In order to communicate effectively, adapt to ongoing social situations and to understand someone's intentions and behaviour, adults and children require theory of mind (ToM). ToM is the ability to attribute mental states such as beliefs, intents, desires, etc.—to oneself and to others. This ability extends also to understanding that mental states of others may be different from one's own as well as from the actual reality. For example, in a golden standard "false belief test" (FBT), the studied child is presented with a short narrative where the protagonist places an object in a blue box. Unbeknown to the protagonist, the object is then moved to another (red) box. The child is then asked a question where would the protagonist look for the object (blue or red box). When answering this question, ToM would normally allow us take into account the fact of the protagonist being unaware that the object has been moved, and correctly conclude that he would look for the object in the blue box, just where he had left it. Interestingly however, numerous researches over the last 35 years have shown that children below four years of age fail FBT and incorrectly indicate the red box (consistently with the actual reality, and child's own belief, but inconsistently with the false belief of the protagonist).

ToM deficits can be observed in people with the autistic spectrum disorder (ASD) or in congenitally deaf children of hearing parents who have limited language exposure. More recent research has demonstrated that even 7-months' old infants automatically consider others' beliefs (even false) when forming their own expectations. A very similar mechanism is present in healthy adults. However, such mechanism is impaired in subjects with high-functioning autism, or even in healthy children whose older sibling has ASD. Interestingly, in these groups of subjects, spontaneous mentalizing (implicit ToM) seem to be impaired to a greater degree than explicit mentalizing (explicit ToM).

Recently, neuroimaging techniques allowed us to look for neural underpinnings of both implicit and explicit ToM. In the past, most of the studies indicated that the same ToM network is activated both in implicit and explicit ToM tasks (encompassing the right temporoparietal junction, the precuneus, the posterior part of the temporal lobe and the prefrontal cortex, as well as a part of cingulate cortex). These regions used to be jointly called the "ToM network". Some studies suggest that the ToM network is activated to a greater degree during explicit false mental states attribution. On the other hand, in subjects with ASD, ToM network is disintegrated even if its sub-regions work in a relatively unobstructed manner.

Unfortunately, the research on neural underpinnings of explicit and implicit ToM were only conducted on adults or on children who were at least 6 years old. Therefore the similarity of brain activation during these two processes may result from the fact that in the mature brain, even in the non-verbal implicit tasks the performance was controlled by fully-fledged, explicit ToM mechanism. There is no neuroimaging studies on children at the transitional developmental period of the fourth and the fifth year of life, when the explicit ToM is formed. The proposed project seeks to address this gap and answer the most pressing question in the recent theory of mind research, namely, what is the relation between explicit and implicit mentalizing.

In the proposed project, we plan to use functional near infrared spectroscopy – fNIRS to investigate brain functions underlying the ToM development. FNIRS is a non-invasive technique which takes advantage of the fact that human tissues exhibit relatively low absorption of near-infrared light. By transmitting near-infrared light into the scalp, then detecting the light that scatters back to the surface researchers may measure the changes in concentration of oxygenated and deoxygenated hemoglobin in the brain. Thanks to the close relationship between neuronal activity and changes in local blood flow, fNIRS may be used to examine human brain functions. By precise localization of NIRS' sources and detectors, researchers may measure how specific brain regions response to external stimuli. The fNIRS is a relatively cost-effective (in contrast to fMRI) and non-invasive method that allows to record brain activity in more real-world settings. NIRS has lower spatial resolution then fMRI and it does not enable to investigate subcortical brain areas, but most of the regions encompassing ToM network lie on the surface of the cortex.

We plan to investigate four groups. First, heathy adults, in whom we will apply two functional neuroimaging techniques – fMRI and NIRS. Direct comparisons of the results obtained in fMRI and fNIRS experiments will enable us to validate the precision of our method and to plan the distribution of sources and detectors of near-infrared light accordingly. Secondly, we will examine healthy, typically developing pre-school children to compare brain activity during implicit and explicit ToM in children who pass and fail FBT. Thirdly, we will examine congenitally deaf children threated with cochlear implant before age of 2 who however had been deprived of language exposure. Finally, we plan to investigate children at risk of ASD, whose older siblings have autism. The latter two groups may differ in respect of the efficiency of implicit ToM mechanisms. Accordingly, a direct comparison and reference to typically developing children may yield substantial knowledge concerning the role of implicit ToM and early language experience on the development of more advanced ToM.