

*Blindness, Programming,
Perception and Mulsemmedia:
Case studies of five blind
computer programmers*

Simon Hayhoe

Centre for the Philosophy of Natural and Social Science, London School of Economics



ICT Department, Leicester Grammar School

<http://www.blindnessandarts.com>

Lecture Delivered to BCS, De Montfort University, Leicester, UK

11th January 2011

Introduction

What is Mulsemedia?

Multi Sensory Media

- Obvious advantages for people who are blind and deaf
- Teaches us something about interfaces in general
- It also teaches us something about
 - the culture of computer interfaces
 - how we learn to use them
 - how we interact with them on a deeper level

Hayhoe S (Forthcoming) *Non-Visual Programming, Perceptual Culture and Mulsemedia: Case studies of five blind computer programmers*, In *Multiple Sensorial Media Advances and Applications: New Developments in MulSeMedia* (Ghinea G et. al. Eds). Hershey, Pennsylvania: IGI Global

The Context of the Study

“Blind programmers could compete quite nicely in the IT workplace when the mainframe was king. But today, as graphically oriented Windows tool kits displace the text-based mainframe development, blind programmers are facing an uncertain future.”

Steve Alexander, Blind Programmers Face an Uncertain Future,
ComputerWorld, November 6th 1998

The Context of the Study

- Literature gives first-hand accounts of successful programmers who have become blind later in life and continued programming (Kotian 2008, Filpus 2008)
- Little context given to older people who were educated in older schools for the blind (pre-1981) and became programmers in later life
- No context seems to be given to the experiences of different cultural life experiences of people who are blind and visually impaired

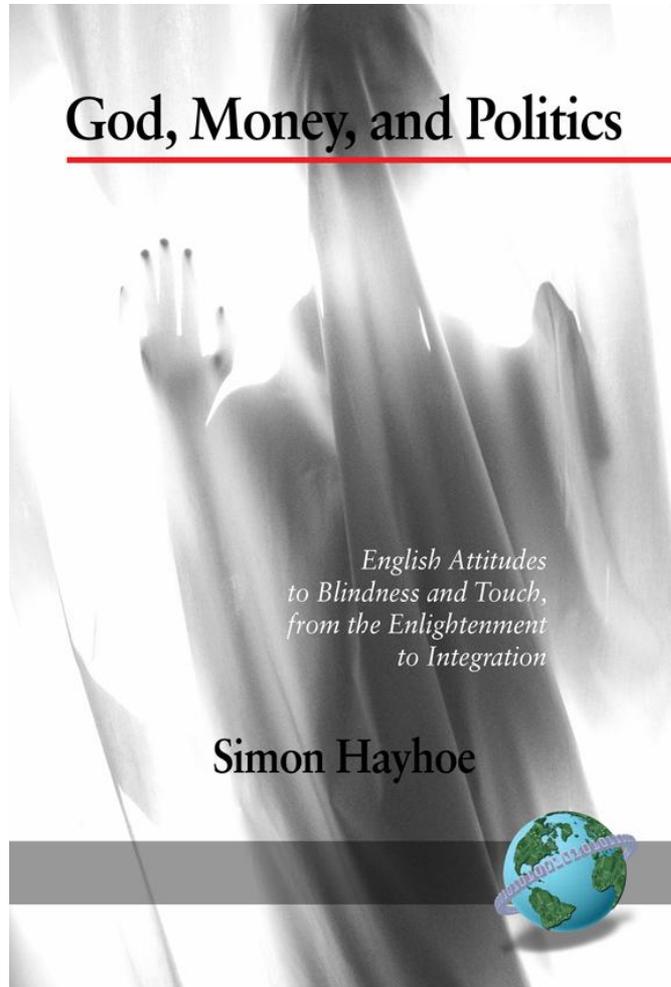
Previous Perceptual Studies of Blindness and Computing

- Literature identifies methods of adapting programming languages and teaching methods for blind programmers (Siegfried 2002, Gildea 1970, Vaspori & Arato1994, Riccobono 2004,)
- There have been some evaluations of individual pieces of software, used to overcome assumed difficulties in using GUIs, and visually based tests for programmers (Bax 1982, Siegfried 2006, Franqueiro & Siegfried 2006)
- No psychological studies have been conducted into *non-visual* programming of 2D visual computing concepts, such as Windows Icons Menus and Pointers (WIMPs) used in Graphical User Interfaces (GUIs), or the *creative* process of programmers who are blind

Previous Studies of Blindness and 2D Art

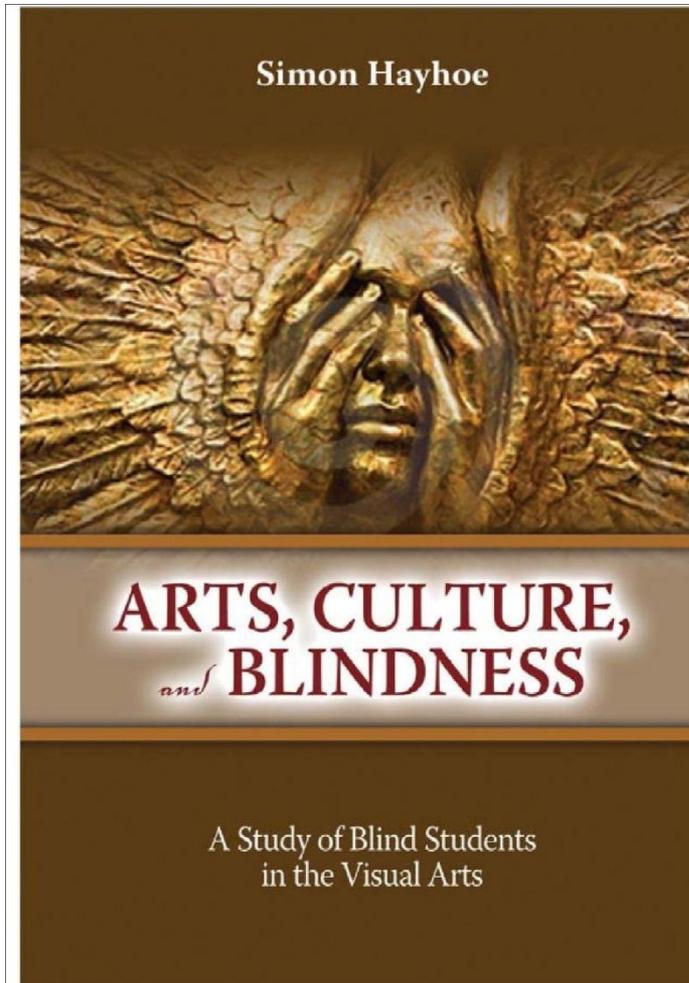
- Previous psychological studies of 2D perception and drawing by people who are totally blind from birth (Kennedy 1983, 1993, 1997, Kennedy & Merkas 2000) show that blind people can understand visual concepts in design and art. However, these same principles do not appear to have been applied to computer interfaces
- Previous cultural and philosophical studies (Hayhoe 1995, 2000, 2002, 2003, 2005, 2008a, 2008b) also show that cultural beliefs have restricted the education of blind students, and reinforced the social myth that blind people are incapable of perceiving 2D images or artistic perception
- Is this cultural model applicable to computing and blindness?
- This study employed the cultural approach it had previously applied to students learning art

The Cultural History of Attitudes to Blindness (Hayhoe 2008a)



- Shows that external factors affect the history and epistemology of blindness:
 - Religious morality
 - Political expedience
 - Economics, and particularly the need to save or produce capital

Culture & Learning in Schools & Universities (Hayhoe 2008b)



- Shows how attitudes towards blindness affected learning:
 - Blind students physically capable of conducting complex art tasks
 - Blind students were more influenced by their beliefs than their non-visual perception

Development of COMBINE

- COMBINE (Computing and Blindness in Education) was set up to survey English speaking programmers who are registered blind, and examine their creative understanding of traditionally *visual* elements of computing
- Set in two stages:
 - First stage: Case studies of experienced computer programmers
 - Second Stage: Case studies of experienced and qualified web developers (forthcoming).

Aims

The aim of this research is to produce a number of case studies that describe non-visual computer programming:

- Investigate whether the understanding of computer interfaces is related to perceptual culture as well as perceptual ability
- Investigate whether it is possible for a person who has never seen to understand visual concepts in informational technology through non-visual senses and memories
- Provoke questions as to the nature of computer interfaces, and whether they can ever be regarded as MulSeMedia style interfaces

Objectives

The objective of this research is to inform a greater understanding of how the mind:

- *Inform accessible MulSeMedia interface design*
- *Investigate the boundaries of accessing computer interfaces through non-visual perceptions and memories*

This is designed to inform better designed visual as well as “non-visual” interfaces and more effective computing methodologies

The Structure of the Study

Foci of COMBINE

- What problems are encountered in non-visual programming?
- How do blind programmers conceptualise programs?
- How do blind programmers design computer interfaces that can be used by both blind and sighted users, particularly those with Graphical User Interfaces (GUIs)?
- Are programmers who are born blind or become blind early in their life different from programmers who have become blind later in their life?
- What do blind programmers understand by visual program concepts, such as:
 - Windows, Icons, Menus and Pointers (WIMPS)?
 - the concept of a two-dimensional interface, such as a form?
 - resizing Windows and objects on a form?

Categories of Memory to be Studied

- No Visual Memory (NVM):
 - Blind from birth
 - Very early blind, from infancy, 0-4 years
- Assimilated Blindness (AB):
 - Blind from mid to late childhood, 4-18 years, educated in schools for blind, primarily non-visual
- Visual Memory (VM):
 - Blind in adulthood, 18+ years

N.B. based on the findings of Lowenfeld (1981), Hayhoe (1995, 2000, 2005)

Classifications of Blindness to be Studied

- Total Blindness (TB)
 - no light perception
- Minimal Light Perception (MLP)
 - some light perception, but little enough to be usable
- Distorted Vision (DV)
 - light perception, but highly distorted and registered blind, e.g. achromatism, photophobia, tunnel vision, no central vision

N.B. based on the definitions of Hayhoe (1995, 2000, 2005), & Coakes & Holmes Sellors (1992)

Data Collection Methodology

The fieldwork is being conducted in two phases:

- Phase one, featured in this report; this consisted of collecting initial e-questionnaires from a number of programmers who are legally registered blind in their own countries, and later interviewing them
- Phase two of the fieldwork is to be verbal interviews and/or questionnaire interviews – depending on the preferences of the teachers - with computing and ICT teachers in schools for the blind, or computing/ICT teachers of students who are registered blind in mainstream education.

Phase One Methodology

- All of the programmers are registered blind in their own country
- The first part of the study was conducted through extended questionnaires – this was initially to be the pilot study alone, but produced data that could also be used in the case studies
- This element of the study was set to establish foci for the extended interviews
- This phase was to identify programmers and web developers interested in participating in the research
- This phase also established a rough profile of programmers who are registered blind
- This phase was also to determine first principles of non-visual programming

Data Collection Process

- The research employed Informed Consent (De Laine 2000)
- This involved describing the aims and objectives, and the methods employed in the research, to the programmers involved in the interviews
- The identity of the programmers was kept anonymous
- Questionnaires used open question methods (Lincoln & Denzin 1994, Griffin 1985) eliciting protracted responses
- Programmers were encouraged to give examples of their difficulties and techniques, and also gave examples of their codes and interfaces

Problems Encountered with the Methods

- Only a small number of programmers are legally registered blind
- Identifying programmers, and requesting time from busy professionals, was difficult as they were specialists distributed internationally
- There are national differences between diagnoses and legal definitions of blindness
- A small number of unique, high-profile subjects may not remain anonymous
- There was a little time available to conduct research, and the tight timescale
- There is ambiguity in language used in computing and psychology, and in the different types of language used by programmers – each had different backgrounds and fields of programming

Case Studies

Summaries of Programmers' Profiles

	Early Blind (Pre-1981)		Late Blind		Early Blind (Post 1981)
	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5
Age	45	57	50	33	26
Gender	Male	Male	Male	Female	Male
Category of Blindness & Memory	TB & NVM	TB & AB	DV & VM	TB & VM	MLP & AB
School Education	School for the Blind	School for the Blind	Mainstream Schools	Mainstream Schools	Mainstream School
Highest Educational Level	Higher Education	Higher Education	Higher Education	Postgraduate	Higher Education
Work Position	Programming	Website Developer	Software Development	Director	Software Engineer
Years Programming	28	36	36	Approx 20+ Years	9
Programming Language(s)	Non-Visual (Cobol, C, Pascal, Fortran & Basic)	Non-Visual (Assembly Language, HTML script)	Mixed (Perl, HTML, SQL, PHP)	Mixed (E.g. HTML, PHP, Java, XML, CSS)	Mixed (E.g. MMC, C++, Java, Visual Basic, XML)

Case Study 1

- Very early, completely blind, 45 year old British man, who attended schools for the blind and then higher education
- Learnt programming in his last years of school through Braille tape applications.
 - “We used a small corner of a computer owned by a company called Metal Box- don't know what sort. Basic was the language. It was a wonderful experience. We just used text editors, and ran what we wrote through a Basic interpreter - I don't think it was compiled.”
- Considers himself to be of a blind culture - language and technology is that of blind users, knows a number of other blind people
- In his earlier programming, he used a teleprinter, and interpreted windows through
 - “teleprinter and BD3 [a Braille paper tape printer for output], next was a teletypewriter and asking someone to read the print out”

Case Study 1

- Has relied on Braille applications for using his interfaces
 - “The first was a "window manager" to control the movement between individual connections to mainframes, on which I mostly programmed or ran applications or used text editors. Each "window" was like a screen of characters--lines of 80 or 132 and 24 or more lines. The second was to a PC through JAWS to run more admin type stuff and access the Internet and Intranet.”
- He does not use, or attempt to use, GUIs in his programming – he actively avoids them
 - “I'm not sure that I have ever met one”
- Mostly uses problem solving methods, working through lines of text – holds logical problems in his mind
 - “My main work... is problem solving, so it is more along the lines of tearing programs up while still trying to keep them reproducing a problem.”
- Accesses the web using a text reader. It was not (and is not) an enjoyable experience
 - “At work, about 10 years ago, [I accessed them] with a PC using JAWS. Oh, it was horrible - still not a lot better.”

Case Study 2

- Completely blind, 57 year old British man. Residual vision until 14 years old. He attended schools for the blind and then university
- Considers himself to be of a blind culture, through language, technology applications
- He began learning to program at university in 1972. His early programs were written in Assembly Language
 - “My first computer program was written at university 1972. The experience was quite interesting and had all the usual frustrations of surmounting the operating system before getting down to the logic (or otherwise) of the program. I used a Teletype and had sighted people reading for me”
- Used Teletype and Braille readers and writers, keyboard and audio interfaces to work through code and as an interface for everyday use. Now uses JAWS.
 - “I currently use JAWS with Braille and speech. I have used Teletype / Optacon, I briefly used the Clarke and Smith Braille Link, which I rejected. The TSI VersaBraille, then IB80 Braille display.”

Case Study 2

- First accessed the web and email over twelve years ago using JAWs [a text reading program read through keystrokes] and Braille applications
 - “I was connected to the Internet whilst working for Marconi in 1996, though I didn’t actively access the Web until 2000, when I established my own computer at home”
- Writes webpages with raw code. Will not work with visual languages
 - “I was one of few who insisted on sticking to Assembly languages before giving up programming in the early 1990’s”
 - “Yes, I write web pages, in basic HTML. As I’ve already said, I’m an information provider, not a web techie. I don’t do Java and visualise the information I’m presenting. The structure of the information informs the structure of the page. Nothing else makes sense to me”
- Particularly relies on structure and disciplined methods when scripting webpages
 - “I don’t impose style or other limitations, leaving users to present our information in a way that best suits them. By providing concise, structured text, we achieve a high level of accessibility and usability for the vast majority of readers”

Case Study 3

- Late blind, 50 year old British man, still with a small amount of distorted sight. He attended mainstream schools and then higher education. Became blind in his late 30s
- Still considers himself not to be culturally blind, either through language or his use of technology. Does not know many other blind people
- Learnt programming visually through a school computer club aged 14, in the early 1970s, using Fortran. Keen maths teacher enthused him. He had access to a local mainframe with which to experience programming throughout his school career
 - “The maths teacher at school was keen on computers and we had a “computer club” where we learnt Fortran, punched cards, sent them to be processed at County Hall, and received the printed output next week.”
- In his earlier programming, he used a text based systems, then moved on to a combination of text and GUI. Now he continues to use a combination of text and GUI

Case Study 3

- Does not use elements of GUIs that he cannot use, such as Flash
 - “I design web pages and can see the interface. However, I disregard elements I cannot use myself such as Flash – I like things to be very plain and simple.”
- There was no mention of a use of Braille in his interview
- Actively uses database languages, such as PHP and SQL to develop an on-line library interface
 - “Perl 5.8 and SQL, together with DOS commands for server-side work, with HTML and PHP 5 on the Web. Currently providing an e-Library of electronic texts via the Web, and trying to automate this as much as possible eg wrote a program that accepts input from a bar-code reader (ISBN number), verifies it, and gets book metadata off Internet site and updates database.”
- Accesses websites using GUI interfaces – although prefers to keep these interfaces visually simple. Surfs the internet using an adapted standard browser
 - “I’ve used Lynx (A DOS TEXT BASED BROWSER) BUT USUALLY USE Internet Explorer for day to day Internet work. (sic.)”

Case Study 4

- Late completely blind, 33 year old British woman. She attended mainstream schools, higher education and is now a part-time postgraduate studying computer science. She became blind at 26 years old
- Still considers herself not culturally blind, either through language or her use of technology. Does not know many other blind people. She does not use Braille.
- Learnt programming using her father's computer before the age of 10, using a text (command) based system. She began by copying programmes from magazines
- In earliest programming experiences she used text only, then used standard GUI systems.
- She cannot imagine the XP interface, which was released after she became blind. She accesses this system using JAWs
 - “I rely entirely on the keyboard to interact with the screen reader and/or OS. For the most part it is an approach I'm capable of and comfortable with. There are inevitable frustrations, but these are born from other people's inability to develop software that will support my goals, rather than my inability to do so with the right tools and skills”

Case Study 4

- She develops websites and programs using web based languages such as Java, HTML, XML and PHP
 - “I can write XML, XHTML/HTML, CSS, Java and a little PHP. I have my own website (tink.co.uk), which is XHTML/CSS/PHP based. I’m just starting to develop a web application in Java, which is to be a recipe archive site. I’m also studying Computer Science with the Open University, majoring in software development with a focus on Java”
- She can imagine GUIs as she programs them for others, in particular the visual metaphors, such as 2D buttons, and allows users to adjust visual settings, such as background colour, on websites
 - “I do code web pages and have done so since before I lost my sight. I have a very good visual recollection of a typical browser interface. Internet Explorer is particularly clear and although Mozilla and Firefox hadn’t come into being when I lost my sight, they follow very similar visual parameters”
- Although Java applets are inaccessible using Jaws, she can imagine their visual appearance as she develops them
 - “I also know enough about current development techniques for accessible Flash to be aware of how it works in the present. Applets I don’t have a visual recollection of, but I’ve coded them from time to time during my current studies. Applets are more or less completely inaccessible with a screen reader, but from a development perspective I know their capacity and capability”

Case Study 5

- Very early blind with no usable vision, 26 year old British man, who attended mainstream schools and then higher education
 - “I’ve had no useful vision all my life.”
- He was given access to computer applications from primary schools, and was used to all forms of application
 - “My first experience of a computer was a BBC at primary school. It was mostly used to teach typing and Braille. It had a very old external speech synthesiser. I was 8 or 9 and it was a good experience. Generally it was mostly educational software used”
- Learnt programming in his last year of school taking a GNVQ in Computing, using Pascal. He used command prompts, audio interfaces and later screen readers
 - “My first real introduction to a proper programming language was at college. I was 17 and studying for a GNVQ in computing. One of the modules was programming in Pascal. Before this I’d done a bit of dos batch script programming but when I first got the hang of Pascal I found something just clicked and I’ve been in to programming ever since. We used a dos IDE called turbo Pascal. This was using a dos screen reader called hal. I wrote all sorts of applications with very simple GUIs”

Case Study 5

- He mainly uses screen readers to translate GUIs, including:
 - “buttons, menus, menu bars, tool bars, scroll bars, icons, balloons, tool tips, edit controls, list and combo boxes to name a few”
 - “screen readers I use have the ability to simulate mouse movement and control from keyboard; and this is normally the last resort to try to access inaccessible applications”
- Uses code indentation and code layout techniques whilst programming for clarity
 - “I can tell you that I use code indentation and code layout techniques and have never had a problem getting any of my interfaces I’ve put together past our MMI people. (Well no more than any of the people I work with)”
- Accesses the web using a screen reader
 - “As everything now uses a GUI of some kind it is impossible to use a computer without encountering the complexity of the GUI”

Initial Findings:

Early Blind (Pre-1981)

- These programmers largely rejected the use of GUIs, and remained with outdated programming interfaces even when they had some early residual visual memory
- Even when they accessed GUIs, they referred to them as non graphical interfaces, and were disparaging about the idea that they were graphical
- Preferred to design using purely text based languages, even when they knew they were outdated
- Preferred designing solely text based interfaces even for sighted users
- Related to Braille text when programming, and considered themselves culturally blind
- Relied on a strong memory of words and numbers
- Coding is very disciplined, and relies on a rigid structure and system in the presentation of its language

Initial Findings:

Late Blind

- Late blind programmers were more willing to design GUIs for sighted users, and had a strong and clear re-collection of previous GUI interfaces.
- They could also imagine new GUIs designed after they had lost their sight
- Late blind programmers did not refer to the use of Braille in their understanding of language, and still preferred to use mainstream courses adapted to their needs
- Although late blind programmers used JAWS, they appeared to refer to visual references whilst reading the text on screen through key strokes, and referred to the interfaces they were reading as GUIs
- They felt it important to design GUIs for sighted users

Initial Findings:

Early Blind (Post 1981)

- This programmer was very comfortable using what he knew were graphical interfaces, even though he relied wholly on screen readers as interfaces
- His comfort with GUI software was perhaps due to his age, and early familiarity with this software
- This programmer still imagined his use of interfaces using visual references, but only as relatively abstract concepts – as objects to be navigated using his screen reader
- Despite never having had real usable vision, he would feel happy referring to GUIs in his program design, and would make every effort to incorporate them in his interfaces using separate software
- He felt the need to design for both blind and sighted users

Conclusion

General Conclusions

- There is evidence that being a member of a blind culture is largely generational and due to education.
- There is evidence that culture and /or education was more important than perceptual factors of blindness

Conclusions on Mulsemedia

- In these case studies, the need to use GUIs and design interfaces with elements of GUIs was not largely based on degree of blindness, thus in terms of Mulsemedia there is scope for producing non-visual systems incorporating elements of GUIs
- It is certainly easier to use and design GUIs when there has previously been visual memory, even when the elements of the GUIs were released after the programmer became blind. Thus in terms of Mulsemedia, a great deal of expertise in using non-visual systems will depend on the user's personal history.
- The early blind programmer educated in mainstream education was more similar to the behaviour of the later blind programmers, showing that education had a greater affect than blindness on the ability of blind people to use and program GUIs. Thus in terms of Mulsemedia, educational and cultural background are more important than perception in the use of interfaces.

Bibliography

- Bax D.D.** (July 1982) *Computer Programmer Aptitude Test for the Totally Blind*. Journal of Rehabilitation 48/3/---
- Coakes, R. L., & Holmes, Sellors P. J.** (1992). An outline of ophthalmology. London: Butterworth-Heinemann.
- De Laine M.** (2000) *Fieldwork, participation and practice: Ethics and dilemmas in qualitative research*. London: Sage.
- Filpus P.** (2008) *Computer Programmer and Analyst*. Downloaded from <http://www.afb.org/Section.asp?SectionID=7&TopicID=267&SubTopicID=83&DocumentID=3179>, December 2008)
- Franqueiro K.G. & Siegfried R.M. (October 2006)** *Designing a Scripting Language to Help the Blind Program Visually*. Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility, October 23-25 2006, Portland, Oregon.
- Gildea R.A.J.** (November 1970) *Guidelines For Training Blind Computer Programmers*. New Outlook for the Blind 64/9/297-300
- Griffin C.** (1985) *Qualitative methods and cultural analysis: Young women and the transition from school to un/employment*, in (Burgess R Ed.) *Field methods in the study of education*. London: Falmer Press
- Hayhoe S.** (1995) *The art education of blind adults*. Thesis presented in support of the degree of MEd by research, Leicester University, British Isles.
- Hayhoe S.** (2000) The effects of late arts education on adults with early visual disabilities. Educational Research & Evaluation 6/3/229-249

Bibliography

- Hayhoe S** (2002) *The Experience of Children with Visual Impairments in Visual Arts Education*. Paper presented at the International Conference on the Politics of Childhood, Hull University, 10th September 2002
- Hayhoe, S.** (2003). *The Development of the Research of the Psychology of Visual Impairment in the Visual Arts*, In E. Axel & N. Levent (Eds.), *Art beyond sight*. New York: The American Foundation for the Blind & Art Education for the Blind.
- Hayhoe S.** (2005). *An examination of social and cultural factors affecting art education in English schools for the blind*. Unpublished doctoral thesis, Birmingham University, England
- Hayhoe, S** (2008) *God, Money & Politics: English Attitudes to Blindness and Touch, from Enlightenment to Integration*. North Carolina: Information Age Publishing
- Hayhoe, S** (2008) *Arts, Culture and Blindness: Studies of blind students in the visual arts*. New York State: Teneo Press
- Hayhoe S & Rajab A** (2000) *Ethical considerations of conducting ethnographic research in visually impaired communities*. Paper presented at The European Conference on Educational Research 2000, Edinburgh University, September 2000
- Kennedy J.M.** (1983) *What Can We Learn About Pictures from the Blind?* *American Scientist* 71/19-26
- Kennedy J.** (1993) *Drawing and the Blind*. New Haven: Yale University Press
- Kennedy J. M.** (1997) *How the blind draw*. *Scientific American*, 276/1/60-65
- Kennedy J.M. & Merkas C.** (2000) *Depictions of motion devised by a blind person*. *Psychonomic Bulletin and Review* 7/700-706

Bibliography

- Lincoln Y.S. & Denzin N.K.** (1994) *Handbook of qualitative research*. Thousand Oaks, California: Sage.
- Lowenfeld B.** (1981b) *Effects of blindness on the cognitive functioning of children*. In *Berthold Lowenfeld on blindness and blind people: Selected papers*. New York: American Federation for the Blind
- Kotian H.P.** (2008) *India's First Blind Computer Programmer*. Downloaded from <http://www.esight.org/view.cfm?id=0&room=n&x=65>, December 2008)
- Riccobono M.A.** (February 2004) *A Brighter Future for Blind Children*. Braille Monitor
- Siegfried R.M.** (March 2006) *Visual Programming and the Blind*. ACM CIGCSE Buletin 38/1/275-278
- Siegfried R.M.** (February 2002) *A Scripting Language to Help the Blind Program Visually*. ACM SIGPLAN Notices 37/2
- Vaspori T. & Arato A.** (1994) *Ten Years of Computer Use by Visually Impaired People in Hungary*. Information Technology & Disabilities 1/3/---