EXPICIT AND IMPLICIT PROCESSES IN HUMAN AVERSIVE CONDITIONING

Thesis by

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For my family

new or old

blood or bond

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Abstract

The ability to adapt to a changing environment is central to an organism's success. The process of associating two stimuli (as in associative conditioning) requires very little in the way of neural machinery. In fact, organisms with only a few hundred neurons show conditioning that is specific to an associated cue. This type of learning is commonly referred to as implicit learning. The learning can be performed in the absence of the subject's ability to describe it. One example of learning that is thought to be implicit is *delay conditioning*. Delay conditioning consists of a single cue (a tone, for example) that starts before, and then overlaps with, an outcome (like a pain stimulus).

In addition to associating sensory cues, humans routinely link abstract concepts with an outcome. This more complex learning is often described as explicit since subjects are able to describe the link between the stimulus and outcome. An example of conditioning that requires this type of knowledge is *trace conditioning*. Trace conditioning includes a separation of a few seconds between the cue and outcome. Explicit learning is often proposed to involve a separate system, but the degree of separation between implicit associations and explicit learning is still debated.

We describe aversive conditioning experiments in human subjects used to study the degree of interaction that takes place between explicit and implicit systems. We do this in three ways. First, if a higher order task (in this case a working memory task) is performed during conditioning, it reduces not only explicit learning but also implicit learning. Second, we describe the area of the brain involved in explicit learning during conditioning and confirm that it is active during both trace and delay conditioning. Third, using functional magnetic resonance imaging (fMRI), we describe hemodynamic activity changes in perceptual areas of the brain that occur during delay conditioning and persist after the learned association has faded.

From these studies, we conclude that there is a strong interaction between explicit and implicit learning systems, with one often directly changing the function of the other.

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Abbreviations

ACC	Anterior Cingulate Cortex
BOLD	Blood Oxygenation Level Dependent
CS	conditioned stimulus
CS+	the conditioned stimulus sometimes followed by a US
CS-	the conditioned stimulus never followed by a US
DLPFC	Dorsal Lateral Prefrontal Cortex
FFA	Fusiform Face Area
fMRI	functional Magnetic Resonance Imaging
FWE	Family Wise Error
FWHM	Full Width at Half Maximum.
GP	Globus Pallidus
GSR	Galvanic Skin Response
Ins.	Insula
IPL	Inferior Parietal Lobule
IPS	Inferior Parietal Sulcus
MFG	Middle Frontal Gyrus
MRI	Magnetic Resonance Imaging
Operc.	Operculum
PFC	Prefrontal Cortex
ROI	Region of Interest
S	Siemen (as in micro Siemen or nano Siemen)
SC	Superior Colliculus
SCR	Skin Conductance Response
SPM	Statistical Parametric Map
STS	Superior Temporal Sulcus
SVC	Small Volume Correction