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Resolving some confusions over attention and consciousness

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Abstract

There is presently an ongoing debate about the relation between attention and consciousness. Thus debate is being fuelled by results from experimental paradigms which probe various forms of the interaction between attention and consciousness, such as the attentional blink, object-substitution masking and change blindness. We present here simulations of these three paradigms which can all be produced from a single overarching control model of attention. This model helps to suggest an explanation of consciousness as created through attention, and helps to explore the complex nature of attention. It indicates how it is possible to accommodate the relevant experimental results without needing to regard consciousness and attention as independent processes.

Keywords: Attentional blink; Object substitution; Change blindness

1. Introduction

The debate is intensifying between those who believe that attention is necessary (but not sufficient) for consciousness (James, 1890; Mack & Rock, 1998) and those who regard these two brain processes as independent (Koch & Tsuchiya, 2006; Lamme, 2003, 2006; Pollen, 2003). The debate presently is based on arguments of the latter protagonists, who assume that attention and consciousness are simple processes. However neither of the processes is likely to be simple. The complexity of attention is indicated by the subtle nature of priming and masking effects, and by a variety of deficits in attention such as neglect and extinction, as well as for the fact that there are both exogenous and endogenous varieties of attention as well as attention focussed on sensory input or motor response modes. The complexity of consciousness arises form the wealth of different states of consciousness: in the normal waking state, under various drugs, in meditation (such as in the so-called pure consciousness), in dreaming, hypnosis, dissociation of identity disorder, and so on.

In order to advance the debate, we explore more fully some of these complex features of attention by use of a recent model providing a deconstruction of attention, and thence of consciousness (Taylor, 2000, 2002a, 2002b, 2003, 2005, 2006, 2007). The model extends to attention the recently successful applications of engineering control concepts to motor control (Desmurget & Grafton, 2000; Sabes, 2000; Wolpert & Ghahramani, 2000). Thus module acting as inverse model controllers and forward models are extended from the motor control domain to attention control. Considerable support has been given for this engineering control approach to attention from recent brain imaging results (Corbetta & Shulman, 2002; Corbetta et al., 2005; Kanwisher & Wojciulik, 2000).

The proposed attention control model uses an efference copy or corollary discharge of the attention movement control signal to provide a precursor signal to the posterior cortical sensory working memory buffer site for the creation of content consciousness. This precursor signal has been proposed (Taylor, 2000, 2002a, 2002b, 2003, 2005, 2006, 2007) as that generating the experience of ownership or of 'being there' (Nagel, 1974) and of leading to the important property of 'immunity to error through misidentification of the first person pronoun' (Shoemaker, 1968). That is why the resulting model is called the COrollary Discharge of Attention Movement Signal, or CODAM for short. This suggestion also allows for the beginnings of rapprochement between science and religion through the explanation, by CODAM, of the meditative state of pure consciousness, seen by many to be at the basis of the religious experience of God across all the world's major religions (Taylor, 2002a, 2002b, 2006). The CODAM model is

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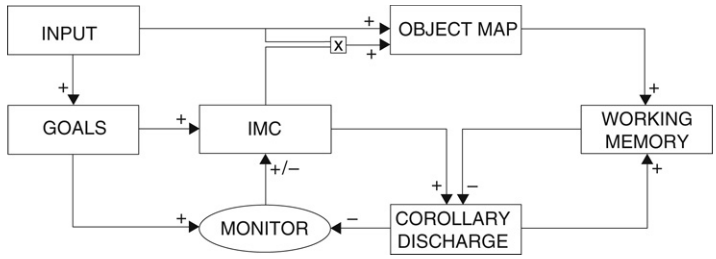

Fig. 1. The CODAM architecture.

applied in this paper to give detailed explanations of the results of the various paradigms being used in the argument about the relation between attention and consciousness.

In the next section an outline of the CODAM model is presented for completeness. It is followed by a description of how the model has been applied to the attentional blink, one of the paradigms at issue, as well as relating it more specifically to recent data (Sergent, Baillet, & Dehaene, 2005). In Section 4 we show how a CODAM-based model can be used to explain object-substitution data of relevance to the argument. Following that in Section 5 we describe how the model can give an attention-based quantitative explanation of some data on change blindness. In Section 6 there is a brief discussion how some recent data on visual object detection in a dual task condition and some motor response data can also be reconciled with an attention-based explanation. The final section as a conclusion, which can be summarised as that consciousness is still best understood as arising through attention paid to a stimulus.

The simulations presented in Sections 3–5 use the CODAM architecture, with the modifications as stated under the various sections. The equations describing the details of the CODAM model are as stated in Fragopanagos, Kockelkoren, and Taylor (2005); there are obvious modifications to these arisings in the specific simulations of Sections 3–5, such as addition of extra inhibition in Section 3, etc.

2. The CODAM model

The basic architecture of the model is shown in Fig. 1.

The figure shows the modules of the CODAM model of attention control, based on engineering control mechanisms. Visual input, for example, enters at the INPUT module and is sent, through a hierarchy of visual processing modules, to activate the object map module, OBJECT MAP. At the same time in the exogenous case it rapidly accesses the GOAL module, so causing bias to be sent to the inverse model controller denoted IMC in the figure (the generator of the signal to move the focus of attention). This sends a modulatory feedback signal to the object map, of multiplicative or additive form, to amplify the requisite target activity entering the object map. As the attention feedback signal is created by the IMC – the inverse model controller, as generator of the attention movement control signal – a corollary discharge of this signal is sent to the MONITOR module, acting as a buffer for the corollary discharge signal (the main output of IMC is destined to amplify activity in lower level cortical regions). This can then be used both to support the target activity form the object map accessing its sensory buffer, the WORKING MEMORY module, and to be compared with the requisite goal from the GOAL module. The resulting error signal from the monitor module is then used to enhance the IMC attention movement signal and so help to speed up access as well as to reduce the activities of possible distracters.

The modules present arise as observed by brain imaging paradigms (Corbetta & Shulman, 2002; Corbetta et al., 2005; Kanwisher & Wojciulik, 2000), plus an extension by use of engineering control models to include an efference copy buffer. CODAM extends thereby numerous models of attention control, especially that of 'biased competition' of Desimone and Duncan (1995) and the more neurally based models of Deco and Rolls (2005), Hamker and Zirnsak (2006), Mozer and Sitton (1998). These models can be seen to be based on ballistic control, rather than the more efficient and sophisticated control by means of forward models and error correctors. The modules in CODAM in figure one are explained more fully in the figure caption.

Event related potentials (ERPs) arise from the interactive processing of input up and down the hierarchy of modules in Fig. 1, with a stimulus entering low-level sensory cortex and attempting to reach its relevant sensory buffer (working memory). This is aided or inhibited by the corollary discharge signal (biased by a goal) so as to allow buffer access to a target stimulus and prevent that access to any distracters. As seen from Fragopanagos et al. (2005) these ERP signals give a description both of activity at the various sites as processing time proceeds as well as how the various sites interact through either excitatory or inhibitory feedforward or feedback effects (as observed by the cortical layer in which the activation commences (Mehta, Ulbert, & Schroeder, 2000). Such interactions are enhanced when a number of stimuli are present in a short period, when the excitatory discharge signal is seen to enhance the growth of the sensory buffer signal or the inhibition form the sensory buffer inhibits further processing in the attention movement signal generation module. These interaction are now being observed in the attention blink paradigm (Sergent et al., 2005), as discussed in the next section.

Other attention phenomena that can be explained in terms of reduced versions of the CODAM mode are: the Posner attention paradigm (Taylor & Rogers, 2002), working memory rehearsal (Korsten, Fragopanagos, Hartley, Taylor, & Taylor, 2006) and the N2pc as well as numerous other attention tasks as demonstrated by the modelling through the other models mentioned earlier, as regarded as simpler versions of CODAM.