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Habituation of the orienting reflex and the development of Preliminary Process Theory

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ABSTRACT

The orienting reflex (OR), elicited by an innocuous stimulus, can be regarded as a model of the organism's interaction with its environment, and has been described as the unit of attentional processing. A major determinant of the OR is the novelty of the eliciting stimulus, generally operationalised in terms of its reduction with stimulus repetition, the effects of which are commonly described in habituation terms. This paper provides an overview of a research programme, spanning more than 30 years, investigating psychophysiological aspects of the OR in humans. The major complication in this research is that the numerous physiological measures used as dependent variables in the OR context fail to jointly covary with stimulus parameters. This has led to the development of the Preliminary Process Theory (PPT) of the OR to accommodate the complexity of the observed stimulus–response patterns. PPT is largely grounded in autonomic measures, and current work is attempting to integrate electroencephalographic measures, particularly components in the event-related brain potentials reflecting aspects of stimulus processing. The emphasis in the current presentation is on the use of the defining criteria of the habituation phenomenon, and Groves and Thompson's Dual-process Theory, in the development of PPT.

1. Introduction

The orienting reflex (OR) was originally described by Pavlov in 1910 (see Pavlov, 1927) as the "*What is that*?" reflex, and investigated for its importance in understanding conditioning phenomena. Initially conceptualised in behavioural terms (turning or orienting of the organism towards a novel stimulus), its study subsequently received new impetus from the publication in the West of Sokolov's innovative work (Sokolov, 1960, 1963a, 1963b). These publications provided workers in psychology and physiology with a mass of innovative data and a new integrative perspective, bridging from behaviour to physiology. In these works, Sokolov identified the OR as the major unit of perceptual functioning, reflexively directing the organism's attention to the important events in the environment, and provided descriptions of its physiological correlates. The implicit suggestion that the OR could serve as a model of the individual's interaction with the environment formed the cornerstone of a major research and development theme in the then-emerging discipline of psychophysiology.

Sokolov considered the OR as a whole-of-body reflex, involving particular changes in a large range of physiological systems, for example, the pupil of the eye, electrodermal (sweat gland) activity, respiration, vascular changes such as vasoconstriction in peripheral arteries and vasodilation in blood vessels close to the brain, and changes in electroencephalographic (EEG) alpha (8–13 Hz) activity recorded from the scalp. Sokolov made two important generalisations regarding the OR. First, in regard to its eliciting conditions, where Pavlov's OR work referred to a reflex sensitive to the slightest change in environmental conditions, Sokolov restricted this to changes of an *innocuous* stimulus. He described high intensity (near-painful) stimuli as eliciting a separate class of response—the defence reflex (DR). This DR complex differs in response components from the OR—for example, cephalic *vasoconstriction* is associated with the DR, contrasting with the cephalic *vasodilation* of the OR. Second, he referred to this complex system as a unitary phenomenon, always using the OR label in a singular sense—"*the* OR".

In his reports on the relationship between properties of the eliciting stimulus and the OR, Sokolov noted that repetition of a novel innocuous stimulus resulted in response decrement or habituation, usually apparent over a dozen or so repetitions. Also, within the innocuous stimulus intensity range, Sokolov described a linear relation between OR magnitude and stimulus intensity, apart from non-linear enhancements at near-threshold levels.

2. Some early contradictory results

Testing of Sokolov's core OR characteristics required a parametric approach, using initially novel innocuous stimuli of a range of moderate intensities to explore intensity effects, and with repeated

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presentations to explore habituation. Exploration of the unitary aspect can only be done by using a range of measures, preferably directly based in Sokolov's work. The bulk of such studies, as with all the work reported here, used human subjects.

Intensity and trials effects from subjects presented with cycles of 1000 Hz auditory tones at 20, 30, 40 and 50 dB sound pressure level (SPL) were examined by Barry (1977a). Tones were presented with a long variable interstimulus interval (ISI), and each subject received 8 cycles in a continuous sequence to explore habituation. As dependent measures, 5 phasic variables used by Sokolov (the electrodermal skin conductance response [SCR], pause in respiration [RESP], peripheral vasoconstriction in the fingers [PVC], cephalic vasodilation in the temporal area [CVD], and EEG alpha band desynchronisation [α-D]), and one additional measure (the evoked cardiac response of heart-rate (HR) deceleration [ECR1]), were examined at each stimulus presentation. The first presented stimulus produced brief phasic responses in all these systems: increased sweat gland activity reflected in the SCR, a slowing of respiration, PVC, CVD, α-D, and HR deceleration. But beyond this initial response, differences in stimulus parameters produced response patterns differing between the measures. There were linear effects of intensity in the SCR and PVC measures. There was response decrement with repetition in SCR, RESP, and α-D. Phasic responses in two other variables, ECR1 and CVD, showed no variation with stimulus parameters, occurring unchanged across all stimuli. That is, across the 6 measures, 4 patterns over the two independent variables were apparent. Only 1 measure showed the effects of intensity and trials expected from Sokolov's work: the SCR. One showed intensity but not trials effects (PVC). Two showed trials but not intensity effects (RESP and α-D). Two showed neither trials nor intensity effects (ECR1 and CVD). This pattern of response fractionation was confirmed in subsequent studies (Barry, 1977b, 1978, 1979), with remarkable stability.

This 4-fold patterning was demonstrated in a study which extended from the previous auditory results into the visual modality, and explored the nature of stimulus repetition effects in a dishabituation paradigm (Barry & James, 1981a). Thompson and Spencer (1966) provided a list of criteria useful in identifying response decrement to stimulus repetition as habituation, a reversible process, rather than relatively irreversible processes such as fatigue or a neuronal refractory cycle phenomenon. The core defining attributes of habituation in the OR context are response decrement to repetition of an innocuous stimulus, response recovery to the presentation of a novel innocuous stimulus, and enhanced responding (or dishabituation) to re-presentation of the original stimulus. In Barry and James (1981a), subjects received a series of 10 visual stimuli (white squares on a black background), followed by 1 stimulus of different size, and then 5 of the original size. Alternate subjects began with large or small squares, and received the other size as the change stimulus. Elicitation of the OR in this paradigm was expected to be marked by within-subject evidence of habituation: a large initial response followed by response decrement over the first 10 stimulus presentations, response recovery to the change stimulus, and enhanced responding (dishabituation) to the subsequent re-presentations of the initial stimulus. The between-subjects manipulation of stimulus magnitude over the initial stimulus sequence was expected to be apparent in larger responses to the larger stimuli. However, rather than all the measures demonstrating that predicted habituation and stimulus–magnitude pattern, four different patterns were observed, illustrated schematically in Fig. 1.

The reliability of this 4-fold patterning of response fractionation, sharply disconfirming Sokolov's unitary OR generalisation, led to the formulation of alternative accounts of stimulus–response patterning in the OR context, eventually developing into what is now known as Preliminary Process Theory (PPT), the core elements

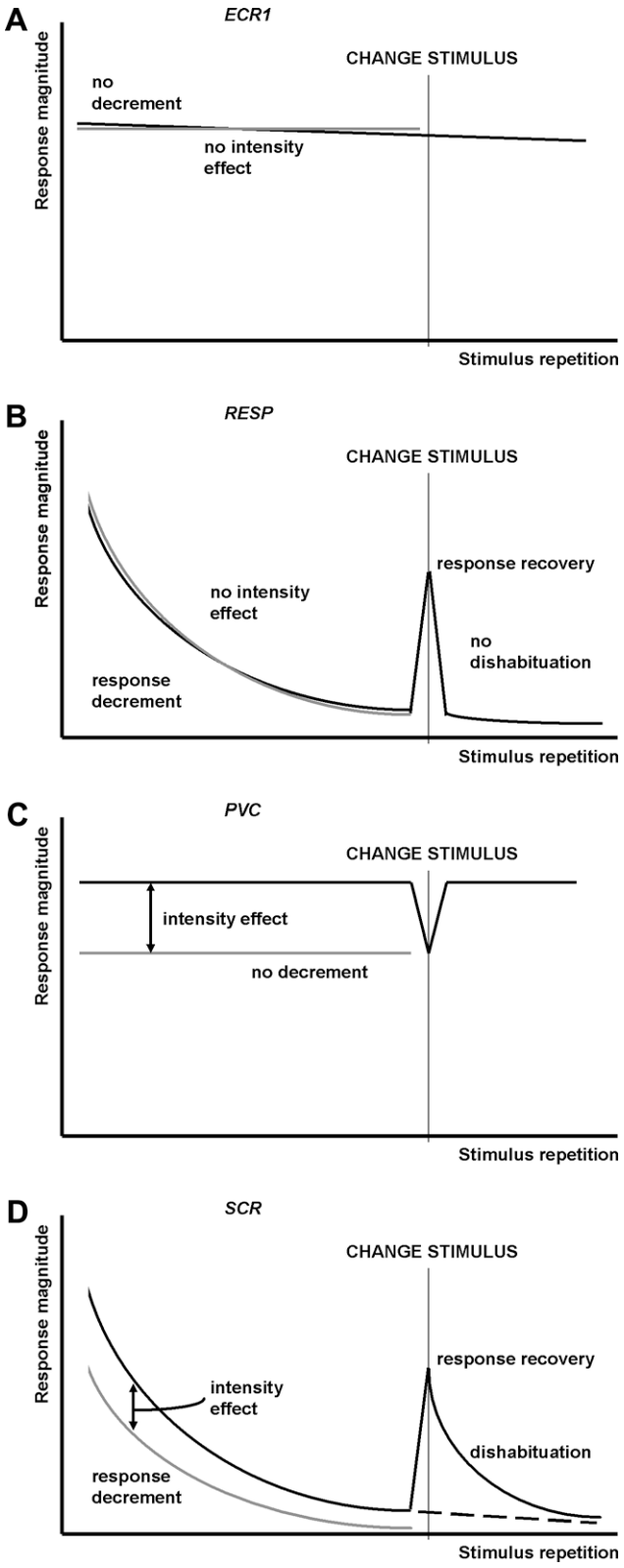

Fig. 1. A schematic representation of the four different stimulus–response patterns demonstrated in Barry and James (1981a). Response amplitudes for heart-rate deceleration (ECR1), respiratory pause (RESP), peripheral vasoconstriction (PVC), and the skin conductance response (SCR), are shown as functions of stimulus repetition, for 10 presentations of one stimulus followed by a different stimulus (change), and 5 re-presentations of the first stimulus. For clarity, stimulus–intensity effects are shown only over the initial habituation portion of the pattern. Only the SCR (panel D) showed the stimulus repetition and intensity effects expected of the OR.