DOES REAL-TIME VISUAL FEEDBACK IMPROVE PITCH ACCURACY IN SINGING?

PAT WILSON

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The soul never thinks without a mental image.

Aristotle. (Hett, W.S., trans.) (1936). *On the soul; Parva naturalia; On breath*. Cambridge, MA, Harvard University Press, p. 428.

One seeing is worth a hundred listenings.

Chinese proverb quoted in Cole, Hugo. (1974). *Sounds and symbols: Aspects of musical notation*. London, Oxford University Press, p. 122.

Abstract

The aim of this investigation was to investigate the effects of computer-based visual feedback in the teaching of singing. Pitch accuracy, a readily-measured parameter of the singing voice, was used in this study to gauge changes in singing for groups with and without visual feedback. The study investigated whether the style of feedback affects the amount of learning achieved, and whether the provision of concurrent visual feedback hampers the simultaneous performance of the singing task.

The investigation used a baseline–intervention–post-test between-groups design. Participants of all skill levels were randomly assigned to a control group or one of two experimental groups – with all participants given one hour of singing training. At intervention, the two experimental groups were offered one of two different displays of real-time visual feedback on their vocal pitch accuracy, while control participants had a non-interactive display. All sessions were recorded, and the vocal exercise patterns performed at baseline, intervention and post-test phases were acoustically analysed for pitch accuracy. Questionnaires assessed both general health and the amount of singing and music training of all participants; people in the two experimental groups were also given a further questionnaire about the visual feedback.

The results indicate that visual feedback improves pitch accuracy in singing. Cognitive load related to the decoding of visual information was a factor at intervention. At post-test, the two groups who had used real-time visual feedback demonstrated marked improvement on their initial pitch accuracy. There was no significant difference between the results of participants from the two experimental groups, although the participants with some background in singing training showed greater improvement using a simpler visual feedback design.

The findings suggest that a hybrid approach integrating standard singing teaching practices with real-time visual feedback of aspects of the singing voice may improve learning.

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Submission Statement

The work contained in this thesis has not been submitted for a degree to any other university or institution.

The conduct of this research was approved by the University of Sydney Human research Ethics Committee.

Pat H. Wilson

Date:

This thesis entitled 'Does real-time visual feedback improve pitch accuracy in singing?' by Pat Wilson is in a form that is acceptable for submission for the degree of Master of Applied Science, Communication Sciences and Disorders.

Presentations arising from this thesis

Conference presentations with refereed abstracts in published conference proceedings

Wilson, P., Callaghan, J. and Thorpe, C.W. (2005). 'The singer, the song, the voice and its visuals: Can real-time visual feedback help singing students? In *Deliver the Voice. 7th Voice Symposium of Australia.* Sydney: Australian Voice Association.

Wilson, P., Thorpe, C. W., and Callaghan, J. (2005). 'Looking at singing: Does real-time visual feedback improve the way we learn to sing?' In *2nd APSCOM Conference*. Seoul, South Korea: Asia-Pacific Society for the Cognitive Sciences of Music. [Book ISBN 89-5708-088-0; CD-ROM ISBN 89-5708-090-2]

Conference presentations

Wilson, P., Lee, K., Callaghan, J. and Thorpe, C.W. (2005). Seeing the singing voice: The effect of different visual displays in real-time visual feedback for singing training. In *Research for a Healthy Future – Colloquium 2005.* Faculty of Health Sciences, University of Sydney, 1st – 2nd December.

Wilson, P. (2004). Seeing, singing and computing. *One-day Showcase, Information and Communications Technology*, College of Sciences and Technology, University of Sydney, 13th August. (Poster presentation)

Wilson, P. (2003). How to be a good-looking singer: The effect of the visual displays in real-time visual feedback for singing training. *Postgraduate Research Day*, Australian Centre for Applied Research in Music Performance, Conservatorium of Music, University of Sydney, 8th October.

Wilson, P. (2002). Looking and singing: The effect of the visual display of elements in real-time visual feedback on learning in singing. *Research Day,* School of Communications Sciences and Disorders, Faculty of Health Sciences, University of Sydney, November.

Awards for papers based on this research

First Prize: Australian Music & Psychology Society (AMPS) Inc. Graduate Student International Conference Travel Assistance Scheme Award (April 2005). The award was based on the quality of the abstract of my paper for the *Second International Conference of the Asia-Pacific Society for the Cognitive Science of Music*, Seoul, South Korea, August 2005.

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Glossary

Acronyms and technical terms used in scientific fields related to the areas of this research

ADC	Analog-to-digital convertor
ANOVA	Analysis of variance
BFP	Bio-feedback programmes
CAL	Computer-assisted learning
CQ	Closed quotient
CLT	Cognitive load theory
EGG	Electroglottogram
FFT	Fast Fourier Transform
F_0	Fundamental frequency
GUI	Graphic user interface
HCI	Human-computer interaction
HE	Heuristic evaluation
Hz	Hertz
ICT	Information and communications technologies
ILT	Information and learning technologies
IV	Information visualisation
KP	Knowledge of performance
KR	Knowledge of results
LEMG	Laryngeal electromyography
LTM	Long-term memory
PA	Public Address system
PC	Personal computer
SPL	Sound pressure level
SPR	Singing power ratio
UIMS	User-interface management systems
VDT	Visual display terminal
VEP	Visual evoked potential
VSL	Videostrobolaryngoscopy

Preface

How am I going? This is a question which arises frequently when a person sets about the acquisition of a new set of neuromuscular skills. Learning to sing draws together a complex web of inter-related tasks which has always challenged tyro singers. Both singers and their teachers have traditionally sought improved means of defining and assessing these tasks. Anything that assists the understanding of the neuromuscular, emotional, aesthetic and intellectual work involved in singing has been welcome. This investigation examines a new means of offering immediate feedback to a singer. It is software which displays information about a singer's voice in (near) real-time on a computer screen.

While it is no new thing for singers to use visual inputs whilst singing, nor is it unusual for singing teachers to use visual information as an element in the teaching of singing, the nature of the information provided by this software begs a more thorough exploration of the way in which singers learn to sing, and, by extension, whether real-time visual feedback of aspects of a singer's voice is beneficial in their learning process. Two different modes of presentation of visual information about the singer's voice were used in this study, as well as a non-interactive control mode.
Research questions addressed in this study include:

- Does visual feedback improve performance?
- How do singers process visual information whilst singing?
- Is there an interference effect associated with simultaneous processing of aural, visual and other sensory information by singers?
- Do singers benefit from knowledge of results (KR)?
- If so, what sort, how much, and when?

Faced with visually-based technological assistance in the area of singing pedagogy, the task of practical research is to derive a coherent visual language for a process which has until now been predominantly auditory, linguistic and kinaesthetic.

As technological advances continue to offer us new ways of seeing and understanding our world, so must pedagogical processes adjust in response to these developments. It is necessary that the worth of such advances is critically examined in the light of their likely pedagogical usefulness.

P.H.W.

Pitch designation

In this thesis, pitch notation follows the Scientific Pitch Notation convention. Here is a comparative list of this, and other, pitch labelling conventions.

Comparative international pitch labelling conventions

Frequency (Hz)	Note name	**Scientific Pitch Notation**	Helmholz Pitch Notation	Another common pitch notation system
783.9	G	G_5	g''	g^2
740.0	F sharp	$F\#_5$	f#''	$f\#^2$
698.4	F	F_5	f''	f^2
659.3	E	E_5	e''	e^2
622.3	D sharp	$D\#_5$	d#''	$d\#^2$
587.3	D	D_5	d''	d^2
554.4	C sharp	$C\#_5$	c#''	$c\#^2$
523.2	C	C_5	c''	c^2
493.9	B	B_4	b'	h^1
466.2	A sharp	$A\#_4$	a#'	$a\#^1$
440.0	A	A_4	a'	a^1
415.3	G sharp	$G\#_4$	g#'	$g\#^1$
392.0	G	G_4	g'	g^1
370.0	F sharp	$F\#_4$	f#'	$f\#^1$
349.2	F	F_4	f'	f^1
329.6	E	E_4	e'	e^1
311.1	D sharp	$D\#_4$	d#'	$d\#^1$
293.7	D	D_4	d'	d^1
277.2	C sharp	$C\#_4$	c#'	$c\#^1$
261.6	**Middle C**	C_4	c'	c^1
246.9	B	B_3	b	h
233.1	A sharp	$A\#_3$	a#	a#
220.0	A	A_3	a	a
207.7	G sharp	$G\#_3$	g#	g#
196.0	G	G_3	g	g
185.0	F sharp	$F\#_3$	f#	f#
174.6	F	F_3	f	f
164.8	E	E_3	e	e
155.6	D sharp	$D\#_3$	d#	d#
146.8	D	D_3	d	d
138.6	C#	$C\#_3$	c#	c#
130.8	C	C_3	c	c
123.4	B	B_2	B	H

{Hirano, 1980 #167, p. 16}