

Neurophysiological Approach to Examining Knowledge/ Belief in the Prayer of an Untrained Person: A Case Study

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Abstract An adult female (22 years) of Christian orthodox religion was examined during the silent Lord's prayer, the most common, short prayer, with the aim of possible differentiation between belief and knowledge in her experience, analyzing the behavior of subgroups of theta and beta cerebral EEG rhythms, which occur through constant and occasional activation of cerebral regions. The participant was not trained in reading the prayer to herself or other people. EEG examination was performed by Nihon Kohden Corporation, EEG—1200-K Neurofax apparatus, in the monopolar longitudinal montage in the system of 10/20 electrodes aimed at determining the peak frequency value of each exploratory site. The method of result analysis was based on connecting cerebral regions into networks of 3 or more members according to identical peak frequency value, which was observed within subgroups of theta and beta frequencies and analyzed through a proximity index and continuity and discontinuity of activation during the

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observed period. Out of the definite observation sample of 3 s from each subperiods (beginning, middle and end), a window of 2 s was moving from the beginning till end of the period with 200-ms time lag. This resulted in six subsamples for each electrode and for each experimental situation (resting state, situation of prayer). Stable and unstable activity of the regions was assessed within subgroups via cartographic formulas equivalent to the states which subgroups of theta and beta imply in psychophysiological sense. The results indicated that through participant's inner dialogue—monologue there are elements of both knowledge and belief, and that this phenomenon is possible considering insufficiently specific circumstances of the experiment and the participant herself, such as her relatively young age and insufficient practice of praying. The paper discusses the types of connections between regions which imply knowledge and those related to belief according to our understanding and regarding findings in literature.

Keywords EEG · Theta · Beta · Cartographic regions · Information processing · Silent speech

Introduction

Numerous previous studies of meditative activities, which used very different approaches, could not establish specific relation between knowledge and belief during those activities. This inspired us to examine whether characteristics of cortical EEG rhythms during a short pray (In the wider sense, prayer can be seen as a form of meditation) would provide better understanding of the ratio of belief and knowledge in the case study of the examined person.

The basic form of comparison of the activation of connected cerebral regions through joint frequency and in subgroups of theta and beta was chosen as a result of our practical work to prove the connection lines of cortical regions regarding knowledge, in the work with healthy individuals, as well as patients with problems in communication. Furthermore, previous literature does not emphasize the contribution and significance of connecting auditory regions with other regions for the assessment of knowledge compared to belief, in a pray, as a form of a silent speech. Also, bihemispheric connection of regions into complexes of knowledge and complexes of belief did not clearly include emotional regions for the reception and emotional processing. Engagement of temporal and spatial engrams is not in the focus in the studies of this type. The most basic observation about behavior of beta activity compared to theta via their subgroups implying certain psychophysiological effects can be found. This needs to be taken into consideration because it has not been considered in contemporary literature.

Methodology

We examined an adult female (22 years) of Christian orthodox religion who has academic degree. The participant was recorded in the duration of 3 min during silent (speechless, without lip movements) Lord's prayer, which she had long known by heart and during resting state. The participant received explicit instruction to focus on the task and to control spontaneous wandering of the mind as much as possible. The recording was carried out in the morning hours, in comfortable conditions, in a sitting position. Quantitative EEG profile was measured by Nihon Kohden Corporation, EEG—1200-K Neurofax apparatus which provides 19 EEG channels. The fixed cap with Ag/AgCl round electrodes with electro-conductive gel is used. The electrodes are placed according to 10/20 International system of electrode placement.

Referent electrodes were A1 and A2 (lobulus of the earlobe) with the possibility of additional change of reference montage. The impedance was kept below 5 k Ω , with not

more than 1 k Ω difference between electrodes. The high-pass filter was set at 0.53 Hz, and the low-pass filter at 35 Hz. Before the examination, participant was recorded during a resting state with eyes open in order to eliminate artifacts or other EEG abnormalities with regard to characteristics of wave morphology.

According to the research goal, material for processing was obtained from the analysis of frequencies (peak frequencies in spectrum analysis table) expressed in the hertz (Hz) unit for the theta and beta rhythms. A total of 19 electrodes in monopolar and longitudinal montage were used: 8 electrodes on left (Fp1, F7, F3, C3, P3, T3, T5, O1), and corresponding right (Fp2, F8, F4, C4, P4, T4, T6, O2) cortical regions, with three midline (vertex) regions (Fz, Cz, Pz), and with one referent electrode on the corresponding ear of each side.

We proceeded from the assumption that the proximity intensity of connecting regions, within the same peak—frequency value, is in the function of the number of networks and the number of engaged regions. Hence, the proximity index, although without analysis of phases, was the highest when all 19 possible EEG regions were involved.

The 10-s artifact-free samples were taken from the beginning, middle, and end of the recording for both experimental tasks (lasting three minutes, respectively). For further analysis, out of each sample of 10 s, the sample of 3 s was taken for both rhythms. Finally, within the period of 3 s, a window of 2 s was moving from the beginning till end of the period with 200-ms time lag. This resulted in six subsamples for each electrode and for each experimental situation (resting state, situation of prayer).

Six two-second mini-periods were classified according to individual frequencies in which they appeared. Further, they were additionally classified into subfrequency groups of theta and beta for both experimental tasks (theta: 4–6 and 6–8 Hz and beta: 13–15, 15–20, 20–24, and 24–36 Hz). We extracted constant individual frequencies (“stable activity”)—those which appeared in all three subperiods of 3 s, respectively (beginning, middle, and end) and at least four mini-samples within each subperiod. This resulted in a total of 18 mini-periods for each subperiod and for each subgroup of theta and beta in the form of a network. A network was defined as at least three active regions of the same peak frequency value expressed in Hertz, which occurred in each of these subperiods in at least four mini-periods (Table 1), unlike the frequencies which did not meet these conditions. Those were defined as “unstable” frequencies. The created subgroups of peak frequencies according to groups of theta and beta were manifested through the frequency of activation of certain regions and their networks. The assumption was that the network must have at least 3 members (active regions), whereas the number of key points (at which other similar networks can be connected) determined the overall frequency of networks of different frequencies, through stable and unstable form of activity. In this manner, we obtained networking frequency in the required proximity of each of 19 regions within subgroups of theta and beta in stable and unstable relations.

The aim of this study was to attempt to differentiate between belief and knowledge in the experience while reading the prayer. It was conducted by observing the behavior of subgroups of theta and beta cortical EEG rhythms which occur through constant and occasional activation of cortical regions.

Results

Table 1 presents constantly engaged networked regions, according to subgroups of theta and beta in prayer and at rest, in relation to the left and right hemispheres and midline (vertex) region altogether, as well as the difference in favor of prayer (+) or resting state

(–). There is a marked asymmetry between two experimental tasks. In addition, the asymmetry increases with the increase in EEG signal frequency. Finally, the engagement of regions during situation of prayer is significantly prevailing.

There is a significantly decreased frequency according to subgroups, particularly over the right hemisphere and a significant prevalence of the engagement of regions during resting state (Table 2).

Within the constant activity, the results indicate significant advantage of corresponding regions during situation of prayer compared to those during resting state, particularly by the left hemisphere if there are bihemispheric compositions of advantage in both situations (except in 6–8 Hz subgroup). In the unstable form, results indicate significant advantage of corresponding regions during resting state when compared to the situation during situation of prayer.

Tables 3 and 4 present significantly more asymmetry of totally engaged regions and corresponding regions in the situation at rest compared to the situation of prayer in both situations, stable and unstable forms of activity for each theta and beta subgroups. However, right-sided asymmetry in the stable form in beta 20–24 Hz, and left-sided in the unstable form was recorded only during situation of prayer.

Discussion

Our study primarily indicates a pronounced existence of an event in the asymmetrical left-sided activity during situation of prayer in the form of continuity, unlike the resting state, where an event, if any, took place in a discontinued way and with significantly smaller advantage of the left hemisphere. This is considered a contribution to the confirmation of the existence of the “event” in general (Shapiro and Walsh 2003). A significantly higher number of engaged regions during situation of prayer, connected in the form of left-sided asymmetry, found in our study, represents confirmation of the research of the event in general. The advantage of networking of regions in such an event within shallow consciousness implied by 6–8 Hz theta of connected left auditory regions and those for attention, and speech language communication, as well as the plan of interpretation of the experience (happening), although within shallow subconsciousness, is associated with the light deviation from reality, which was insufficiently covered in literature (Travis and Arenander 2004). Together with the overall advantage of the networking of theta in the favor of situation of prayer, this can indicate a certain form of belief, particularly because of significantly bigger left asymmetry in situation of prayer compared to the resting state. However, significant asymmetry between the corresponding regions of the left and the right hemispheres in theta during the prayer, or total asymmetry were not found; also, asymmetry was not found in the resting state, which would reduce the value of the event of subconsciousness close to the situation of belief of the participant (Austin 2000). It may agree with the finding in literature that consciousness and subconsciousness are inversely related (subconsciousness suppresses consciousness and vice versa) (Austin 2000). The difference between situations is confirmed by the finding that in the unstable form of activity for the resting state there is positive asymmetry but exclusively for Fp1 region, only without connecting with auditory speech processing as in the stable form of prayer.

Positive symmetry in favor of the situation of prayer, prevalently its left hemisphere, was found in 13–15, 15.20 and 24–36 Hz subgroups, whereas in 20–24 Hz subgroup there was a relatively neutral relation. Studies of beta activities according to subgroups did not

Table 3 Asymmetry between resting state and situation of prayer

Rhythm subgroups	Situations	
	Prayer	Rest
<i>Stable activity</i>		
Theta 4–6 HZ	0	0
Theta 6–8 Hz	Fp1, T3	0
Beta 13–15 Hz	F3, O1, P4, O2	0
Beta 15–20 Hz	Fp1, C3, T3, P3, O1, F7, F8, T4, O2	0
Beta 20–24 Hz	C3, T3, P3, O1, C4, O2	Fp1, F3, F7, T5, T6, Fz
Beta 24–36 HZ	F3, C3, P3, T5, O1, T4, P4, O2	T3, Fp2, C4, T6
<i>Unstable activity</i>		
Theta 4–6 HZ	0	0
Theta 6–8 Hz	0	Fp1
Beta 13–15 Hz	0	O1, P4
Beta 15–20 Hz	0	Fp1, C3, T3, P3, O1, F8, T4, T6, O2
Beta 20–24 Hz	Fp1, F3, T5, T6, Fz	O1, C4
Beta 24–36HZ	T3, O1, Fp2, C4, T6	F3, C3, P3, T5, T4, P4, O2, Fz, Cz

Table 4 Interhemispheric asymmetry (L/R)

Rhythm subgroups	Situations	
	Prayer	Rest
<i>Stable activity</i>		
Theta 4–6 HZ	0	0
Theta 6–8 Hz	0	Fp2
Beta 13–15 Hz	0	O1, P4
Beta 15–20 Hz	0	F3, F7, Fp2, F4, C4, P4
Beta 20–24 Hz	F4, F8	Fp1, T4, O2
Beta 24–36HZ	C3, P3, T5, T4	T3, Fp2, F4, C4, T6
<i>Unstable activity</i>		
Theta 4–6 HZ	0	0
Theta 6–8 Hz	0	Fp1
Beta 13–15 Hz	0	O1, P4
Beta 15–20 Hz	0	Fp1, F8, T4, P3, T6, O2
Beta 20–24 Hz	F3, C3, T3	Fp2, T3, O1
Beta 24–36HZ	O1, C4, T6	Fp1, F3, C3, T4, T5

receive adequate attention (Fell et al. 2010) probably because short transcendental state such as prayer was examined in individuals devoted to belief and trained individuals (which obviously was not the case of our participant). On the other hand, our experiment also considered silent prayer as a special form of revision of the learned text based on the relatively stable system of connected auditory, temporal spatial regions, those for focused attention and motor ones in particular. Our papers (Radicevic and Dobrijevic 2009;

Radicevic et al. 2009) on children with expressive speech disorder indicated not only the existence of the sound image of a word (when looking at a picture) but also the processing in speech language regions in the so-called state at rest. Our paper then indicated that significant activation of auditory regions in the so-called resting state can denote a certain kind of inner revision. This can explain significant activation of auditory regions in the situation at rest in the form of shorter interhemispheric asymmetries. On the other hand, literature came closer to researching the role of connecting the regions within theta and alpha and beta only above 36 Hz (Fell et al. 2010). However, these findings were not observed through beta subgroups which imply corresponding psychophysiological output. This was confirmed through NFB treatment, which was one of our earlier directions in differentiating knowledge from belief.

Our findings within the theta rhythm are close to findings in literature in regard to the increase in global theta activity in prayer, which implies significant slowdown of EEG activity, with preservation of conscious acting (opposite to sleeping). However, this paper noticeably showed that the preserved conscious aspect has its profile in beta subgroups which in a way comprise areas of the conscious in the form of regions connected into systems, which more closely define certain areas of knowledge. This can be seen in connecting primary and complex auditory and spatial–temporal regions alongside visual regions with primary (frontal) and executive (central) motor regions. The findings are in significant accordance with study by Austin (2000).

The findings also indicated that the mechanism of control of inner inhibition during the thinking activities implied by 13–15-Hz subgroup at rest expressed through the connection of regions O1–P4 is significantly expanded in prayer by the inclusion of both right visual and left frontal regions. Moreover, it is several times more expressed in the stable activity during situation of prayer compared to the resting state, whereas it disappears in the unstable activity during situation of prayer. In the resting state, it continuous to exist in the same form of connections both in relation to prayer and as a form of tight bihemispheric connections within the resting state. Finally, it can be concluded that for central inhibition in the resting state O1–P4 control is sufficient, whereas in the situation of prayer an additional activity of the visual right and the frontal left hemispheres is necessary, which seems logical for undisturbed process of thematically directed speech of prayer compared to the stable or unstable activity in the resting state (Thatcher et al. 2007). There is no advantage of the resting state compared to the situation in prayer in the stable form of activity, or in regard with the connection of regions in 15–20-Hz subgroup which implies memory and elementary learning (Ivanovski and Malhi 2007), whereas in prayer this advantage is provided by significantly more regions which include all parameters of speech language communication of the left hemisphere, and visual and temporal ones on both sides, associated with right emotional regions. Big reliance on bilateral visual regions with the moderate activity of the emotional one for attitude and expression does not exclude the possibility that the participant had an abstract (conscious) source of an image (icon?). This is significantly different from the resting state. However, neither this subgroup nor 13–15-Hz subgroup manifested asymmetry in the situation of prayer.

Our research showed significant difference between the situation of prayer and the so-called resting state, considering the number of engaged regions and their profile both in theta (Aftanas and Golocheikine 2001) and in beta subgroups (Fell et al. 2010; Thompson and Thompson 2003). Those on the side of the left hemisphere were more engaged in the situation of prayer and that this difference was particularly expressed in theta subgroup which implies shallow subconsciousness as well as in beta subgroups which imply central

motor inhibition (13–15 Hz) and learning and knowledge (15–20 Hz). Generally, such a finding would indicate utilization of knowledge in the situation of prayer compared to the resting state.

The profile of significantly engaged regions in 20–24-Hz subgroup (so-called combined beta) which primarily implies processing of the learned text (Thompson and Thompson 2003; Martinović 2009; Buzsaki 2006) and believing it, includes both-sided motor and visual regions during prayer, as well as temporal regions, and only left primary auditory regions. This would indicate a certain form of confidence in the experience of an image and motor activity, as well as the time, which is approximate to awareness of the moment of event, in contrast to the resting state dominated by reliance on emotional experience and auditory expectation, as well as the possible plan of action. This decision (or the confirmation of this attitude) shows that in the situation of prayer it comes from the right interhemispheric asymmetry of emotional orbitofrontal structures and carries the component of “new,” a kind of discovery of a new experience and can denote a kind of belief together with the mentioned intersituational asymmetry (Thompson and Thompson 2003).

There are a number of reasons for an assumption that the structure of 24–36 Hz beta response holds an actual answer to the goal of our research, the subgroup which implies doubt of what 20–24 Hz actually confirms (Thompson and Thompson 2003) and that the biggest part of the structure of the region of this response is represented in the prayer not only in situations but also in interhemispheric asymmetry on the left in the formula C3, P3, T5, and that time is a factor in the experience of the content of the prayer in the center of that doubt, dilemma, or distrust. Although the resting state shows asymmetry not only in the situation of prayer, but also interhemispherically, it is predominantly right hemispheric and comprises regions of planning and listening, therefore completely different compared to those during situation of prayer.

Generally, the depth of descent into subconsciousness is more significantly present in prayer and is connected with regions of planning, which is obviously connected with the activation of the auditory region, which is most probably related to silent speech. The behavior of beta subgroup, the one concerned with learning, shows significantly larger involvement of regions in prayer, which once again imposes the relation with the activity of silent speech. If beta subgroup 20–24 implies confirmation of the findings of prayer (decision making) that the participant in a way stood behind her words and that this was within rather determined emotional regions of the right hemisphere (Thatcher et al. 2007), then there is a possibility that this is a new belief which lies in the background with what is connected with learning and maybe the meaning of belief in the existence of another truth and not only the one directly connected with speech. The responses higher than 24–36 Hz could confirm the doubt in regard with the learned text about a different truth (dualism); and locating these doubts connected with parietal regions of the left hemisphere responsible for understanding of time (Thatcher et al. 2007; Coan and Allen 2004) would be the reflection of the possibility of these two truths persisting at the same time.

Conclusion

An untrained young person in meditative activities, although examined during silent prayer, showed an event different from the resting state in the form of significant activation of the regions responsible for learned knowledge, and only insufficiently reliable signs of belief. It seems that P3 region plays a significant part in the activity of belief.

Compliance with Ethical Standards

Conflict of interest The authors have declared that no conflict of interest exists.

Ethical Standard All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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