An Analysis of Visual Consciousness

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ABSTRACT: *The nature of consciousness has excited the imagination of scientists and researches for years. In the past, some were of the opinion that a single part of the brain is important for the emergence of consciousness, while some disagreed, one of the first being the psychologist William James, who claimed that what is important for its emergence is the function of the brain as a whole and that parallel function of different parts is key. In our study we focus mainly on the research of visual consciousness. We want to find out whether there is a difference in the emergence of visual consciousness between healthy participant (children ages 6-16) and children diagnosed with ADHD. We attempt to measure the emergence of visual consciousness using an experimental paradigm designed.*

Keywords: Visual Consciousness, ADHD, Visual Attention, Visual Integration

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1. Introduction

The nature of consciousness has puzzled mankind since the beginning of time. What is consciousness, how can our physical brain interpret subjective experience, what are qualia? The question also presents itself as in where in the brain does consciousness lie. All these are questions that scientists have been posing for years and still today.

What is consciousness, where is consciousness formed, which neural correlates are responsible for consciousness, all these are questions that scientists and philosophers are occupied with today and were occupied with in the past. The search for rigorously

defined neural correlates has been going on for decades. Some recent studies these days identify the thalamus as a central structure implicated in conscious awareness [4]. The thalamus works as a relay station or a passageway of sensory information into certain parts of the cerebral cortex [4], which means that all information we are consciously aware of (except olfactory) meets the thalamus at some point.

The study we present in the paper, tests visual awareness using an experimental paradigm developed by Dr. Nádasdy and colleagues. The task comprised visual integration of image fragments presented on a computer screen. The project connects the neuro scientific and psychological aspects of visual consciousness.

We assume a critical point in time when visual consciousness (of recognition of an image as a whole or non-whole) emerges and we posit that this time of emergence is delayed with certain developmental or neurological (neuropsychological) disorders, namely in ADHD children.

2. Theoretical Basis

As the body of neurological knowledge has dramatically grown in the past few decades, so too has grown the interest in and search for neural correlates of consciousness. While some were occupied with the search of a common center of the brain responsible for conscious awareness, others search for multiple regions or systems that play an important role in the production of consciousness. William James was one of the first advocates of this position. He claimed that consciousness is a result of the common effort of the whole brain (Principles of Psychology, 1890/1950, as cited in [3]). However, an increasing quantity of empirical evidence shows that some parts of the brain are much more important than others when it comes to the production and expression of conscious awareness. These are mainly the thalamocortical system and the reticular system of the brain stem [3].

In the search for brain regions involved in the creation of consciousness there is a structure that has gathered a lot of attention – the thalamus. The thalamus is a structure in the midbrain found at the top of the brain stem. In the mid-1800 the idea already appeared that the thalamus is the sensory center of the brain. Neuroanatomical examinations of patients showed that thalamic regions in an otherwise unaffected brain caused major sensory dysfunction. These neuroanatomical findings showed that the thalamus plays a key role in the processing of sensory information [4]. Later neuroanatomical studies of the thalamus and its connections to other parts of the brain highlighted its function in sensory processing and integration. It is important to note that it was discovered that all sensory information travels through the thalamus before reaching the corresponding parts of the cortex [3].

Francis Crick [1] contributed much to the literature on consciousness by suggesting that the TRN (thalamic reticular nucleus) and the dorsal thalamus play a key role in consciousness by means of controlling and expressing an internal attentional searchlight as first suggested by Treisman and colleagues (1991, as cited in [1]). Crick suggested the TRN produces rapid firing in thalamic relay neurons to control the brain's attentional searchlight, acting on Malsburg synapses to create conjunctions of neurons, expressed by cell assemblies, which Crick believes to be the neural expression of the attentional searchlight.

By researching attentional capacity of the brain at tasks comprising different types of search, researchers noted that the brain searches consecutively, focusing on one object at a time, before moving on to the next [1].

In his attempt to explain how the thalamocortical system controls attention, Crick suggested the following mechanism: when sensory signals pass through the TRN on their way to the cortex, this causes excitation. Crick suggested that the TRN and dorsal thalamus work together to increase activity at the most active thalamocortical pathways and at the same time reduce activity in less active parts of the thalamocortical network. He described this mechanism as "… the heating up of the warmer parts of the thalamus and the cooling down of the colder parts" [1] (page 4587).

3. Hypothesis

Our hypothesis is that there is a certain amount of information needed to be able to put together image fragments with confidence (confidence here not referring to the reported level of confidence by subjects). Hence, the decision point to reach a certain level of confidence for a given image is consistent across healthy subjects. This point can be standardized for a selected set of pictures and the test can be validated. Having the image set standardized, the test should be sensitive to disorders

implicated in consciousness, attention, mental focus, and visual integration processes such as functions compromised in ADHD. We also wish to find out whether our test is appropriate for the detection of such disorders.

The main research goal is to test the hypothesis and based on this construct a theoretical framework describing the differences at the emergence of visual consciousness in healthy children and children with ADHD.

4. The Experiment

4.1 Method

Participants sit down in front of a computer screen on which four very similar pictures appear, divided by black lines. The participant decides whether the images compose one joint picture or whether they are different. They record their decision by pressing a key on the computer keyboard. At every keystroke the lines between the images thin until the entire picture is revealed and it becomes clear whether the images form a whole. The pictures include themes from everyday life (houses, cars, landscape, furniture etc.), various kinds of animals and abstract pictures, like pictures of the universe, microscopic cells etc.

In our study, visual consciousness is experimentally tested using a between-subjects design. The independent variable is the manipulation of trials. During solving time, the task has seven levels equivalent to every phase of testing. The dependent variable is the judgment of participants about the continuity of the images presented in every phase (by pressing a computer key).

4.2 Progress

So far 48 children have taken part in the study. The control group consists of 20 students of the Kidri evo elementary school, (10 female, 10 male), aged between 8 and 9 years. The participants were primary school children that took part in the research study voluntarily with parental or legal guardian consents. There are 28 children (27 male, 1 female) in the target group, 8 children age 6-8, 15 age 11-14 and 5 age 10-12.

The criterion for inclusion was an age of above 5 years and under 15 years. The final sample of the group of all participants was planned to encompass at least 50 children (25 tested children in the control group and 25 tested children with a psychiatric ADHD diagnosis).

4.3 Procedure

The test is composed of 100 trials, presented in series on a computer screen. In every trial, 4 similar images were shown on the screen, divided by black borders slightly covering the images (in the shape of a cross). Every trial included eight phases where the borders between images diminish in 7 steps from thick to very narrow. Lastly, in the 8th phase, it is revealed whether the four fragments join into a whole or remain different.

By pressing the “S” key it is meant that the subject believed that the presented fragments are part of a continuous picture, pressing “R”, the person believed that the images are part of four different pictures and pressing “N”, the subject was unsure about the continuity of the presented image fragments.

An exit command was also added to the program in case any participant wanted to stop before finishing the task. In this case, the participant had the option of pressing the “escape” key on the keyboard, which would save their data and immediately leave the program.

4.4 Expected Results

We call the moment during the task when subjects suddenly see and decide that the picture fragments are merging an “aha” experience. We define this moment as the emergence of visual consciousness. The moment when different subjects reach this level of visual consciousness, we predict, should depend on how effectively they process and analyze image fragments. Children diagnosed with ADHD may not be able to integrate the fragments of visual information as effectively as children with normal cognitive control do. Hence, with this task we aim to quantify the execution of visual consciousness.

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