

EXPLICIT AND IMPLICIT PROCESSES IN HUMAN AVERSIVE CONDITIONING

Thesis by

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In Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

California Institute of Technology

Pasadena, California

2006

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For my family

new or old

blood or bond

Acknowledgements

It seems unfair that I receive a degree for the work that many have done. To all of you, I can only hope I have helped you, or can help, in return. Research grinds to a halt without funding to keep it moving. I would like to thank the following for their sponsorship:

Sandia National Labs, the David and Lucile Packard Foundation, the Gordon and Betty Moore Foundation, the Keck Foundation, the National Institutes of Health, the National Institutes of Mental Health, the National Science Foundation (and ERC), the Wellcome Trust and the William T. Gimbel Discovery Fund in Neuroscience at Caltech

All of my collaborators were both great scientists and enjoyable colleagues. I would like to thank all of you. Nao and Connie spent time on the early conditioning work, transforming its direction. Conferences would not have been the same without you. Ben Seymour was the king of pain and scotch eggs at the FIL. The study of trace and delay conditioning was made a great deal more entertaining with him and John O'Doherty in the control room. I also thank the rest of the FIL for their endless help and discussion. For those who have the opportunity, the FIL is a great place to live and work. Brian Cleary for his time spent thinking about functional DTI, a project that I hope will be continued. Thanks to Tony Bruguiere for a great deal of time spent scratching our heads over noise in an MRI environment. Beena, Kats, and Romi all deserve thanks for introducing me to psychophysics and for a great project not included in this thesis (Khurana et al., 2006). I would like to thank the members of the Conscious Mouse Club for thought provoking discussion at meetings well after most have gone home.

Members of the Caltech Biological Imaging Center were excellent in their efficiency and assistance. The always knowledgeable Mike Tyszka and Steve Flaherty

helped make both skin conductance recording during fMRI and the rapid acquisition of DTI images possible. Nothing would be accomplished at the CBIC without Mary Munoz.

There are a number of professors who had to suffer my harassment and sometimes serve on my committees. They have all provided valuable input and I am glad to have spent time interacting with them, thank you. Ralph Adolphs, John Allman, David Anderson, Michael Fanselow and Shinsuke Shimojo all had the thankless task of serving on my committees. Ray Dolan was my host at the FIL for two projects. I rotated in Gilles Laurent's lab and still consider his lab to be one of the best at Caltech. Henry Lester was part of the Conscious Mouse Club and was a tireless advocate of clarity in presentation.

John O'Doherty deserves special thanks for introducing me to SPM and MRI as well as The Queen's Larder. I would still be lost in colored blobs had it not been for his capable direction. You have been a great friend, and I wish you even greater success here at Caltech.

I would like to thank my advisor Christof Koch. The time spent analyzing, climbing, debating, driving, running, talking and writing have all been valuable to me. You have served as a model for both academics and attitude. I thank you for your guidance and friendship. I also thank you for providing opportunities that have greatly enriched my stay at Caltech.

My interest in research was started by John Roth at the University of Utah. He has a talent for puzzles and communication that make his work very unique. He focused time and effort on each project in his lab on an almost daily basis without micromanaging, an extremely rare skill. I am very grateful for my time in your lab.

Finally, I would like to thank those who made it possible to be happy at Caltech. My family, for they are who define me and nothing is possible without them. Thanks to Klab, my doctoral family. I thank all of my friends at Caltech. I had only met a few rare individuals who were as interesting, intelligent, and educated as the whole pack I met here. Foremost among them is my fiancé Karli Watson, who continues to baffle me to this very day (and I hope she always will).

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