The Columnar Hypothesis for the High-Pass Filter Effect in ASD

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It has been suggested that one of the underlying causes of Autism Spectrum Disorder (ASD) is the presence of a High-Pass Filter Effect applied to cognitive perception (DellAnna, 2018a). Such an effect leads to an enhancement of local details at the expense of global patterns. This paper proposes a possible cause for the High-Pass Filter Effect, which is increased columnar density.
It is already known that brains of people affected with ASD tend to have denser cortical column fields (Casanova, Buxhoeveden, Switala, & Roy, 2002). This paper, however, explains the way in which denser cortical columns fields lead to sharper, narrower categorizations in the intermediate perceptual areas of the cortex, which in turn induce the High-Pass Filter Effect and, consequently, most of the symptoms characteristic of ASD.

Introduction

The brains of the people affected by the Autism Spectrum Disorder (ASD) tend to have denser cortical column fields (Casanova et al., 2002). This paper proposes that denser cortical column fields induce a High-Pass Filter Effect, which in turn produces most of the behaviors commonly associated with ASD, as described in (DellAnna, 2018a) and in (DellAnna, 2018b).

Cortical columns and categorization

Neurons in the cortex are organized in the form of cortical columns, which are also known as minicolumns. Neurons in a column share the same receptive field (the set of inputs), and columns are organized into regions. Furthermore, information in each region of the brain is encoded using sparse distributed representations; only a small percentage of neurons in a region is active at the same time (Hawkins, Ahmad, & Dubinsky, 2011, p. 14), which represents the pattern found in the set of inputs. For example, a set of active neurons might represent a Labrador and would be activated upon recognizing a pattern in the lower cortical area represented by the neurons that are activated after perceiving a fluffy yellow animal, with four paws, a long tail, a big nose, and a smiling face.
Assuming that one is witnessing an object that she/he have already learned about, the perception process takes place as follows: lower sensorial regions get activated based on the inputs received from the optical nerves. Intermediate regions receive the input from the lower regions, recognize a certain pattern that they have observed in the past, and accordingly fire a subset of the neurons that they contain. This subset of activated neurons is the sparse distributed representation of the object being witnessed and is utilized as an input for the higher regions (Hawkins et al., 2011).
Columns in an area create sparse distributed representations of concepts. Moreover, a set of columns activating in two similar but not identical ways are likely to represent semantically close concepts (Hawkins & Ahmad, 2016, p. 10). In many cases, this implies that a given set of columns is responsible for encoding categories. For instance, in a person who is not well versed in art, a painting by Monet and one by Van Gogh might appear to be two instances of the "Impressionist paintings" category; in that person's brain, probably, the set of columns responsible for encoding paintings activates in the same manner on both instances (both times, the pattern formed by the activated columns represents "a painting in the Impressionist category"). Alternatively, in the brain of an art expert, the set of columns responsible for encoding paintings is likely to activate in two different, though similar, ways; once, it activates to represent "a painting in the Monet category" and once to represent "a painting in the Van Gogh category".
It follows the notion that a higher number of columns in a given area allows that area to represent a higher number of more complex categories (Hawkins et al., 2011, p. 14). The brain of people affected with ASD have denser cortical column fields (Casanova et al., 2002); it is then likely that their cortex is structured to divide cognitive concepts over a higher number of categories.

The High-Pass Filter Effect

The High-Pass Filter Effect is one of the causes for ASD (DellAnna, 2018a).
The general definition of a high-pass filter, as taught during electronics or computer science classes, is: "a filter that lets narrow and local changes pass through and blocks broader patterns instead". Such a perceptual filter causes people to better perceive local variations (details) at the expense of

overlooking peripheral features (context). The book "The World Through a Magnifying Glass" explains the reason this propensity to favor local details over peripheral features or contexts gives rise to most of the symptoms of ASD.

Denser cortical column fields cause a High-Pass Filter Effect

The previous two sections reported that the people affected with ASD have denser cortical columns. Moreover, they pointed to the fact that such individuals tend to divide cognitive concepts over a higher number of categories and that the High-Pass Filter Effect causes most of the symptoms of ASD. This section explains the way in which those concepts are connected, that is, the way in which denser cortical columns cause an High-Pass Filter Effect.

With more columns functioning in a region, each column represents more detailed patterns observed in a input (Hawkins et al., 2011, p. 14). This means that even small variations in the input due to noise might lead to a different column getting activated. This, in turn, means that the same real-world object, if noisy, will activate different columns each time, which implies that each column, when active in the representation of a given object, will be activated less number of times. Consequently, rules will be picked up slower. In particular, if our brain predicts the activation of a column but then that column is not activated because of noise, the connections leading to that column (whose activation was predicted) would become weaker, thereby impairing the overall learning (as per Hebbian theory). If this concept is not clear yet, the reader is urged to read the example presented in the following subsection.

The consequence of this phenomenon is that the noisier the field, the more the presence of numerous categories available for classification impairs the learning speed; conversely, the less noisy a field is, the less the presence of numerous categories available for classification impairs the learning speed (in very detailed and non-noisy fields, the learning speed will actually improve). The following example will clarify this phenomenon.

It must be noted that our cortex is quite noise-resistant. I am not saying that denser cortical column fields cause total incapacity pertaining to learning noisy fields; I am only stating that it slows down the process with respect to less denser fields. This can have several cascading effects (DellAnna, 2018b).

Example: learning sequences in noisy fields

To demonstrate the way in which contextual fields appear to be noisy to the people affected with ASD, I will use a thought experiment, using a few sequences of shapes.

Let's imagine that there is a rule in the external world which states that two four-sided pieces in a row are always followed by a circle. For instance, let's imagine the following sequence (the shapes in bold follow the above-stated rule): **rhomboid, square, circle**, triangle, **square, rhomboid, circle**, star, square, star, **trapezoid, square, circle**. Neurotypicals, who have a weaker High-Pass Filter Effect and therefore tend to use less categories, could include rhomboids, squares, and trapezoids (all of which have four sides) in the "squares" category, without recognizing them to be separate sub-categories; their lack of a High-Pass Filter Effect fails to highlight the differences between the different shapes (this is not literally true, of course; it is just an exaggerated metaphor used to illustrate the way in which perception works).

Consequently, Neurotypicals would see the sequence as follows: square, square, circle, triangle, square, square, circle, star, square, star, square, square, circle. It would only take them a few seconds to infer the rule that "two squares in a row are always followed by a circle". Conversely, a person affected with ASD, who puts squares, trapezoids, and rhomboids in separate categories instead, would see the sequence as follows: rhomboid, square, circle, triangle, square, rhomboid, circle, star, square, star, trapezoid, square, circle. It is much harder for him/her to notice the aforementioned rule. However, such individuals might report that they inferred another rule stating that stars are always adjacent to squares. This rule is not a rule in reality, but a product of randomness obtained when generating the sequence; in other words, noise. Noticing the inappropriate level of detail (too much detail in a contextual field) prevents the people on the Spectrum to learn the broad patterns and causes them to learn false, narrower patterns that only represent noise; their learning process is impaired.

It must be noted that if the sequence did not represent a noisy field (where the rule is broad, such as two four-sided pieces in a row are always followed by a circle) but a non-noisy field (where the rule is narrow and specific, such as rhomboids are always followed by a square), then a person with ASD, who employs more detailed categories, would be advantaged with respect to the learning process. This is one of the reasons people with high-functioning ASD are usually quite proficient in learning non-noisy, detailed fields, such as computer science, and fare poorly when it comes to learning noisy contextual fields, such as interpersonal communication.

Conclusions

The fact that the people affected with ASD have denser cortical column fields, which lead to them to classify cognitive objects over more numerous categories, is a candidate to be considered with regard to the causes behind the High-Pass Filter Effect, which produces most of the behaviors commonly found in ASD.

References

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