of interoceptive accuracy (i.e., IAcc). Growing concerns, however, have been raised regarding the validity of this task, as well as the validity of the IAcc scores that are derived from it. In the present study, healthy participants (N = 123) performed both the original task and an adapted version of it that stressed the importance of reporting only their perceptually felt heartbeats. In the original task, we found that participants report relying on three different strategies (i.e., detection of heartbeats in a specific body location, detection of heartbeats in a diffuse way and heart rate estimation) to complete the task. In the adapted task, we found that IAcc scores are drastically reduced (about 50%) when asking participants to avoid relying on non-interoceptive signals and to only report the heartbeats they perceive. These findings confirm that the HCT task is largely contaminated by the influence of non-interoceptive processes. Implications of these findings for research on interoception are discussed.

1. Introduction

Interoception refers to the perception and integration of one's physiological signals (Barrett & Simmons, 2015; Cameron, 2002; Craig, 2002). It is thought to play a key role in cognitive and emotional processes (e.g., Critchley & Garfinkel, 2017, 2018), psychopathology (e.g., Critchley & Garfinkel, 2017) and in a variety of other psychological phenomena (Ceunen, Vlaeyen, & Van Diest, 2016). How interoception influences psychological functioning, health and decision-making has been conceptualized in both early (e.g., James, 1884) and contemporary psychological theories (e.g., Barsalou, 2008).

A valid investigation of interoception requires assessing how good people are at perceiving their internal condition. The most frequently used tool for assessing objective interoceptive abilities (i.e., interoceptive accuracy) is the heartbeat counting task (HCT; Schandry, 1981; see also Dale & Anderson, 1978). In this task, participants are asked to count their heartbeats at rest and without feeling their pulse, for different time intervals. The difference between the numbers of reported and recorded heartbeats is thought to index interoceptive accuracy (i.e., IAcc). IAcc scores derived from this task have been related to a variety of psychological outcomes, such as emotion regulation capacities (e.g., Füstös, Gramann, Herbert, & Pollatos, 2012), decision-making (e.g., Werner, Jung, Duschek, & Schandry, 2009) and psychopathology (e.g., Pollatos et al., 2008).

Several researchers, however, have raised concerns about the validity of this task. In particular, they proposed that reliance on knowledge and beliefs about heart frequency is likely to be involved in the HCT (e.g., Flynn & Clemens, 1988; Montgomery & Jones, 1984). This view was recently supported by Ring, Brener, Knapp, and Mailloux (2015), in a study showing that enhancing knowledge about heart rate increases performance on the task. Another piece of evidence comes from a study by Windmann, Schonecke, Fröhlig, and Maldener (1999), where heart rate was manipulated in patients fitted with cardiac pacemakers. The latter manipulation left heartbeat counts unchanged. Finally, there is also little change observed in reported heartbeats when posture is manipulated, despite large differences in heart rate across postures (Ring & Brener, 1996).

More recently, Zamariola, Maurage, Luminet, and Corneille (2018) questioned the construct validity of the IAcc scores based on psychometric analyses. In particular, these authors found in a large sample of healthy participants that (1) IAcc scores massively (i.e., 95%) reflect underreporting heartbeats and (2) that correlation between reported and recorded heartbeats is larger at average than at higher quintiles of IAcc scores. Consistent with Ring and Brener (2018), these authors explained that several processes are likely to contribute to reports of heartbeats count in this task, among which true perception of cardiac signals may represent only one among several non-interoceptive contributors (including the use of beliefs about heart rate at rest, or

* Corresponding author.
E-mail address: olivier.desmedt@uclouvain.be (O. Desmedt).

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decision threshold in reporting counted heartbeats).

As evidence has accumulated that challenges the validity of the HCT, research efforts have been invested in the development of alternative tasks for measuring interoceptive accuracy (e.g., Ring & Brener, 2018) and in advancing our understanding of control variables that may increase the predictive validity of the task (e.g., Murphy et al., 2018).

1.1. The present study

The present research aimed at advancing our understanding of the contribution of non-interoceptive processes to IAcc scores in the HCT. As just mentioned, it has long been suggested that performance in the HCT partly reflects the contribution of beliefs about heart rate (e.g., Flynn & Clemens, 1988; Montgomery & Jones, 1984). This reliance on knowledge may explain associations between IAcc scores and a variety of outcomes. For instance, a positive relation between IAcc scores and intelligence may be explained by a more accurate knowledge about heart rate at rest among people with higher intelligence (Murphy et al., 2018).

The present study provides a straightforward examination of the contribution of heart rate estimation (i.e., a non-interoceptive process) to IAcc scores in the HCT. We did so by making it clear to the participants (in an adapted version of the task) that they cannot rely on heart rate estimation and are instead requested to only report felt heartbeats in completing the task. Comparing IAcc scores on the original and adapted tasks provides insights into the role of non–interoceptive processes in the original task. If the original – HCT involves only heartbeat detection, then adapted instructions should have no influence on the IAcc scores.

We additionally collected self-reported measures about strategies used in the original task and we related them to IAcc scores. Specifically, after the completion of the original task, participants were asked to report to what extent they relied on one of three possible strategies for reporting their counting: detection of heartbeats in a specific body location, detection of heartbeats in a diffuse way and heart rate estimation. To our knowledge, asking participants to report the strategies they used during the task has never been investigated in previous studies. If IAcc scores validly reflect the use of interoception, there should be a report of only using interoceptive strategies (i.e., detection-based strategies) and no report of using a non-interoceptive strategy (i.e., heart rate estimation).

The current study extends in several ways another study by Ehlers, Breuer, Dohn, and Fiegenbaum (1995). These authors compared two conditions. In one condition, participants were requested to report all their felt heartbeats. In a second condition, they were requested to report only their confidently felt heartbeats. IAcc scores were largely reduced in the second condition. The present study differs in many respects. First, we compared the *original*–HCT instructions (one that instructs participants to count; see below) to an adapted task (one that instructs them to only report felt heartbeats). Only comparisons to the original task allow investigating mechanisms involved in that particular task. Second, comparisons between the original and adapted tasks were made intra-participants instead of inter-participants, therefore allowing for improved control. Third, as just explained, we collected measures on self-reported strategies and we related them to performance on the task. This information was absent from Ehlers et al. (1995)'s study; it informs us of the strategies spontaneously used by the participants and, as we will see, allows supporting the validity of our manipulation. Fourth, contrary to Ehlers et al. (1995)'s adapted task, we did not impose a stringent decision threshold on counting reports (i.e., participants were not requested to report only their confidently felt heartbeats). Imposing a strict criterion on counting would have mechanically lowered performance at the task. This is because IAcc scores essentially capture underreporting of heartbeats (see Zamariola et al., 2018).

2. Method

2.1. Participants and procedure

123 healthy students (76 females, M_{age} = 22.3, SD = 3.127) were recruited in exchange for a small honorarium (5 euros) via advertisements on mailing lists. This research project received the approval from the Ethical Committee of the Research Institute for Psychological Sciences.

Participants were tested individually. They were first asked to complete the International Physical Activity Questionnaire – short form (IPAQ-SF) (Craig et al., 2003). Next, they completed the original – HCT. Then, they were asked to report the extent to which they relied on each of three strategies when completing the task and to report their anxiety during the task. Finally, they performed the adapted HCT, with modified instructions that precluded the use of belief-based inferences.[1]

2.2. Materials

2.2.1. Original and adapted heartbeat counting task

Polar Watch RS800CX heart monitor was used in order to measure heart rate (e.g., Kingsley, Lewis, & Marson, 2005). First, following Mental Tracking Method by Schandry (1981), participants in the original – HCT were instructed to report the counted number of heartbeats without feeling their pulses (for instructions, see Appendix A; Schandry, 1981). Contrary to Schandry (1981, p. 484), but similar to many other researchers (e.g., Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015; Ring et al., 2015; Tsakiris, Tajadura-Jiménez, & Costantini, 2011), we asked participants to report counted heartbeats, not to report "counted or estimated heartbeats". Indeed, we did not want to inflate the use of estimation strategies in the counting task. Hence we relied on a conservative approach in the current study. Then, the task was replicated with adapted instructions prompting participants to focus on interoceptive signals only (for instructions, see Appendix B). Three time intervals (25 s, 35 s, 45 s), each separated by a pause of 20 s, were used. The reverse order in time intervals was used for the adapted – HCT in order to promote independent judgments on the two tasks. One acoustic cue signaled the beginning and the end of each time interval. The software Polar ProTrainer5 was used to extract the objective number of heartbeats. The adapted – HCT always followed the original one. This order was implemented in order to guarantee that instructions in the adapted task would not bias performance on the original one. To our knowledge, no practice effect has been demonstrated on performance on the HCT (e.g., Ring et al., 2015). And, if anything, any such practice effect would result in better, not worse, performance on this task. Of note, practice effects may be assessed if using a control group involving two consecutive completions of the original task (Ring et al., 2015).

2.2.2. Self-reported strategies

Directly after the original – HCT, participants were asked to report to what extent they had used each of three strategies: "I counted the heartbeats I felt at a specific body location" (*specific detection*), "I counted the heartbeats I felt in a diffuse way" (*diffuse detection*) and "When I was not feeling heartbeats, I tried to estimate my heart rate" (*estimation*). All scales went from 1 (never) to 5 (always).

[1] Additional measures (time perception, knowledge about personal heart rate, TAS-20, DASS21, awareness of hypotheses and anxiety during the adapted-HCT) were collected at the end of the experiment. All the interactions between those variables and the type of instructions were non-significant (except for anxiety). This could be explained by a lack of power for detecting interaction effects. Future studies should examine these questions with larger samples.

3. Results

All data are accessible at the following address: https://osf.io/n27yk/

3.1. Data exclusion

1.6% of the data (N = 2) were removed from the analyses due to problems in following study instructions.

3.2. Strategies reportedly used in the original task

All three strategies were reported: *specific detection* ($M = 3.58$, $SD = 1.24$), *diffuse detection* ($M = 2.23$, $SD = 1.196$), *estimation* ($M = 2.96$, $SD = 1.172$), which all differed from the “1” anchor in the Likert-type of scale at $p < .001$. A negative correlation was found between reported use of *specific detection* and *diffuse detection* ($r = -0.43$, $p < .001$), and *specific detection* and *estimation* ($r = -0.219$, $p = .016$). No significant correlation was found between reported use of *diffuse detection* and *estimation* ($r = 0.031$, $p = .738$). Importantly, 91.8% of participants reported estimating, at least sometimes, their heart rate during the task.

3.3. Adapted HCT

IAcc scores were computed according to the standard formula: 1/3 Σ (1–(|actual heartbeats – reported heartbeats|)/actual heartbeats). IAcc scores were reduced by half (see Fig. 1) in the adapted – HCT ($M = 0.30$, $SD = 0.225$) as compared to the original – HCT ($M = 0.61$, $SD = 0.18$, which is very close to levels found in past studies; e.g., Ring & Brener, 1996), $t_{120} = 17.3$, $p < .001$, $d = 1.57$.

Finally, the type of strategy preferentially used (the two detection-based vs. the one estimation-based strategies) predicted the difference of performance between the original – HCT and the adapted one ($\beta = -0.457$, $ET = 0.006$, $t = -5.608$, $p < .001$). Supporting the validity of both the self-reported measures and of our manipulation, this indicates that the more participants reported relying on an estimation (relative to an actual counting), the more the modified instructions decreased their mean score at the task.

4. Discussion

IAcc scores largely reflect non-interoceptive processes. First, participants report estimating heart rate in the original – HCT. Second, consistent with this self-report, asking them to report only heartbeats they perceive greatly reduces their IAcc score. Do IAcc scores in the adapted – HCT better capture participants’ cardiac interoceptive accuracy? We invite caution about this conclusion. We found here IAcc

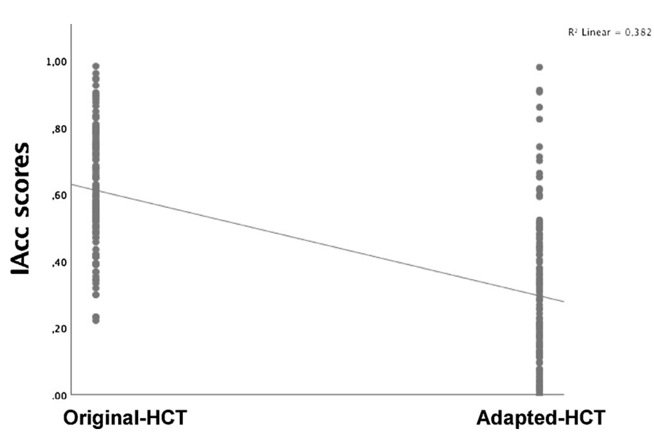

Fig. 1. Mean difference between original – HCT and adapted – HCT.

scores in the adapted – HCT to be exclusively (i.e., 100%) driven by under-reporting of heartbeats. As explained by Zamariola et al. (2018), this under-report may be driven either by a reduced sensitivity to cardiac signals or to higher decision thresholds in reporting heartbeats. Individuals in the original – HCT may have achieved a high IAcc score without detecting any cardiac signal (i.e., by relying only on accurate beliefs about personal heart rate; Brener & Ring, 2016). Complementarily, two individuals with similarly high interoceptive abilities may earn a low or high IAcc score in either the original or adapted – HCT, just because their decision threshold for reporting a heartbeat differs. Of interest, Ehlers et al. (1995)’s study suggests that IAcc scores might have been lowered further if we had applied a stringent decision criterion in the adapted task.

Two potential limitations of the current study should be discussed. First, this study involved a non-clinical population. Therefore, the contribution of non-interoceptive processes to IAcc scores in clinical populations remains to be assessed. Second, we included no control variables such as BMI, systolic blood pressure, age or gender in the present study. A recent research by Murphy et al. (2018) suggests that the predictive validity of IAcc may be increased when controlling for a number of covariates. Admittedly, some of these factors may be associated with a stronger or weaker reliance on heart rate estimation. For instance, heartbeat signals may be more intense at higher levels of systolic blood pressure (O’Brien, Reid, & Jones, 1998), resulting in a lower reliance on estimation and larger reliance on felt heartbeats (Ring et al., 2015). As a result, modifications in instructions as used here in the adapted task might decrease IAcc scores less under higher levels of systolic blood pressure. These questions are awaiting further empirical investigation. Meantime, we would like to invite researchers who have used or are still using the HCT to reconsider its meaning, and to preferably invest research efforts in the creation of new interoceptive tasks that rely on signal detection analyses (e.g., Brener & Kluvitse, 1988; Ring & Brener, 2018).

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Appendix A

I'm inviting you to comfortably sit in your chair. Once you feel comfortable, try not to move during the task. In a moment, when you hear an acoustic signal, I will ask you to start silently counting your heartbeats without feeling (touching) your wrists or neck pulsations. When you hear a second signal, I will ask you to stop counting and tell me the exact number of heartbeats you counted. We will repeat this exercise several times.

Appendix B

I'm inviting you to comfortably sit in your chair. Once you feel comfortable, try not to move during the task. The instructions for this task are simple but it is very important to follow them carefully. In a moment, I will ask you to try to sense your heartbeat without actively feeling (touching) your wrists or neck pulsations. You may feel them, you may not feel them at all or you may occasionally feel some. When you hear a signal, you will have to start silently counting the heartbeat you feel. When you hear a second signal, I will ask you to tell me the exact number of heartbeats you felt. We will repeat this exercise several times. For this task, it is very important that you only count the heartbeats you really feel, without trying to guess your heart rate. I really insist that you only count what you feel. It could mean reporting no beat at all, some beats or all beats that actually happened.

References

Barrett, L. F., & Simmons, W. K. (2015). Interoceptive predictions in the brain. *Nature Reviews Neuroscience, 16*(7), 419.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617–645.

Brener, J., & Kluvitse, C. (1988). Temporal location of S+ and S- signals in the whitehead heartbeat discrimination procedure. *Psychophysiology, 25*, 436–437.

Brener, J., & Ring, C. (2016). Towards a psychophysics of interoceptive processes: The measurement of heartbeat detection. *Philosophical Transactions of the Royal Society, 371*(1708) 20160015.

Cameron, O. G. (2002). *Visceral sensory neuroscience: Interoception. Visceral sensory neuroscience: Interoception.* New York, NY: Oxford University Press xii,359 p.

Ceunen, E., Vlaeyen, J. W., & Van Diest, I. (2016). On the origin of interoception. *Frontiers in Psychology, 7*, 743.

Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience, 3*(8), 655.

Craig, C. L., Marshall, A. L., Sjorstrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise, 35*(8), 1381–1395.

Critchley, H. D., & Garfinkel, S. N. (2017). Interoception and emotion. *Current Opinion in Psychology, 17*, 7–14.

Critchley, H. D., & Garfinkel, S. N. (2018). The influence of physiological signals on cognition. *Current Opinion in Behavioral Sciences, 19*, 13–18.

Dale, A., & Anderson, D. (1978). Information variables in voluntary control and classical conditioning of heart rate: Field dependence and heart-rate perception. *Perceptual and Motor Skills, 47*, 79–85.

Ehlers, A., Breuer, P., Dohn, D., & Fiegenbaum, W. (1995). Heartbeat perception and panic disorder: Possible explanations for discrepant findings. *Behaviour Research and Therapy, 33*(1), 69–76.

Flynn, D. M., & Clemens, W. J. (1988). On the validity of heartbeat tracking tasks. *Psychophysiology, 25*(1), 92–96.

Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2012). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience, 8*(8), 911–917.

Garfinkel, S. N., Seth, A. K., Barrett, A. B., Suzuki, K., & Critchley, H. D. (2015). Knowing your own heart: Distinguishing interoceptive accuracy from interoceptive awareness. *Biological Psychology, 104*, 65–74.

James, W. (1884). What is an emotion? *Mind, 9*(34), 188–205.

Kingsley, M., Lewis, M. J., & Marson, R. E. (2005). Comparison of polar 810s and an ambulatory ECG system for RR interval measurement during progressive exercise. *International Journal of Sports Medicine, 26*(1), 39–44.

Montgomery, W. A., & Jones, G. E. (1984). Laterality, emotionality, and heartbeat perception. *Psychophysiology, 21*(4), 459–465.

Murphy, J., Millgate, E., Geary, H., Ichijo, E., Coll, M. P., Brewer, R., et al. (2018). Knowledge of resting heart rate mediates the relationship between intelligence and the heartbeat counting task. *Biological Psychology, 133*, 1–3. https://doi.org/10.1016/j.biopsycho.2018.01.012.

O'Brien, W. H., Reid, G. J., & Jones, K. R. (1998). Differences in heartbeat awareness among males with higher and lower levels of systolic blood pressure. *International Journal of Psychophysiology, 29*(1), 53–63.

Pollatos, O., Kurz, A. L., Albrecht, J., Schreder, T., Kleemann, A. M., Schöpf, V., et al. (2008). Reduced perception of bodily signals in anorexia nervosa. *Eating Behaviors, 9*(4), 381–388.

Ring, C., & Brener, J. (1996). Influence of beliefs about heart rate and actual heart rate on heartbeat counting. *Psychophysiology, 33*(5), 541–546.

Ring, C., & Brener, J. (2018). Heartbeat counting is unrelated to heartbeat detection: A comparison of methods to quantify interoception. *Psychophysiology,* e13084. https://doi.org/10.1111/psyp.13084.

Ring, C., Brener, J., Knapp, K., & Mailloux, J. (2015). Effects of heartbeat feedback on beliefs about heart rate and heartbeat counting: A cautionary tale about interoceptive awareness. *Biological Psychology, 104*, 193–198.

Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology, 18*(4), 483–488.

Tsakiris, M., Tajadura-Jiménez, A., & Costantini, M. (2011). Just a heartbeat away from one's body: Interoceptive sensitivity predicts malleability of body-representations. *Proceedings of the Royal Society of London B: Biological Sciences, 278*(1717), 2470–2476.

Werner, N. S., Jung, K., Duschek, S., & Schandry, R. (2009). Enhanced cardiac perception is associated with benefits in decision making. *Psychophysiology, 46*(6), 1123–1129.

Windmann, S., Schonecke, O. W., Fröhlig, G., & Maldener, G. (1999). Dissociating beliefs about heart rates and actual heart rates in patients with cardiac pacemakers. *Psychophysiology, 36*(3), 339–342.

Zamariola, G., Maurage, P., Luminet, O., & Corneille, O. (2018). Interoceptive accuracy scores from the heartbeat counting task are problematic: Evidence from simple bivariate correlations. *Biological Psychology, 137*, 12–17. https://doi.org/10.1016/j.biopsycho.2018.06.006.