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Special considerations relating to regulation of the heart rate in left-handed and right-handed children aged 7-8

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Abstract

Heart rate variability of left-handed and right-handed children in three different situations was compared. The first record was made in quite situation; the second one was made when child answered the questions about rewards in family and the third one when she (he) answered the questions about punishment. We have shown that heart rate variability of left-handed children in three situations did not change significantly, but regulation of heart rate variability of right-handed children in emotional situations changed significantly.

Keywords: left-handedness, right-handedness, children, heart rate variability

The development of handedness is one of the most intriguing problems of contemporary science. A preference for one or another extremity has been documented on an individual level for many mammals, and among humans it is characteristic to divide the population unevenly into those who prefer the left hand and those who prefer the right (Nikolaeva, Leutin, 2006).

It turns out that among many animal species those that have pronounced motor asymmetry exhibit greater cognitive capabilities (Bisazza et al., 1998; Cashmore et al., 2008). The likelihood of a high level of intelligence has been shown to vary among boys and girls under the age of eight (Nikolaeva, 2010). Since intelligence is often considered to be an adaptive mechanism, it can be supposed that motor and sensory asymmetry are in some way connected with the primary mechanism a person uses to adapt to their surroundings.

In the European part of Russia, the majority of the population favor their right hand when involved in various activities. By contrast, as a number of authors have revealed, natives of the Far North favor their left hand (Nikolaeva et al., 1995). It has been found that, in addition to having a preference for their left hand, the Selkups, who inhabit this part of the country, prefer to use their left side overall, in both the motor and sensory spheres. In other words, not only do they have a dominant left hand, but also a dominant left foot, eye and ear. It has also been discovered that they have a low level of blood cholesterol and they are unlikely in the extreme to suffer from cardiovascular disease.

In these harsh, inhospitable regions of Russia, oil extraction takes place, and it involves the use of a rotational working schedule in which workers from other, often faraway, regions come to work for two weeks and then return home, where they also spend two weeks, thus alternating their stays at home with work stints. It turns out that the number of left-handers who enter these jobs does not differ from their number in the general European population. After seven years of working such shifts, however, there is a sharp increase in the number of left-handers. As it happens, right-handers do not simply quit such jobs; they do so because of a steady increase in blood pressure.

These statistics allow us to assume that there is a causative connection between handedness and the process of adapting to complex conditions within a person’s surroundings. It is known that when there are new environmental conditions to contend with, the right hemisphere of the brain is activated (Nikolaeva, Leutin, 2011). It is characteristic of the right hemisphere to process information in a gestalt fashion, from which we can presume it is possible to evaluate any indicators of change in the external environment and elaborate a new plan of action.

It has been shown that for right-handers central regulation of the sympathetic nervous system is also a function of the right hemisphere (Craig, 2004). Consequently, the presence of stress or frequent changes in adaptation strategies (when involved in rotating shift work) can overburden the cardiovascular system and might lead to a breakdown in the regulation process and a steady increase in blood pressure.

Furthermore, it has been proven that for left-handers many functions of the brain are less specialized (McManus, 2002; Pfannkuche et al., 2009; Meguerditchian et al., 2013). This means that, for these people, during the process of adaptation activation of the right hemisphere will not be accompanied by a substantial increase in the burden imposed on the centers of sympathetic regulation, since they will be shared between the hemispheres. As a result, adaptation will not lead to a breakdown in the regulation of the cardiovascular system, since any changes will be within the limits of the adaptive resources.

This begs the question as to how early differences in the primary regulation of the heart develop. Can we detect such differences in elementary school children during the period when they are adapting to the educational process? Is it possible that the development of right-handed attributes during the formulation of handedness will increase intensive changes in the heart rate when a person recalls emotional states?

Materials and methods

In order to answer these questions, 145 schoolchildren (they were an average of 7.2 ± 0.4 years old) were surveyed. Here and elsewhere, the results are given in the [Mean] ± [SD]) format. The conditions for inclusion in the experiment were the following: the absence of chronic disease, the presence of a sine heart rate and written permission from the parents to take part in the research, along with an explanation of what will happen at every step along the way. Those children whose parents did not given permission to participate were not included.

Before the study began, it was determined which hand was dominant for each of the children by administering a series of tests: the Interlocked Fingers Test, the Napoleon Pose Test (Nikolaeva, 2005), the Shoulder Test (with their eyes closed, the child raises both hands in front of them, and it is determined which hand is raised higher without any visual monitoring), the Applause Test, the Object Grasping Test, and the Jar Lid Unscrewing Test. In each of these activities, it was determined which hand was the active one. Each test was performed three times.

In addition, these tests were conducted once: Drawing a Circle and Square with Closed Eyes and The Hand That Holds the Pen and Pencil, as well as the Tapping Test (Nikolaeva et. al., 2008). These tests were chosen because it had earlier been shown that the performance of these activities was a reasonably stable indicator for children of this age.

The results of all the tests were assigned a numerical rating: left-handed performance was given a score of 0; symmetrical performance (the child performed the activity first with one hand and then, when the test was repeated, with the other) a score of 1; and right-handed performance a score of 2. Children with an average value within the range of 0.0-0.7 were considered to be left-handed; those within the range of 1.3-2.0, right-handed; and the rest, mixed-handed.

Power analysis (Faul, 2007) was carried out during the planning stage (a priori) and again during the calculation and report stage (post hoc), using G*Power software, furnished to the authors for the purposes of this study by the University of Düsseldorf. To process the heart rate measurements (Tarvainen, 2014), the Kubios HRV program was used, and it was made available for this research by the Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics of the University of Eastern Finland, in Kuopio, Finland. Statistical analysis was performed by using the IBM SPSS Statistics program (version 23).

Recording of the heart rates was conducted individually, and it consisted of three stages. Electrodes were placed on a child’s arm, in the area of the wrist, with the contact pad on the inside. At the point of the contacts, the skin was doused with water. The child sat in a comfortable chair. At each stage, 300 consecutive heart beats were recorded (from this point on, heart beats are taken into account after the processing of technical and biological artifacts on the electrocardiogram recording, the time between R peaks on the ECG is called the NN interval, and the standard deviation from their average value is noted as SDNN). Such a prolonged ECG recording was chosen so that the entire assessment, beginning with the placing of the electrodes and ending with the recording of the answers, would take no longer than ten minutes. The heart rates were recorded using the Omega Medicine hardware and software system (the Dinamika Company, St. Petersburg, Russia).

In Stage 1, the heart rate was recorded with the child at rest. In Stage 2 (the valence of the emotional state = “+”), the heart rate was registered while the child was recalling situations of encouragement made possible by their parents. In Stage 3 (the valence of the emotional state =“ – "), the heart rate was noted while the child was recalling situations involving punishment. The child’s answers were recorded on the data sheet. The questions used in the conversation were taken from the E. Nikolaeva (2006) questionnaire.

It is extremely difficult to create conditions that generate an emotional response, especially in children. Talking about punishment or encouragement does not presuppose any sort of investigation into the real situation inside a family; it is simply a way of discovering the child’s perception of this situation. It has been proven that it is the perception of a situation that evokes an emotional response from a child (Bohanek et al., 2005). In fact, in this case a child recollects a situation to the extent that his spare capacities allow him to – in other words, the child will unconsciously omit the most traumatic circumstances (Nikolaeva, 2006). Since there were no children in our sample group who had been physically punished, it can be supposed that the level of emotional activation corresponded to what would be considered moderate. The procedure used in this study made it possible to evaluate a shift in control from a calm state of awareness to an emotional state, as well as a changeover from an emotional state of a positive valence to a negative one, or vice versa.

It can be assumed that the dynamics of the heart rate will be minimally intense for left-handed children and will be at its peak for right-handers.

Results and discussion

Figure 1 shows the trajectory of the conditions of the heart rate within a range from quiet state to “recollection of encouragement” to “recollection of punishment” (Sugihara, 1990). It can be observed that the heart rate for all children in dynamic tranquility (axis X) has the same span: the range of values is from 55 to 105 bpm.

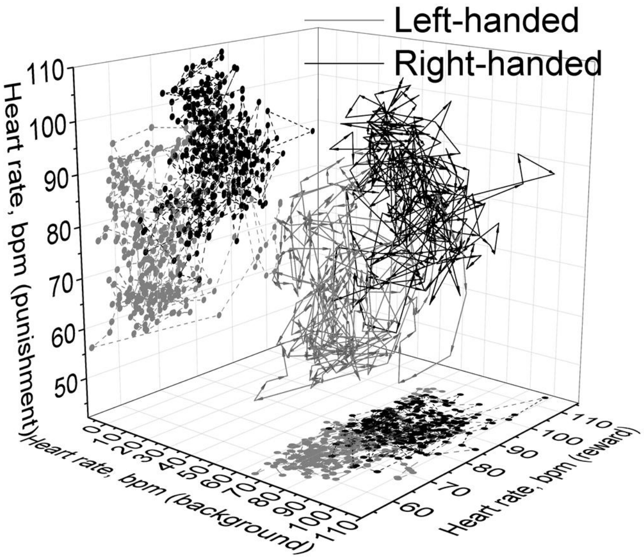

Figure 1. Trajectories of heart rate states of a left-handed child (grey color) and a right-handed child (black color) in a space of states “quiet state” – “recall of rewards” – “recall of punishments”. On the coordinate axes X, Y, Z there are heart rates.

During recollection of encouragement within the family (axis Y), the span of the heart rate for a left-handed child does not change, but for a right-hander its lower limit changes from 65 to 105 bpm. During recollection of a situation involving punishment (axis Z), the upper limit of the heart-rate span changes for both groups: for left-handers, from 55 to 95, and for right-handers, from 65 to 110 bpm. Based on this data, it can be supposed that the dynamics of the heart rate for a right-handed child during a shift to an emotional state are more pronounced that are those of a left-handed child. As a result, the three-dimensional point cloud of heart-rate conditions for a right-handed child “shifts” when compared to that of a left-hander.

At the beginning of the experiment, the average HR value was 72.5 ± 8.7 bpm (for the left-handed children) and 77.3 ± 10.0 bpm (for the right-handed children), the difference being at the level of $p <<< 0.001$, power = 1.000. At the end of the experiment, the average HR value was 72.8 ± 11.1 bpm (for the left-handers) and 87.8 ± 9.4 bpm (for the right-handers), the difference being at the level of $p <<< 0.001$, power = 1.000. Thus, it can be observed that the heart rate for a left-handed child at the beginning of the experiment (quiet state) and at the end of the experiment (after the first emotional state and at the end of the second, which had the opposite valence) did not show a significant change ($p>>0.05$). By comparison, the HR for a right-handed child in the same situation increased by 10 beats a minute ($p <<< 0.001$; power = 1.000), which would correspond to an intensive stress load during physical activity (an increase in the HR should not exceed 12 beats a minute in relation to quiet state).

Figure 2 presents the trajectory of the conditions of the heart rate for those children in the plane of embedding (a Poincaré plot) from “quiet state” to “recollection of punishment” (i.e., from the beginning to the end of the experiment) with a configuration of the dispersion ellipse (Tarvainen, 2014). It can be noted that during these stages of the experiment the point clouds of the heart-rate conditions for a left-handed child are practically the same. The dispersion ellipses confirm this: there is no statistical difference in their configuration and location ($p>>0.05$).

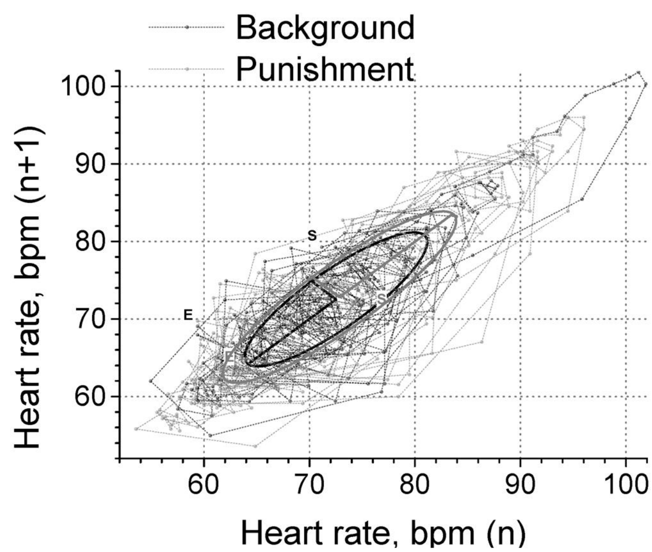

Figure 2. Trajectory of heart rate states of a left-handed child in a space of states “quiet state” – “recall of rewards” – “recall of punishments” with using Poincaré plot. On the coordinate axes X, Y, Z there are heart rates. On the axis X- heart rates (bits per minute), on the axis Y – the same heart rates but with forward shift (one point). Axles of the ellipses of dispersion are SD long period (on the line from lower left corner to upper right corner) and SD short-period (perpendicular to previous). Marks S mean a beginning of a trajectory, E – its end.

The picture for a right-handed child is different (Fig 2): the point clouds of the heart-rate conditions at the beginning and at the end of the experiment are out of line with each other. Although the configurations of the diversion ellipses are similar, the centers of the ellipses have shifted ($p <<< 0.001$; power = 1.000).

There are no any differences between stages of left-and mixed- handed children. Power analysis confirms the differences of heart rate both between background and recalling situations of encouragement and background and recalling situations of punishment.

We have received the differences just for right-handed children. It could be assumed that there is no enough a discriminant power of one parameter – handedness (but it describes the most part of dispersion). Maybe we need some more parameters of lateral preferences, for example eye-ness, footedness, ear-ness.

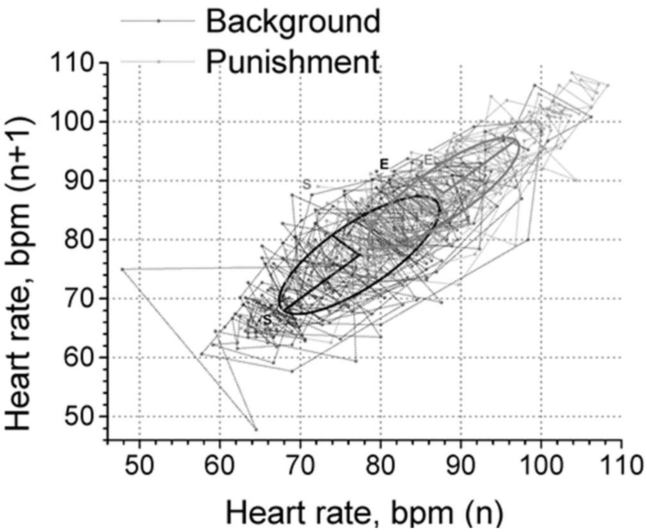

Figure 3. Trajectory of heart rate states of a right-handed child in a space of states “quiet state” – “recall of rewards” – “recall of punishments” with using Poincaré plot. The same tables of symbols as on the Figure 2.

Thus, an analysis of the results (see the tables) shows that the intensity of the heart-rate dynamics among 7-8 year-old children when they are in emotional states of different valences increases along the line from left-hand dominance to mixed-hand dominance to right-hand dominance.

Table 1. Heart rate in left- and right-handed children aged 7-8 on different stages of the experiment

Stage of experiment	handedness/number of children		
	Left/n=35	Mixed/n=64	Right/n=46
background A	84.32±20.14	85.69±17.72	87.74±14.64
“+” (B)	86.14±20.04	87.53±18.90	91.32±15.26
“–“ (C)	85.96±20.96	87.41±17.53	91.76±14.84
W (B–A)	p= 0.017*	p<0.001*	p<0.001*
Power (B–A)	0.719	0.914*	0.995*
W (B–A)	p=0.599	p=0.636	p=0,285
Power (C–B)	0.053	0.057	0.096
W (C–A)	p=0.123	p=0.004*	p<0.001*
Power (C–A)	0.328	0.735	0.992*

Notes: There are no any differences between groups for heart rate (U Mann-Whitney) and distribution (F Fisher, Moses Test); the differences between stages in a group for heart rate (W-test Wilcoxon, α =0,05; exact 2-tails); Power = (1–β err Prob), α = 0,05; 2-tails;
“+” – a stage of two, recalling reward; “–“ – a stage tree, recalling punishment; * – p<0,05; Power≥0,80.

Our findings are in keeping with the hypothesis that there is a difference in the regulation of the heart rate between people with different types of handedness. While in right-handed children emotional stress is extensively reflected in their heart rate variability, in left-handers there is no link between emotional stress and autonomic manifestations. In adulthood, this means that serious changes in the regulation of emotional stress leads to myocardial infarction more often with people who have all of the right-side attributes: right-hand, right-foot, right-eye and right-ear dominance.

Further research might focus not only on an analysis of how cardiological changes are linked to the characteristics of handedness but of how they are related to other lateral attributes as well.

An examination of these mechanisms allows us to comprehend the evolutionary workings involved in the phenomenon of lateral preferences in the sensory and motor spheres and, at the same time, to understand how people with such attributes are distributed in various climatic and geographical conditions.

Acknowledgments

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