The human brain, like the brains of many animals, is adapted to perceive and operate on numbers: e.g. ordering numerical quantities from the smallest to the largest, comparing two numbers, adding or subtracting two sets of objects, even without their exact enumeration. This original system is not exact - it only approximates the number, and the accuracy of the estimation decreases with the size of the number. Interestingly, the processing of numbers by the brain/mind is related to space, e.g. we react faster to small numbers with the left hand, and large numbers with the right hand, small numbers automatically draw attention to the left, and large numbers to the right, as if the attention is shifted along an imaginary left-to-right oriented "number line". In one of the neuroimaging studies on arithmetic processes, a machine learning algorithm that learned to recognize brain activity during saccades (quick eye movements shifting the focus of visual attention in the visual field), classified brain activity during addition as a saccade to the right. In general, the areas in the parietal and frontal parts of the brain that contain neurons responding to numbers are adjacent to or partially overlap with the areas that direct spatial attention and action.

Other effects of number processing, although not directly related to space, nevertheless evoke spatial associations. For example, often unable to calculate the result accurately, we tend to choose a result that is too large in addition and too small in subtraction. This is the so-called "operational momentum" effect. If we combine this effect with the spatial-numerical associations shown earlier, we can try to explain it as shifting attention too far along the imaginary number line to the left in subtraction and to the right in addition. However, research into the number-space relationship and the brain's bases of number processing has mostly been conducted with adults or school-aged children who do not have to rely on the inaccurate primitive system of approximate number, but have the ability to count, know the exact meanings of number-words in their language, and digits in the Arabic notation, also have cultural, script direction-related habits of ordering symbols from left to right (in other cultures, like Arabic, where texts are written and read from right to left, the effect of associating numbers with spatial directions is often reversed - small numbers are associated to the right and large to the left). Studies, especially neuroimaging, involving preschool children are scarce. This can be justified. On the one hand, conducting such research with young children is difficult, and on the other hand, most researchers focus their attention on mathematical education - a very serious civilization problem. However, there may be a flaw in this approach. Preschool age is the age when the primary system of perceiving and processing numbers becomes efficient (although its operation can be observed even in newborns), and at the same time the child gradually learns to count. Problems as they appear at this stage may therefore affect the course of further stages of mathematical education. Knowledge about the role of the original approximate number system and the spatial aspects of number processing in the process of acquiring numerical symbols is fragmentary and full of contradictions. There are both similarities and differences between the brain's processing of non-symbolic numbers (perceived approximate sizes of sets) and symbolic numbers. However, there is some evidence that in the earliest stages the relationships between these systems are stronger than later (and mutual), and the spatial organization of the mental representation of number plays an important role in this.

Our project was conceived as a partial filling of this knowledge gap. We intend to study brain activity and spatial attention while performing the most basic numerical operations - comparing numerical quantities and simple arithmetic - by preschool children (3 - 6 years old) who have not yet started formal mathematical education. We want to combine two modern research techniques: imaging of brain activity with the near infrared spectroscopy (fNIRS) and eyetracking. The fNIRS method allows to measure local changes in oxygen supply to the cerebral cortex in response to the task performed. It is slightly less accurate than functional magnetic resonance imaging (fMRI), but much less tedious and more child-friendly. In turn, eye-tracking not only shows what the gaze is directed at, but also, by measuring changes in the diameter of the pupil, allows to determine the cognitive effort that needs to be put into the task. We hope that thanks to properly planned experimental manipulation of the magnitude of numbers, the way they are presented (as a set or as a digit), their location in space (on the right or left side) or arithmetic operations (addition or subtraction) in a series of experiments with preschool children we will be able to connect the most characteristic signatures of the non-symbolic and symbolic number processing system with brain activity and allocation of the spatial attention resources, and relate these to the developmental processes that take place in the "number brain" when children learn to count and assimilate the concept of an exact number, based on a fixed unit, and thus start to know the exact meanings of numerical symbols (number-words and digits)