THE INITIATION OF BINOCULAR RIVALRY

David Fengming Li

A thesis submitted in partial fulfilment of the requirements

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The University of Sydney

The University of Sydney
Faculty of Health Sciences
School of Biomedical Sciences

DECLARATION

The work presented in this thesis is the original work of the author except as acknowledged in the text. I hereby declare that I have not submitted this material either in whole or in part for any other degree at this or any other institution. Publications arising from this work are listed in Chapter 10.

David Fengming Li

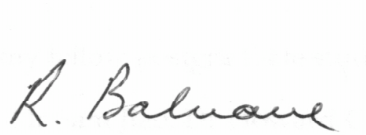
23/03/2006

Date

The University of Sydney
Faculty of Health Sciences
School of Biomedical Sciences

SUPERVISOR'S CERTIFICATE

This is to certify that this thesis, entitled *The Initiation of Binocular Rivalry*, submitted by David Fengming Li in partial fulfilment of the requirements for the degree of Doctor of Philosophy, is ready for examination.

Supervisor	Associate supervisor
	
Dr Alan Freeman	Dr Ron Balnave
School of Biomedical Sciences	School of Biomedical Sciences
24/3/06	23/3/2006
Date	Date

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CONTENTS

ABSTRACT

Binocular rivalry refers to the perceptual alternation that occurs when the two eyes are presented with incompatible images: when one monocular image is dominant, the other is suppressed. Rivalry has been closely studied but the neural site at which it is initiated is still controversial. The central claim of this thesis is that primary visual cortex is responsible for its initiation. This claim is supported by evidence from four experimental studies.

The first study (described in Chapter 4) introduces the methodology for measuring visual sensitivity during dominance and suppression and compares several methods to see which yields the greatest difference between these two sensitivities. Suppression depth was measured by comparing the discrimination thresholds to a brief test stimulus delivered during dominance and suppression phases. The deepest suppression was achieved after a learning period, with the test stimulus presented for 105 ms, and through the use of post-test masking.

The second study (Chapter 5) compares two hypotheses for the mechanism of binocular rivalry. Under the *eye suppression* hypothesis, visibility decreases when the tested eye is suppressed, regardless of the test stimulus features. *Feature suppression*, however, predicts that reduction of visibility is caused by suppression of a stimulus feature, regardless of the eye to which the feature is presented. Eye suppression claims that monocular channels in the visual system alternate between dominance and suppression, while feature suppression assumes that the inhibition is between feature detectors in higher cortex. The experiment used a test stimulus similar in features to one, but not the other, rivalry-inducing stimulus. Test sensitivity was found to be lowered when the test stimulus was presented to the eye whose rivalry-inducing stimulus was suppressed. Sensitivity was not lowered when the test stimulus was presented to the other eye, even

when the test shared features with the suppressed stimulus. The conclusion is that feature suppression is weak or does not exist without eye suppression, and that rivalry therefore originates in the primary visual cortex.

If binocular rivalry is initiated in the primary visual cortex, stimuli producing no coherent activity in that area should produce no rivalry. In the third study (Chapter 6) this idea was tested with rotating arrays of short-lifetime dots. The dots with the shortest lifetime produced an image with no rotation signal, and an infinite lifetime produced rigid rotation. Subjects could discriminate the rotation direction with high accuracy at all but the shortest lifetime. When the two eyes were presented with opposite directions of rotation, there was binocular rivalry only at the longest lifetimes. Stimuli with short lifetimes produce a coherent motion signal, since their direction can be discriminated, but do not produce rivalry. A simple interpretation of this observation is that binocular rivalry is initiated at a level in the visual hierarchy below that which supports the motion signal.

The model supported by the results of the previous chapters requires that binocular rivalry suppression be small in the primary visual cortex, and builds up as signals progress along the visual pathway. Along with the existing physiological evidence, this model predicts that for judgements dependent on activity in high visual cortex: 1. Binocular rivalry suppression should be deep; 2. Responses should be contrast invariant. The fourth and last study (Chapter 7) confirmed these predictions by measuring binocular rivalry suppression depth in two ways. First, two similar forms were briefly presented to one eye: the difference in shapes required for their discrimination was substantially greater during suppression than during dominance. Second, the two forms were made sufficiently different in shape to allow easy discrimination at high contrast, and the contrast of these forms was lowered to find the discrimination threshold. The

results in the second experiment showed that contrast sensitivity did not differ between the suppression and dominance states. This invariance in contrast sensitivity is interpreted in terms of steep contrast-response functions in cortex beyond the primary visual area.

The work in this thesis supports the idea that binocular rivalry is a process distributed along the visual pathway. More importantly, the results provide several lines of evidence that binocular rivalry is initiated in primary visual cortex.