Spectral Parameters of Heart Rate Variability as Indicators of the System Mismatch During Solving Moral Dilemmas

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Spectral Parameters of Heart Rate Variability as Indicators of the System Mismatch During Solving Moral Dilemmas

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Abstract. Variability in beat-to-beat heart activity reflects the dynamics of heart-brain interactions. From the positions of the system evolutionary theory, any behaviour is based on simultaneous actualization of functional systems formed at different stages of phylo- and ontogenesis. Each functional system is comprised by neurons and other body cells, the activity of which contributes to achieving an adaptive outcome for the whole organism. In this study we hypothesized that the dynamics of spectral parameters of heart rate variability (HRV) can be used as an indicator of the system mismatch observed when functional systems with contradictory characteristics are actualized simultaneously. We presented 4–11-year-old children (N = 34) with a set of moral dilemmas describing situations where an in-group member achieved optional benefits by acting unfairly and endangering lives of out-group members. The results showed that LF/HF ratio of HRV was higher in children with developed moral attitudes for fairness toward out-groups as compared to children who showed preference for in-group members despite the unfair outcome for the out-group. Thus, the system mismatch in situations with a moral conflict is shown to be reflected in the dynamics of heart activity.

Keywords: System evolutionary theory · Heart brain interactions · Spectral parameters of heart rate variability · Moral dilemmas · In-group · Out-group

1 Introduction

Changes in heart rate variability (HRV) reflect the brain – heart interactions (e.g., [10, 14, 22, 24]). HRV indexes have previously been considered as indicators of changes in brain activation [24]. The baseline HRV is different in people in a state of coma as compared to healthy people, some authors suggested that HRV can serve as an indicator of the intensity of brain activity [17]. Thayer and colleagues [23] argued that changes in HRV reflect the hierarchy in organization of an organism and usually observed in response to indeterminacy and mismatch. The authors suggested that HRV could indicate the "vertical" integration of the brain mechanisms controlling an

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organism. It was noted that research into the relationship between heart and brain activity could open new horizons for the study of psychophysiological bases of individual behaviour [12].

Considered from the positions of the system evolutionary theory [2, 5, 21], any behaviour is based on simultaneous actualization of functional systems [3] formed at different stages of phylo- and ontogenesis. Each functional system is comprised by neurons and other body cells, including those of the heart, the joint activity of which contributes to achieving an adaptive outcome for the whole organism. From these positions, "HRV originates in cooperation of the heart with the other components of actualized functional systems" and reflects the system organization of behaviour (see [6]: p. 2).

Our previous studies have found that in the process of individual development children gradually shift from supporting in-group members, even when they behave unfairly towards out-group members, to prioritizing fairness towards all other individuals, irrespective of what group they belong to [19, 20]. We argued that learning to support fairness towards out-groups is associated with forming new functional systems enabling this more complex behaviour. However, fairness towards outgroups can be contradictory to earlier formed unconditional in-group preference. Situations like this can be described as *the system mismatch, when functional systems with contradictory characteristics are actualized simultaneously*. Here we hypothesize that in a situation of a conflict between in- and out-group members, fairness towards out-groups would predetermine the occurrence of a system mismatch reflected in HRV. To test this hypothesis, we analyzed the spectral parameters of HRV in children solving moral dilemmas with a conflict between in- and out-group members.

2 Materials and Methods

Thirty-four children participated in the study: 4–5-year-old pre-schoolers (N = 19; Mean = 5,14; Med = 5; S.D. = 0,43; 25% = 4,48; 75% = 5,35) and 10–11-year-old school children (N = 15; Mean = 10,62; Med = 10,92; S.D. = 0,52; 25% = 10; 75% = 11). The experimental protocols were approved by the Ethics Committee of the Institute of Psychology Russian Academy of Sciences. Parents of all participants were provided with detailed information about procedures of the study and signed informed consent forms to allow their children to participate. Each child was individually interviewed in a separate room. All children were presented with a set of moral dilemmas describing situations when a limited resource was essential for the survival of an out-group member and beneficial, but not vital, for the well-being of an in-group member. In each dilemma, an in-group member took away the resource, putting an out-group member's life at risk, and children had to choose who to support in this situation.

Heart rate was recorded during the entire experiment using a photoplethysmograph RB-16CPS (Neurolab) and wireless sensor Zephyr HxM BT. BMInput (A.K. Krylov) and HR-reader (V.V. Kozhevnikov) software were used.

Pulsograms were recorded into sequences of RR intervals by "Neuru" program (A.K. Krylov). The spectral parameters of HRV were calculated using RRv7 software (I.S. Shishalov) (window length — 100 s; step — 10 s). We analysed the following spectral parameters of HRV: low frequency power of HRV (LF), high frequency power of HRV (HF), total power of HRV (TP), and LF/HF ratio [13].

Responses to dilemmas were coded as “1”, if a child chose to support an out-group member, and “0”, if a child chose to support an in-group member. Average scores characterising individual responses to all dilemmas were also calculated. For the analyses, all participants were subdivided into two groups: those who supported out-group members in more than a half of the dilemmas (“out-group supporters”) and those who supported in-group members in more than a half of the dilemmas (“in-group supporters”).

Statistical analyses were performed with IBM SPSS Statistic 17. Significance at $p < 0.05$.

3 Results

Average scores characterising individual responses to all dilemmas were different between pre-schoolers and school age children, with pre-schoolers supporting out-group members less often (Mann-Whitney U test: U = 73.5, z = –2.43; p = 0.015). No significant difference between the “in-group supporters” and “out-group supporters” was observed in LF, HF or TP. Higher values of LF/HF ratio were shown in “out-group supporters” as compared to “in-group supporters” (Mann-Whitney U test: U = 1.0, z = –2.939; p = 0.003, for 4–5-year-olds; and U = 4.0, z = –2.66; p = 0.0008, for all children). No difference in LF/HF ratio was observed between the groups of 4–5-year-old and 10–11-year-old children within the subgroup of “out-group supporters” (see Fig. 1).

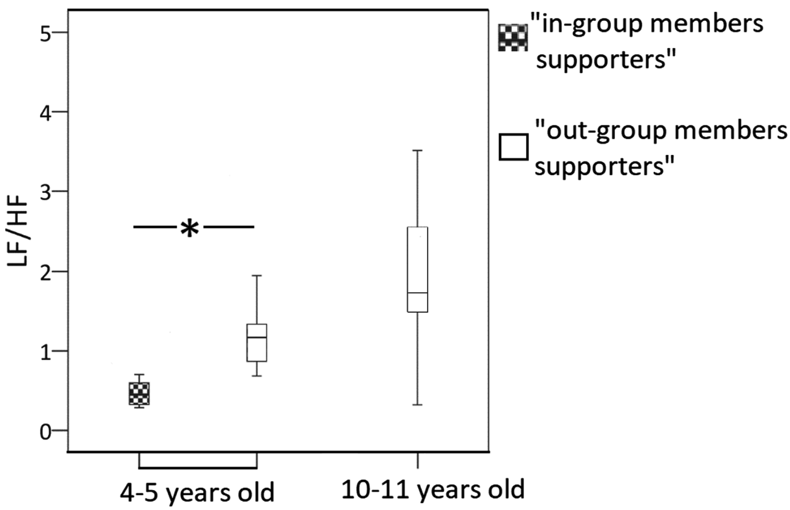

Fig. 1. Higher values of LF/HF ratio in children supporting out-group members as compared to children supporting in-group members in situations with a conflict where out-group members were treated unfairly by in-group members * Mann-Whitney U test, p < 0.05.

There was an insufficient number of "in-group supporters" among the 10–11-year-old children for such statistical comparison.

4 Discussion

In this study we tested the hypothesis that in a situation of a conflict between in- and out-group members, fairness towards out-groups would predetermine the occurrence of a system mismatch, which is observed when functional systems with contradictory characteristics are actualized simultaneously; and such a mismatch would be reflected in HRV.

As mentioned above, any behaviour, including moral dilemma solving, is supported by simultaneous actualization of functional systems formed at different stages of individual development. Our previous work [19, 20] demonstrated that young pre-school age children tended to exhibit unconditional in-group preference, which is considered a behavioural strategy based on actualization of functional systems formed early in individual development, including those associated with parochial altruism (unconditional in-group preference with aggressive behaviour toward out-groups [1, 9, 11]). Older children were shown to develop a more complex behavioural strategy to support those treated unfairly, including members of out-groups, which requires actualisation of later-formed functional systems. This is consistent with the view that reciprocal altruism toward out-group members requires higher cognitive complexity [16]. It is possible that the whole structure of individual experience is reorganised through the formation of "new" systems enabling a new type of behaviour, which may require some time. The development of moral attitudes towards out-groups occurs gradually and requires accumulation of a sufficient number of episodes associated with the "new" moral behaviour. The conflict between the earlier and later formed systems activated simultaneously can be described as an instance of the system mismatch, because these systems have contradictory characteristics.

The results of this study showed that in situations involving a conflict where out-group members are treated unfairly by in-group members, the decision to support out-group members was associated with higher values of LF/HF ratio of HRV. Higher values of LF/HF ratio are usually observed during stress [7, 8, 15, 18], which is also considered as a situation of the system mismatch [4]. Thus, the results of this study indicate that characteristics of social behaviour and its development, as observed in case of moral attitudes toward in- and out-group members, can be manifested in the dynamics of individual psychophysiological states.

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