

RESPONSE OF THE HUMAN JAW TO MECHANICAL STIMULATION OF TEETH

A thesis submitted

for the degree of

DOCTOR OF PHILOSOPHY



by

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“...you realise the sun doesn't go down it's an illusion caused by the world spinning 'round...”

'Do You Realise??' The Flaming Lips, 2002

For Isabella,

Question everything, as even the most routine observations can have extraordinary answers.

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1. ABSTRACT

Animal experiments indicate that the main form of feedback for jaw-closing muscles is from periodontal mechanoreceptors (PMRs). However, due primarily to limitations on methods, this is yet to be confirmed in humans. The main aim of this thesis was to investigate the reflex contribution of PMRs to the human jaws using vertical (axial) stimulation. To this end the electromyographic and bite force responses of the jaw to a number of different mechanical stimulus conditions, delivered to both the upper central incisors and the upper right first molars, were investigated.

The principal hypothesis was that PMRs are responsible for the majority of the reflex responses seen in the human jaw muscles. Furthermore this reflex response is modulated by different characteristics of the stimulus such as: rate of rise, maximum force applied, the amount of constant offset force (preload), the level of muscle contraction and also the physical characteristics of the subject's jaw including: dental health and tooth spacing.

These studies have contributed towards the understanding of the neuronal wiring and the receptor systems contained in the jaw. The results indicate that PMRs around the incisors are of fundamental importance for the development of reflex patterns but little if any PMR related reflexes exist around the molar teeth. The reflexes originating from the PMRs around the incisors are modulated by different mechanical characteristics of the stimulus, thus helping to explain how the jaw muscles perform numerous and complex patterns of activation which move the jaw in many different ways and develop forces that are optimum for the task at hand.

2. DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution, and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed:

Date:

3. PUBLICATIONS

The following is a list of peer reviewed journal publications arising from this thesis to date.

Brinkworth R.S.A. & Türker K.S. (2003). A method for quantifying reflex responses from intra-muscular and surface electromyogram. **Journal of Neuroscience Methods** 122(2): 179-193.

Brinkworth R.S.A., Türker K.S. & Savundra A.W. (2003). Response of human jaw muscles to axial stimulation of the incisor. **Journal of Physiology** 547(1): 233-245.

Brinkworth R.S.A., Türker K.S. & Male C. (2004). Response of human jaw to axial stimulation of a molar tooth. **Experimental Brain Research** 159 (2): 214-224.

Brinkworth R.S.A. & Türker K.S. (2004). EMG, force and discharge rate analysis of human jaw reflexes in response to axial stimulation of the incisor. **Experimental Brain Research** In Press: Acceptance Date 20th May 2004.

Türker K.S., Brinkworth R.S.A., Abolfathi P. P., Linke I. R. & Nazeran H. (2004). A device for investigating the neuromuscular control of the human masticatory system. **Journal of Neuroscience Methods** 136(2): 141-149.

Possible future publications arising from this thesis include:

Brinkworth R.S.A. & Türker K.S. Jaw movement alters the reaction of human jaw muscles to incisor stimulation.

Brinkworth R.S.A. Labview based application for recording and analysis of human movement experiments.

Brinkworth R.S.A. A review of mechanically evoked reflexes in the jaw.

Previous publications:

Brinkworth, R.S.A., Whitham, E. & Nazeran, H. (2004) Establishment Of Paediatric Biochemical Reference Intervals. **Annals of Clinical Biochemistry** 41(4): 321-329.

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As with all modern scientific work it was impossible to perform such high quality work without a large team of collaborators. I would like to thank each of them and highlight the various contributions they have made to each section.

Chapter 6: A Method For Quantifying Reflex Responses From Intra-Muscular And Surface Electromyogram

Published: The Journal Of Neuroscience Methods, 2003, Volume 122, Issue 2, Pages 179-193

Original Concepts	Russell S.A. Brinkworth Kemal S. Türker
Experimental Design	Russell S.A. Brinkworth
Experiments	Russell S.A. Brinkworth
Data Analysis	Russell S.A. Brinkworth
Manuscript Writing	Russell S.A. Brinkworth
Manuscript Editing	Kemal S. Türker
Incorporating Reviewers Changes	Russell S.A. Brinkworth

Chapter 7: Response Of Human Jaw Muscles To Axial Stimulation Of An Incisor Tooth

Published: The Journal Of Physiology, 2003, Volume 547, Issue 1, Pages 233-245

Original Concepts	Kemal S. Türker Wayne Sampson
Experimental Design	Kemal S. Türker Russell S.A. Brinkworth Andrew W. Savundra
Equipment Design and Construction Experiments	Ian Linke Russell S.A. Brinkworth Andrew W. Savundra Purdie L.M. Yeo
Data Analysis	Russell S.A. Brinkworth
Manuscript Writing	Russell S.A. Brinkworth
Manuscript Editing	Kemal S. Türker Andrew W. Savundra
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Chapter 8: Response Of Human Jaw Muscles To Axial Stimulation Of A Molar Tooth

Published: Experimental Brain Research, 2004, Volume 159, Issue 2, Pages 214-224

Original Concepts	Kemal S. Türker Russell S.A. Brinkworth
Experimental Design	Kemal S. Türker Russell S.A. Brinkworth Courtney Male
Equipment Design and Construction Experiments	Ian Linke Courtney Male
Data Analysis	Russell S.A. Brinkworth
Manuscript Writing	Russell S.A. Brinkworth
Manuscript Editing	Kemal S. Türker Courtney Male
Incorporating Reviewers Changes	Russell S.A. Brinkworth

Chapter 9: EMG, Force And Discharge Rate Analysis Of Human Jaw Reflexes In Response To Axial Stimulation Of An Incisor Tooth

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Original Concepts	Kemal S. Türker
	Russell S.A. Brinkworth
Experimental Design	Russell S.A. Brinkworth
Experiments	Russell S.A. Brinkworth
	Purdie L.M. Yeo
Data Analysis	Russell S.A. Brinkworth
Manuscript Writing	Russell S.A. Brinkworth
Manuscript Editing	Kemal S. Türker
Incorporating Reviewers Changes	Russell S.A. Brinkworth

Chapter 10: A Device For Investigating Neuromuscular Control In The Human Masticatory System

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Pages 141-149

Original Concepts	Kemal S. Türker
	Peter Abolfathi
	Homer Nazeran
Experimental Design	Kemal S. Türker
	Russell S.A. Brinkworth
Equipment Design and Construction	Ian Linke
	Kemal S. Türker
	Peter Abolfathi
	Homer Nazeran
Experiments	Russell S.A. Brinkworth
Data Analysis	Russell S.A. Brinkworth
Manuscript Writing	Kemal S. Türker
	Russell S.A. Brinkworth
	Peter Abolfathi
Incorporating Reviewers Changes	Russell S.A. Brinkworth

Chapter 11: JAW MOVEMENT ALTERS THE REACTION OF HUMAN JAW MUSCLES TO INCISOR STIMULATION

Unpublished: Under Review

Original Concepts	Russell S.A. Brinkworth
Experimental Design	Russell S.A. Brinkworth
Experiments	Russell S.A. Brinkworth
Data Analysis	Russell S.A. Brinkworth BiometricsSA
Manuscript Writing	Russell S.A. Brinkworth
Manuscript Editing	Kemal S. Türker
Incorporating Reviewers Changes	Russell S.A. Brinkworth

Appendix 1: A LabVIEW®-based Software Application For Recording And Analysis Of Human Movement Experiments

Unpublished

Original Design and Implementation	Mutlu Kadife Kemal S. Türker
Software Specifications and Parameters	Russell S.A. Brinkworth
Basic Programming and Functionality	WaveCom Instruments
Additional Functionality Programming	David Mewett
Advanced Features and Compatibility	Russell S.A. Brinkworth

Appendix 2: Control Systems

Unpublished

Specifications and Parameters	Russell S.A. Brinkworth
Delta Controller	WaveCom Instruments
PID Controller	James Errington
Real-Time Multifunction Control System	Russell S.A. Brinkworth