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Design of Smart Head-Mounted Display Technology: A convergent mixed methods study

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BACKGROUND

- In 2015, 3.9 million US adults ≥45 years old had visual impairment (VI) and the annual cost of providing vision-related care to this population was $145 billion.[1,2] By 2050, the prevalence of blindness and VI is expected to double, and the annual cost may increase to $375 billion.[3]
- Head-mounted displays (HMD) are image processing systems originally developed for military use more than 25 years ago.[4] HMD include 3 main elements: a scene camera, microelectronics to manipulate the video, and microdisplays in front of the eye.
- While commercially available HMD have recently been developed to assist those with low vision, there exists a notable gap in understanding both the range of functional impairments best addressed with HMDs, and the factors impacting preference among low vision users.[5]
- Understanding these factors will allow for future development of HMDs best suited to assist individuals with low vision, as well as decrease device abandonment.

PURPOSE

The purpose of this study was to explore the factors impacting preference for head-mounted display (HMD) technology among individuals with visual impairment. Our hope is this information will be used to further refine HMD design to better assist those with low vision.

METHODS

Participants with a wide range of visual impairments and diagnosis of either: age-related macular degeneration, diabetic retinopathy, glaucoma, or retinitis pigmentosa were recruited from the Kellogg Eye Center (UM) or Western Michigan University.

General Inclusion Criteria:

- Age ≥18 years and self reported visual impairment

General Exclusion Criteria:

- Diagnosis of cognitive impairment, need for interpreter, or physical disability precluding mobility

Study Visits Involved the Following-

- Impact of Visual Impairment Questionnaire (IVI)
- Study team members taught each participant to use three difference types of HMD. Participants were instructed in using HMDs to look at objects near & far, and to read text.
- Afterwards participants completed a semi-structured interview

Interviews were audio recorded, transcribed, and coded by two independent coders. Thematic analysis was conducted using the software MAXQDA 2018

RESULTS

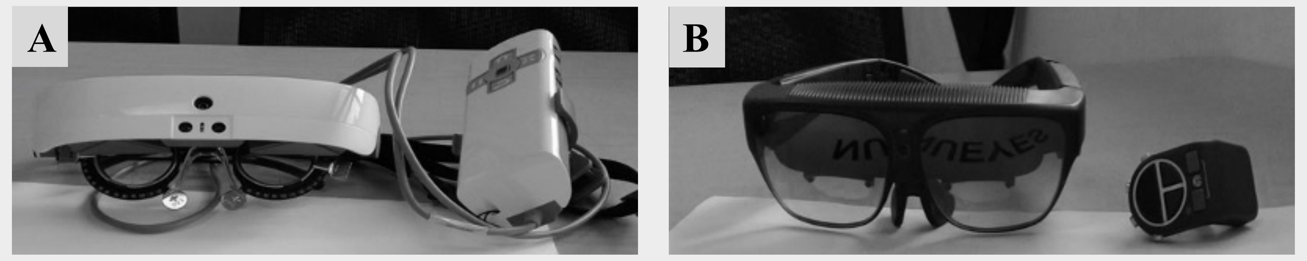


Figure 1. Head Mounted Displays tested in this study. **1A**) eSight Model 3; **1B**) NuEyes Pro; **1C**) Epson Moverio BT-200

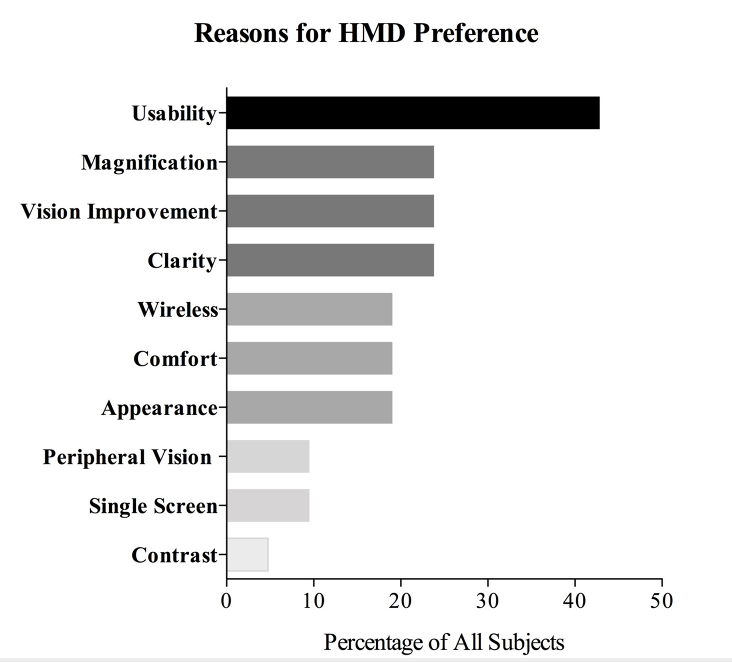
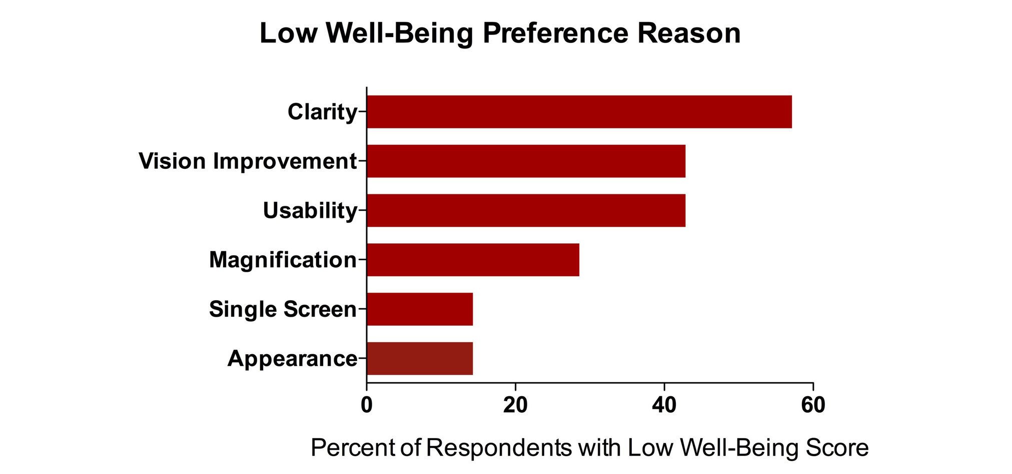


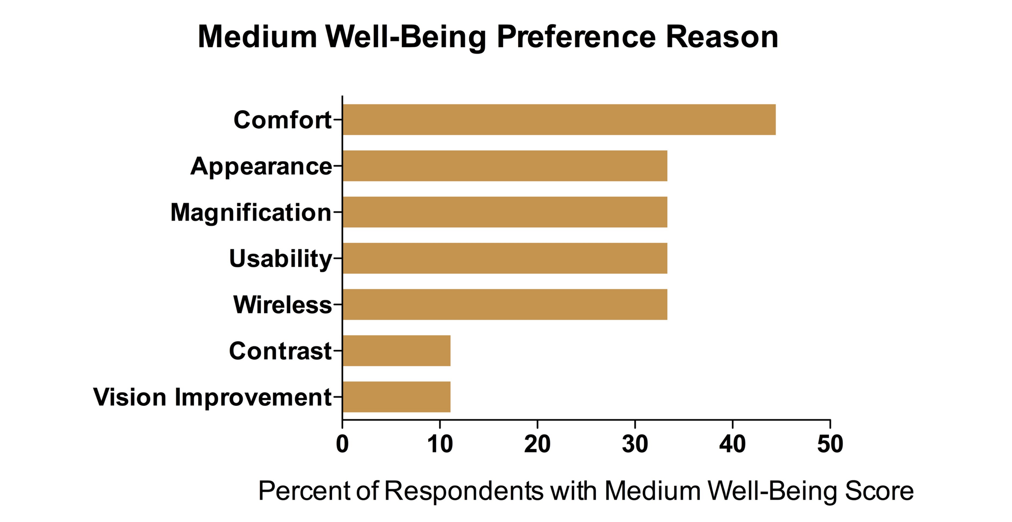
Figure 2. Reasons for HMD Preference. When participants were asked to select the HMD they preferred, the majority cited usability as a key factor.

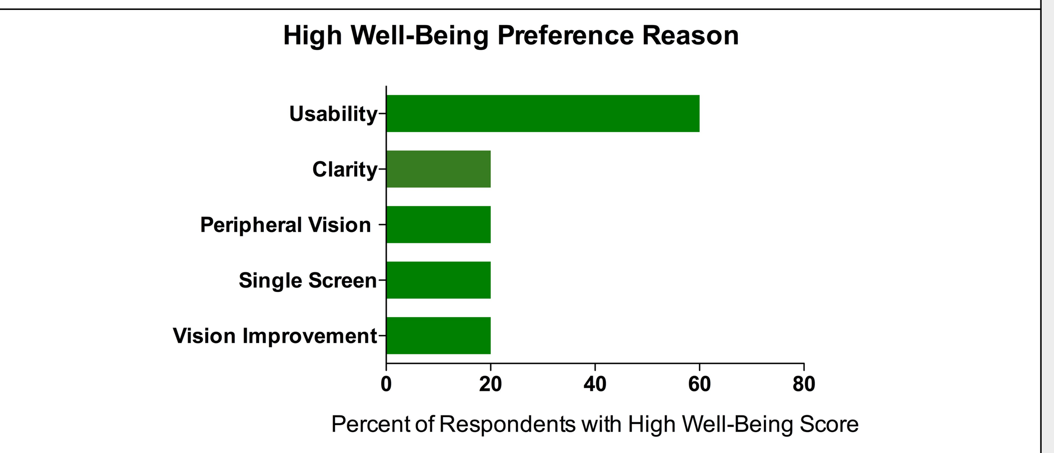
Table 1. Joint display linking vision-related well-being with participant preference for HMD

IVI Well Being	Dx	Age	Sex	BCVA	Type of VI	Preference
-1.81	GL	36	F	20/80	mixed	eSight
-1.23	AMD	71	F	20/30	central	eSight
-0.53	GL	61	F	20/30	mixed	eSight
-0.37	GL	72	M	20/20	peripheral	eSight
-0.32	DR	30	F	20/50	central	eSight
-0.22	DR	51	M	20/100	mixed	eSight
-0.22	RP	61	F	20/40	peripheral	NuEyes
-0.04	AMD	83	M	20/50	central	Epson
0.15	DR	67	M	20/80	central	NuEyes
0.15	AMD	71	F	20/40	mixed	eSight
0.17	RP	49	M	20/40	peripheral	NuEyes
0.35	RP	37	F	20/80	mixed	NuEyes
0.63	RP	58	M	20/30	peripheral	Epson
0.69	DR	39	M	20/150	mixed	NuEyes
0.69	RP	33	M	20/40	peripheral	NuEyes
0.93	RP	74	F	20/40	peripheral	Epson
0.93	RP	56	M	20/40	peripheral	NuEyes
0.99	AMD	80	M	20/70	central	eSight
1.11	GL	67	M	20/40	peripheral	NuEyes
1.54	RP	58	M	HM	mixed	NuEyes
1.84	DR	73	F	20/40	peripheral	eSight

HMD Preference Reasons







CONCLUSIONS

- Participants with the lowest self-reported well-being prefer eSight. Most have central or mixed vision loss. Clarity, usability and vision improvement were most cited as reasons for preference
- Participants with self-reported well-being in the middle tended to prefer NuEyes. Most have peripheral or mixed vision loss. Appearance, wireless capability, and magnification were most cited as reasons for preference
- Those with the highest self-reported well-being tended to have peripheral vision loss and no clear preference for one HMD. Usability was most cited as a reason for preference.
- While majority of participants reported difficulties with mobility, none of them could envision using the HMDs tested to walk or navigate and many cited safety concerns using HMDs in public, future HMD designs should address this disparity.

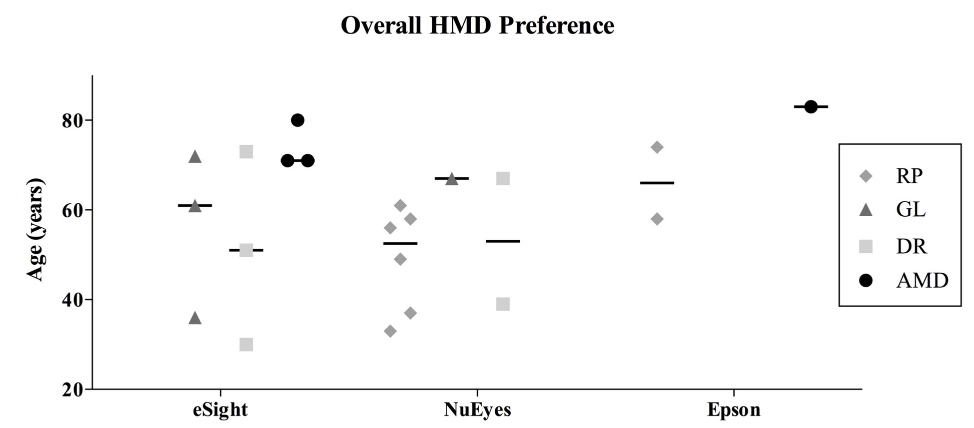


Figure 3. Overall HMD preference by ocular diagnosis. Individuals with RP tended to prefer NuEyes

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