DOCUMENTATION
Updated December 2019
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Motor tracking heartbeat detection (HBD) Task

The HBD task comprises four conditions, with 7 blocks:

1. Exteroceptive condition (blocks 1 and 2): It provides a control measure assessing participants' capacity to attend to external stimuli –i.e., exteroceptive accuracy (EA). They are binaurally presented with an audio of a recorded heartbeat (digitally constructed from an actual electrocardiogram record of a researcher), which they had to follow by pressing a key with their dominant hand. This condition comprises two blocks lasting 2 minutes each. In the first block, recorded heartbeats are presented at a constant and regular frequency (60 bpm), while in the second block, recorded heartbeats are manipulated to have the same overall frequency (60 bpm) but at irregular intervals. Both blocks of the exteroceptive condition are always presented in the same order, before moving on to the interoceptive condition.

Instructions given to participants: *"In this part of the test, you will hear the beating of a heart recorded from another person. You must follow every heartbeat by tapping the "z" key on the laptop keyboard. Do not try to anticipate your responses by guessing the recorded heart rhythm; instead, tap as fast as you can after each beat you hear"*.

2. Interoceptive condition – baseline (blocks 3 and 4): This condition provides an objective measure of the subjects' ability to track their own heartbeats –i.e., interoceptive accuracy (IA). Participants are asked to tap a key with their dominant hand following their own heartbeats. It includes two blocks of 2 minutes each, with identical instructions.

Instructions given to participants: *"Now, you must follow the beating of your own heart by tapping the "z" key for every beat you feel. You should not guide your responses by checking your arterial pulse in your wrists or neck. If you are unable to feel these sensations, you should appeal to your intuition trying to respond whenever you think your heart is beating"*.

3. Feedback condition (block 5): Participants are given the same instructions as in the interoceptive condition, along with simultaneous auditory feedback of their own heart provided through online ECG register. This condition comprises one block of 2 minutes.

4. Interoceptive condition – post feedback (blocks 6 and 7): This condition is identical to condition 2, but effects of learning following feedback are expected.

Indexes to compute accuracy in each condition of the HBD task

a. Modified Schandry's index (mSI): This index is calculated as the absolute difference between (actual or recorded) heartbeats and total motor responses. The following formula is computed:

$$mSI = 1 - \frac{(\text{Recorded hearbets} - \sum \text{Total responses})}{\text{Recorded heartbeats}}$$

Note that the coefficient is displayed as a precision score (and not as an error score), varying from 0 to 1, with higher values indicating better performance.

More information about this index can be found at Fittipaldi et al. (under review).

b. Accuracy (ACC) extended window: This index is computed as the previous one, but considering Correct motor responses instead of Total responses. A response is tagged as correct if it occurs in a given window around the R-wave of each heartbeat. The temporal extension of the window is determined for each subject according to his heart rate (HR) to control for potential interindividual differences, as follows:

- For a HR < 69.75, the temporal window goes from minus 0.125 to plus 0.750 ms, being the beat the zero.
- For a HR > = 69.75, the temporal window goes from minus 0.100 to plus 0.600 ms, being the beat the zero.
- For a HR > = 94.25, the temporal window goes from minus 0.075 to plus 0.400 ms, being the beat the zero.

(- To calculate the EA index, a window between minus 0.125 to plus 0.750 ms after the recorded heartbeat is used.)

The following formula is used to compute ACC:

$$ACC\_extended\ window = 1 - \frac{(\text{Recorded hearbets} - \sum \text{Correct responses})}{\text{Recorded heartbeats}}$$

The score varies from 0 to 1. Higher scores indicate better performance.

c. Accuracy (ACC) post-beat window: This index is identical to the previous one, but here the window is time-locked to the R-wave extending to positive values. The score varies from 0 to 1. Higher scores indicate better performance. More information can be found at Salamone et al. (2018).

d. d' extended window: This index is calculated in accordance to the Signal Detection Theory (SDT). The SDT is a framework to analyze tasks that consist of distinguishing ambiguous stimuli as signal or noise. In the context of the HBD task, a heartbeat is considered signal, while the absence of a heartbeat is noise. Subject reactions can be classified as yes (represented by pressing the keyboard) or no (represented by not pressing the keyboard). A "yes" response is considered correct if it occurs in a given window around each R-wave. The temporal extension of the window is determined for each subject according to his HR, exactly as in the ACC index. In STD terminology, a correct response is called a *hit*, while the absence of a response in the defined temporal window is considered a *miss*. In addition, the STD formula weighs the strategy of the subject in discriminating signal to noise, in order to penalize successes by chance (e.g. a subject who always responds "yes" would get all the *hits*). Thus, a response outside the window is a *false alarm*, while the absence of a response outside the window is a *correct rejection*. Higher values of d' indicate better discrimination ability and thus better IA. The d' index calculation is represented in the following equation:

$$d'\_extended\ window = z\left(\frac{\sum hit}{\sum hit + \sum miss}\right) - z\left(\frac{\sum falsealarm}{\sum falsealarm + \sum correctrejection}\right)$$

Where z (p) is the inverse normal probability corresponding to cumulative probability.

Higher scores indicate better performance.

e. d' post-beat window: This index is similar to the previous one, but here the window is time-locked to the R-wave extending to positive values. Higher scores indicate better performance. More information can be found at Gonzalez Campo et al. (2019) and Fittipaldi et al. (under review).

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