SUMMIT VIENNA 2015
IS4IS

Extended Abstract

Computational Account of Emotion, an Oxymoron?

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Accepted:

Abstract

In this work we address the belief that cognitive processes such as emotions cannot be modelled computationally. We base our argument on info-computational naturalist approach to cognition, where computation is understood as information processing on several levels of organisation of cognitive agency, and where an agent is defined as an entity capable to act on its own behalf. We also argue that Daniel Kahneman's fast and slow thinking systems can be explained within our model. In doing so we connect information, computation and cognition as a dynamic triangular relationship.

Introduction

We take a broadly naturalist stance toward mental (cognitive) phenomena such as intentionality and allegedly subjective and qualitative aspects pertaining to phenomenal consciousness, in e.g. emotions and sensory experience. Emotions and feelings are occasionally excluded from cognition, and it is often argued that cognitive processes are computational in the way computation is understood as symbol processing, wherefore emotions and feeling cannot be computational phenomena.

We argue that feelings and emotions naturally belong to cognition and even evolutionary precede symbol-manipulating cognition. Furthermore, we draw upon a new understanding of computation known as natural computation or computing nature, which includes both sub-symbolic and symbolic information processing and thus is capable of modelling both sub-symbolic and symbolic cognitive functions.

As Kahneman (2011) argues, we rely greatly in many contexts on our "fast thinking" capabilities that help us manage complex situations quickly. They also help us make first steps in approximations and anticipations. Fast thinking processes are very much based on experience, and thus memory, both evolutionary (built into the morphology of an organism) and developmentally. We propose, as implied by Strannegård et al. (2012), that Kahneman's systems 1 and 2 correspond roughly to sub-symbolic and symbolic cognition, respectively.

Naturalism and its Critique

Our computational approach can be described as naturalist computationalism, as expounded upon by Dodig-Crnkovic (2014). One typical criticism against naturalistic theories of mind is the claim that naturalism identifies the mind with the physical body. The important distinction that this claim fails to make is that *mind is a process and not an object*.
Yet, like running presupposes the existence of a physical body, the mind cannot be decoupled from the body. We argue that a specific physical substrate such as the embodied brain is both necessary and sufficient to explain the natural occurrence of mind. The mind-body distinction was succinctly expressed by Minsky (1988): *minds are what brains do*.

What we claim is that mind as a process can be adequately modelled as computation, specifically *natural computation.* When it comes to critique of computational approaches to mind, there are frequent claims that symbol manipulation, neural networks and dynamical models are all mutually exclusive. Fresco (2014) shows, however, that this criticism is unfounded. All three approaches are applicable, albeit in different domains, levels of organisation, and aspects of cognition.

Problem with Qualia

As a further problem of naturalism (which is often wrongly considered to be identical with physicalism, a stronger stance than naturalism) is often invoked its supposed incapability to account for ”the existence of qualia” and ”the nature of intentionality”.

We agree with Dennett (1996) that qualia are by no means the hard problem of consciousness, but a simple feature of a natural organism. The fact that each of us have our own subjective feeling of pain or joy is not unlike the fact that each of us have our own handwriting. Even though handwriting is not identical with a hand (or a pen!), it is a result of coordinated processes between our hand (keeping a pen), arm, and the rest of the body providing the right posture. Furthermore, senses (with sensors + actuators) such as vision and touch, together with the whole visual process are included via nerves transmitting and partly processing information. The brain, containing memories of previously experienced writing, is integrating information, processing it and making decisions that are further propagated towards the body, arm, hand, fingers, pen… Handwriting as an artefact, then, is a result of information processing in many parts of our body. Moreover, this process proceeds on many levels of organisation – from the molecular (although this level is typically not considered to be computational, we identify molecular processes with natural computation), to the cellular level and up to organs and the organism as a whole Dodig-Crnkovic (2014, 2013). Organisms are themselves part of a distributed cognitive system that provides a social framework from which the rules of the alphabet and other conventions about writing come.

In short, handwriting is not a hand, and in the same way, cognition is not a brain. Qualia just reflect the fact that each human being is a unique human being. The difference in qualia between individuals might be relatively big, as it is in the case of handwriting, but we are capable of communicating our subjective feelings to others who have no problems to interpret them. Even though one person's experience of colour is probably not identical with any other person's, neither are two persons' bodies identical, and we do not find that fact particularly difficult to understand.

Cognition as Computational Process

The aim of this naturalisation project is to understand cognition, including feeling and emotion, in terms of computational processes, from the molecular level up. In a way, it is a modern kind of reductionism, a new kind of *generative reduction* where we do not reduce an object to some smaller more fundamental objects (as physics reduces macroscopic bodies into atoms and even smaller elementary particles down to strings). We are proposing to reduce complex processes to interactions of simpler processes that undergo phase transitions (as observed in nature) – from the level of molecules and their networks to cells and aggregates of cells such as organisms and their networks (Dodig-Crnkovic, 2014). In that way, cognitive processes can be modelled as emerging on different levels of scale in living organisms. The aim, then, is to be able to model cognitive processes and behaviours of different classes of agents based on an understanding of the underlying chemical processes that form biological processes that exhibit cognitive behaviour.

The reductionist project in physics led to the reduction of macroscopic properties of (ideal) gases such as pressure or temperature to the kinematic behaviour of gas molecules. In kinematic theory an ideal gas is modelled as random motion of large numbers of atoms or molecules. However, the important difference between an ideal gas and a living organism is *in the complexity of their structures and interactions*. Unlike an ideal gas, where identical molecules are assumed to move completely randomly, a living organism is highly heterogeneous and quasi-regularly organised with a very complex unit – the cell – as a basis of each organism's organisation. Each cell consists of thousands of different types of parts which form compounds, that later on dissolve in a complex dynamical process. Understanding of an organism's behaviour, even on a cellular level, is a goal we are still far from. However, with present-day research methods and modelling tools (in the first place computational tools) we see that we in the near future will have simulation tools capable of modelling the behaviour of a living organism in increasingly more realistic ways. Starting from the simplest forms of cognition in the living cell we can increase our understanding of the underlying mechanisms that cognition in more complex organisms is based on.

We propose a constructive step in the improvement of our understanding of mental, or better, *cognitive* (as cognitive science has a clear naturalistic and scientific orientation) phenomena, that would connect observed macroscopic behaviour and processes with their complex and layered bio-chemical basis. This project will not reduce feeling to a molecule but will *connect the observed cognitive process with its biochemical generative basis.*

Computational Account of Emotions and Kahneman

The computational theory of mind has been criticised for not providing a satisfactory explanation of emotion. We argue that, on the contrary, computational theories not only explain how emotion arises, but furthermore makes a strong case for the evolutionary advantage of emotion (von Haugwitz et al., 2012). Neuroscience has, over the decades since its foundation, been elucidating the biochemical basis of emotion in the brain, and the physiological effects of various neurotransmitters are increasingly well understood. The neurotransmitters mostly associated with emotion have also been shown to regulate learning in humans by providing an intrinsic reward system, modulating exploration, balancing long- and short-term planning as well as controlling the learning rate (Doya, 2002, 2008). The capability to dynamically modulate these parameters is beneficial in non-stationary environments such as the real world, and an algorithm is proposed by Schweighofer and Doya (2003). A computational model, in terms of the utility function of the organism, for how emotions are generated can be derived from appraisal theory, which suggests that (at least a large class of) emotions arise as a result of the organism's appraisal of a situation, rather than as a function of the situation itself (Marinier and Laird, 2009). We thus have a theory of implementation, evolutionary and mathematical motivation and a generative computational description of emotion.

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