FINAL PROJECT REPORT:
INSIGNEO Bursary for Clinical Translation (2016)

Title:

Increasing awareness of nystagmus and improving patient experience via the application of virtual reality technology.

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Abstract

Nystagmus sufferers experience involuntary eye movement. Most of these individuals adapt to their eye motion early in life but a significant proportion do not. Those who do not adapt must contend with the world constantly moving around them – a debilitating symptom called oscillopsia. The recent commercialisation of virtual reality (VR) technology was the motivation to produce a realistic, evocative simulation of oscillopsia derived from real nystagmus eye tracking data. Virtual reality technology refers to a headset which immerses the wearer in a virtual world by presenting stereoscopically calibrated displays and providing head tracking.

Consequently, the primary aims of this project were:

1. To produce an oscillopsia simulator VR app for download by the general public
2. To create a streamlined mechanism to generate a personalised oscillopsia VR simulation from a patient's eye tracking data, enabling that patient to take it away on their phone

The project has successfully produced an oscillopsia VR app free for download from the Google Play store and Apple App store. A high fidelity demonstration version of the app was also created for the Oculus Rift to showcase at outreach events. Outreach activities exceeded the original specification in the application and the app was extremely well received at these events. Feedback on the Google Play Store has so far received six 5 star reviews and has been downloaded over 30 times within the first 6 days of publication. Submission to the Apple App Store has also occurred although Apple's review process has meant that it is not yet available for download at time of writing. A streamlined procedure for producing a personalised oscillopsia simulation for patients has been produced and implemented so that patients attending clinic for eye movement tracking may take away a personalised app within approximately 15-30 minutes of their consultation.

The success of this project has led to further grant applications with a view to expanding the app to simulate a wide range of visual impairments. Opportunities to correct oscillopsia using an eye-tracking VR headset are also being explored.

Introduction

Nystagmus is an eye movement disorder in which the sufferer experiences repetitive involuntary eye motion. It has been estimated to affect 0.24% of the population in the UK [1]. Nystagmus is broadly classified into two groups: Infantile (present at birth or within the first 6 months of life) and acquired (developed later in life). Patients with infantile nystagmus commonly adapt to the erratic eye motion during early neural development; nevertheless, it adversely affects quality of vision (e.g. visual acuity). However, acquired nystagmus patients rarely adapt and consequently perceive the world as constantly in motion – a debilitating condition known as oscillopsia.

The eye movement experienced by nystagmus sufferers can be in any direction and varies in speed and amplitude. The most common form of nystagmus is a 'jerk' motion (repetitive eye motion with both fast and slow phases) in the horizontal direction. Another type of motion is the slower 'pendular' motion (repetitive slow eye motion). For those who do not adapt to the eye motion early in life (i.e. those with acquired nystagmus who suffer with oscillopsia) it is often severely incapacitating, typically resulting in nausea, vertigo, loss of balance and inability of the sufferer to interact effectively with the world around them. Patients with oscillopsia currently have few opportunities for relief. There are no reliable treatment options and as a result, sufferers can struggle to live independent lives [2]. They can feel imprisoned by their condition and hence opportunities to communicate their experiences can help to remove their sense of helplessness and isolation. In this project we have delivered a tool to help them to communicate the debilitating nature of their condition using virtual reality (VR).

The Oculus Rift and Google Cardboard are two examples of VR headsets which provide the wearer with stereoscopic vision and head tracking capabilities. The Oculus Rift is a dedicated, immersive VR headset which relies on a high specification PC to project a separate stereo display to each eye. Alternatively, Google Cardboard is at the inexpensive end of the VR spectrum, consisting of a cardboard shell containing two lenses and a slot for a smartphone to be inserted, see figure 1. By installing an appropriate app on a smartphone the display is reconfigured to provide a pair of calibrated stereo images, one in front of each lens. The setup delivers a separate view to each eye which is updated as the user rotates his/her head using information from internal sensors in the smartphone/headset. The result is immersion in a facsimile of reality that can be explored at the user's discretion.

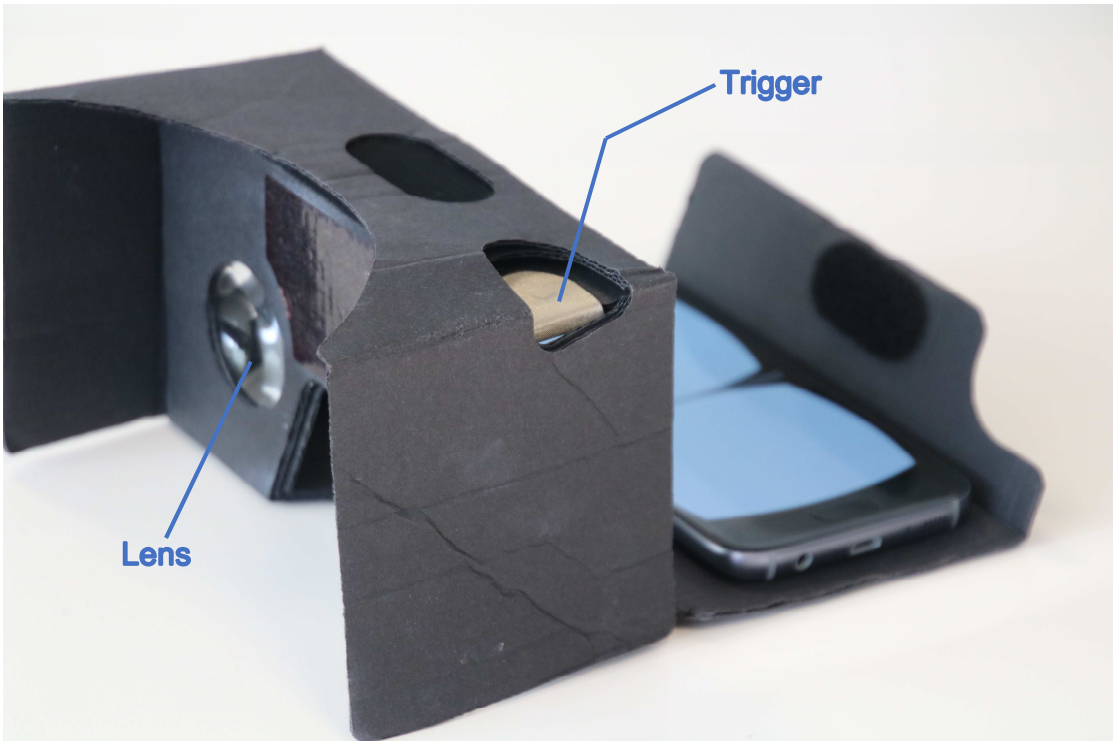


Figure 1: Google Cardboard with a smartphone ready for use

This project has developed a simulation of oscillopsia immersing the viewer in a selection of scenes while imposing erratic eye movements obtained from eye tracking data of nystagmus patients. Two versions of the app have been developed one for the Oculus Rift and one for smartphones. This is the first app of its kind and has already attracted great interest locally throughout the course of this project.

Aims and Objectives

The original bursary application set out two clear overarching objectives:

1. To release an accurate app to simulate oscillopsia
2. To create a mechanism to generate a personalised app within the clinic from a patient's eye tracking data

Dissecting these objectives created a series of distinct tasks that were also outlined within the original application:

Smartphone Development:

1. Acquire examples of 'typical' nystagmus eye movements from volunteers for incorporation into the oscillopsia simulation app
2. To produce an app which effectively simulates oscillopsia for the smartphone
3. Release the smartphone version of the app on the Apple App Store and Google Play Store
4. Create a streamlined mechanism to convert eye tracking data from the newly acquired eye tracking equipment (Eyelink 1000 Plus) so it is ready for the smartphone platform

Oculus Rift Development:

5. Develop a version of the app for the Oculus Rift dedicated VR headset
6. Release the Oculus Rift version on the Oculus Share developer's forum

Exposure of the Work:

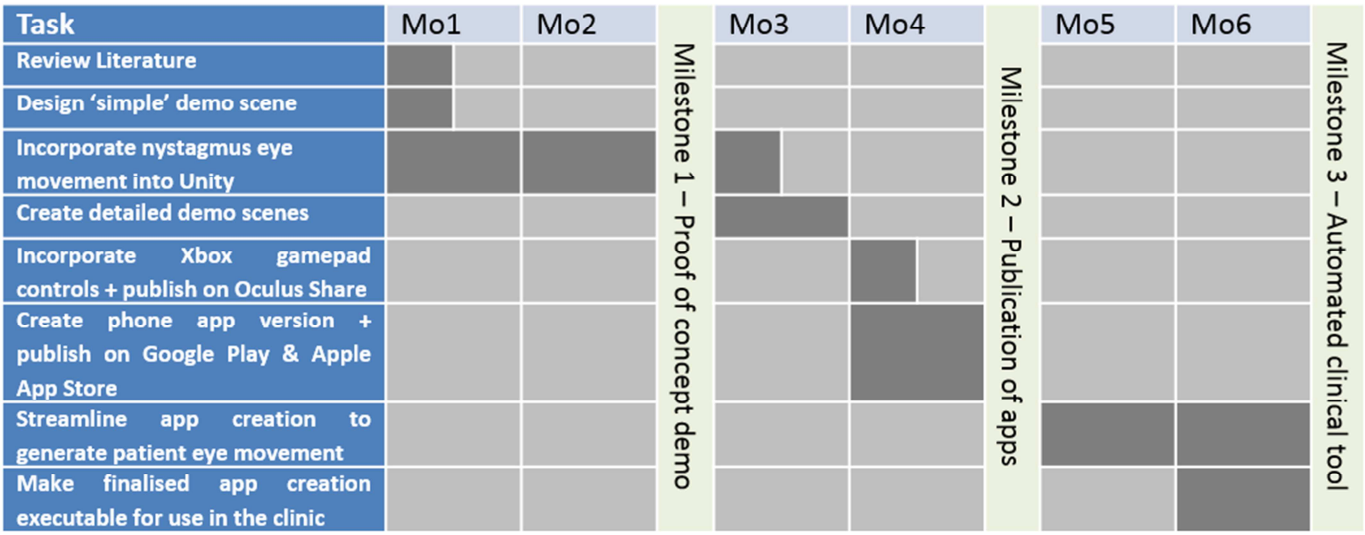
7. Dissemination of the work at the following list of PPI events and conferences:
    a. Sheffield Festival of Life (https://www.sheffield.ac.uk/life) (Local – 18th-24th April 2016)
    b. INSIGNEO showcase (Local – 5th May 2016)
    c. Nystagmus Network Open Day (Reading – 7th May 2016)
    d. Engagement with a patient focus group (Local – PPI exercise 2016)
8. Obtain data about uptake of the app based on feedback from users and experts

Continuation:

9. Explore continuation of the work through collaborations and larger grant applications

For reference the Gantt Chart from the original application is included below:

Table 1: Gantt chart detailing timeline for tasks to be completed



Report on Objectives

This section details how each of the tasks (1-9) have been addressed over the 6-month bursary.

Smartphone development

Task1: Acquire examples of 'typical' nystagmus eye movements from volunteers for incorporation into the oscillopsia simulation app

Prior to project commencement, ethics approval was sought to scan volunteers' eyes with specialist equipment to be incorporated into a published app. Ethics approval was received on the 18th of March 2016 (1 month prior to project commencement). By the end of project month 1 eye tracking data had been acquired from three volunteers, each exhibiting a different type of nystagmus:

i. horizontal jerk nystagmus
ii. vertical jerk nystagmus
iii. horizontal pendular nystagmus

Task 2: Creation of a generic oscillopsia simulator smartphone app for public release

This task formed the core work of the project and was developed and refined from the beginning to the end of the project. The majority of the development was performed within the Unity Game Engine [Unity Technologies, San Francisco, California, USA]. This offers a flexible but refined, rapid development environment, originating from the competitive gaming industry.

Eye tracking data from Task 1 was converted manually into a format suitable to be read by Unity. Computer code was then written in the C# programming language to interpret the data file incorporating the eye rotations within Unity. Bespoke code was then written to impose those rotations onto a virtual reality camera (i.e. the 'virtual eyes').

With the eye rotations accurately recreated, scenes were constructed in which to experience nystagmus/oscillopsia. Real-life recordings/images were used rather than artificial computer generated scenes. The use of realistic scenes was considered to give a better appreciation of what it is like living with the condition. A 360° camera (Ricoh Theta S) was purchased during the project in order to capture three such scenes. A fourth scene (Ballet scene) was captured by Samsung [Samsung, Seoul, South Korea].

1. Traffic Scene: A video recording at a busy road junction to imagine what it might be like getting around and crossing roads with oscillopsia.
2. Reading Scene: A still image where the camera is positioned above a book with large text. This highlights the effect of oscillopsia when performing everyday tasks such as reading.
3. Optician's Room: A still environment incorporating a vision chart to demonstrate the effects on visual acuity.
4. Ballet scene: This scene was captured by Samsung but is freely available for use. It gives an impression of the difficulties in enjoying entertainment.

A main menu scene was also produced and C# code written to navigate between the scenes and select the different types of nystagmus to experience. The screenshot in Figure 2 shows part of the main menu scene.

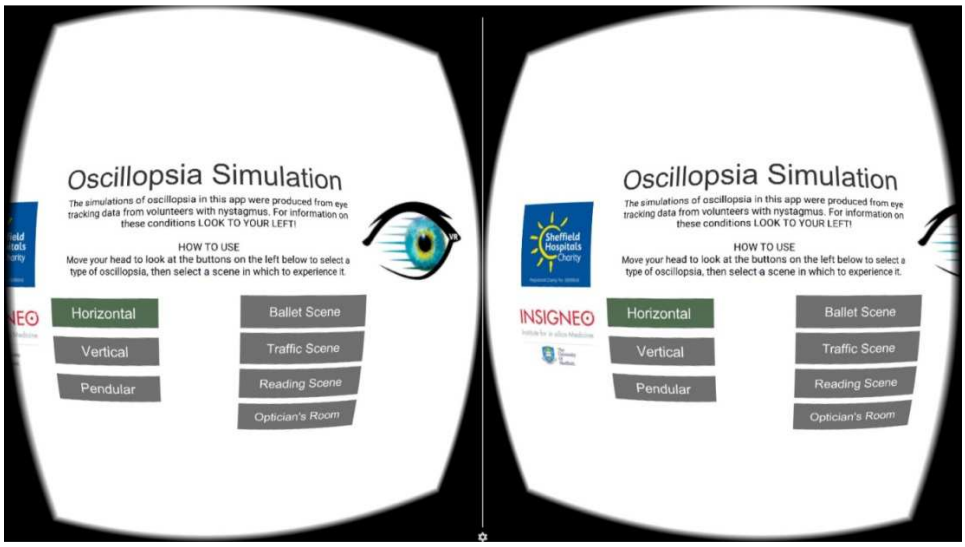


Figure 2: Screenshot of main menu viewed stereoscopically on a smartphone

Task 3: Publication of the smartphone app on Apple and Google app stores

Before the app was released a meeting was arranged with Sheffield Hospitals Charity to demonstrate the app, acquire feedback and discuss branding. The meeting resulted in the decision to brand the app with the SHC logo in several places. It was also agreed that the app should be free for download but that a link to a donation page should be advertised. Following minor changes suggested by SHC, the app was subsequently released on Google Play Store on the 23rd November 2016. The app has also been submitted to the Apple App Store and is awaiting acceptance.

Task 4: Creation of a streamlined mechanism to convert eye tracking data into a VR-ready format

The personalisation of the smartphone app to a patient's specific nystagmus eye movements creates a unique opportunity for oscillopsia suffers to take away a truly personal recreation of what it is like to 'look through their eyes'. A computer program to streamline the conversion of the Eyelink 1000 Plus data into a VR ready format was completed ahead of schedule by Month 5. With this approach, the time to create a personalised oscillopsia experience was cut from over 4 hours to 15 minutes for Android smartphones. The time to create the app for the iPhone requires additional steps but still takes no longer than 30 minutes. The protocol to produce a personalised app for Android phones is presented in Appendix 1.

Oculus Rift Development

Task 5: Development of Oculus Rift version of the app

Although a rudimentary, proof-of-concept VR demonstration was first developed for the Oculus Rift in the early weeks of the project, significant further developments were required beyond this. Oculus Rift development provided a foundation for the smartphone app version which was subsequently prioritised due to the much larger consumer base. The refinements made in the smartphone version were then applied to the Oculus Rift in the latter stages of the project. The high specification inherent to Oculus Rift operation ensures that this is a high fidelity experience, with sharper visuals and more responsive head tracking.

Task 6: Release of an Oculus Rift version of the app on Oculus Share developer's forum

The project start date coincided with a significant upgrade of the Oculus Rift. With the new release came a change in Oculus' business model from a shared system of games/apps to a highly controlled store. As a result, the Oculus Share page on which we intended to publish was removed. The removal was unforeseen and its replacement, an Oculus Store e-shop, came with stringent requirements for app publication. Publishing on this new store was considered prohibitive to the project's progress, and consequently this element was dropped from our checklist. However, a high grade Oculus Rift oscillopsia experience was still produced (Task 4) and remains a valuable showpiece for public engagement – it is just not available for download from the Oculus Store.

Exposure of the Work

Task 7: Dissemination and PPI activities

Throughout the course of the project we have embraced numerous outreach opportunities:

1. Festival of Life, RHH, 20/04/2016 (public)
2. Festival of Life, The Moor Market, 23/04/2016 (public)
3. Insigneo Showcase, University of Sheffield, 05/05/2016 (professional)
4. Nystagmus Network Open Day, Reading, 07/05/2016 (public)
5. STH 3D Day, University of Sheffield, 01/07/2016 (professional)
6. Sheffield Royal Society for the Blind (SRSB) virtual reality demonstration event, SRSB HQ, 14/07/2016 (public)
7. Medical Physics and Engineering Conference, Manchester, 14/09/2016 (professional)
8. 50 & Moor Event, The Moor, 29/09/2016 (public)
9. World Sight Day, SRSB, 13/10/2016 (public)
10. Surgical registrar teaching session, RHH, 19/10/2016 (professional)
11. Nystagmus Network Wobbly Wednesday, Medical School, 02/11/2016 (public)
12. SRSB virtual reality demonstration event, SRSB HQ, 14/11/2016 (public)
13. British and Irish Orthoptic Society Northern Meeting, Newcastle, 16/11/2016 (professional)
14. Numerous PPI meetings throughout the project (mix)
15. Preliminary version of app released on a VR developer's forum – SideloadVR (public)
16. Published final version of the app on Google Play Store and Apple App Store (public)

The level of interest and enthusiasm received from both the public and professionals compelled us to direct significant time and effort into pursuing a wide range of dissemination activities. At all the events listed above there was a high level of interest in our work and it was apparent that people left each session with an awareness and a good appreciation of oscillopsia. The Nystagmus Network Open Day and demonstrations at SRSB attracted a high proportion of individuals affected by the condition. Encouraging comments were received; parents expressing their gratitude for a glimpse into what their children with nystagmus sometimes experience and people with nystagmus describing the virtual reality simulation as a good representation of what they have experienced in the past. A questionnaire handed out during the SRSB events indicated 97% would be interested in downloading the app. Professional outreach at the STH 3D day gained the attention of local clinical colleagues. At the event an ocular surgeon expressed an interest in modifying the app for a particular subset of oscillopsia patients (gustatory oscillopsia), an investigation into this potential clinical use is ongoing.

This project has made a real commitment to outreach, exceeding the terms of the original grant application and bringing positive benefit to the work as a result.

Further details of each of the outreach events is provided in Appendix 2.

Task 8: Acquire data on app uptake and feedback from users

Release on the developer's forum, SideloadVR, resulted in over 70 downloads between its release on 24/10/2016 and the 20/11/2016. Release on the Google Play store received over 30 downloads in the first 6 days of release prior to any advertisement. The app has received six 5-star reviews on Google Play, most of which commented on the valuable appreciation gained for the condition. Release on the Apple App Store is pending as it traverses Apple's pre-release review process and is awaiting feedback.

Task 9: Continuation of the work through further grant applications

Continuation has been sought through requests for funding to support two main avenues:

i. The correction of oscillopsia in VR by tracking the eyes and correcting a display in real time

   The latest release in VR technology permits the eyes to be tracked within the VR headset. We aim to exploit this advancement by moving the display within the VR headset to synchronise with the patient's eyes to present the oscillopsia sufferer with a stabilised image. This would introduce a significant improvement to quality of life for these patients.

   An application for the correction of nystagmus was submitted to the MRC Confidence in Concept funding route in May 2016. This received some positive feedback but was unsuccessful primarily due to comments concerning the business case. A second application has been sent to the National Eye Research Centre in November 2016.

ii. The extension of the simulation of oscillopsia to a wide range of other ocular conditions to create a 'Visual Impairment Suite'.

   A strong relationship with the Sheffield Royal Society for the Blind (SRSB) has been built as a direct result of this project. This has led to the concept of extending the simulation of oscillopsia (which has already been of use to SRSB) to a wide range of other visual impairments. Three sets of resources are planned to show the effects of different visual impairments: YouTube videos, smartphone VR app and a high fidelity VR headset experience. The application proposes that SRSB becomes the flagship centre to pilot the VR visual impairment resources with the placement of a high fidelity VR experience in the concourse of their building in Sheffield city centre. The application is strengthened by the SRSB's role as a natural outlet for the work.

Both application routes have been a direct result of this project and would not have been conceivable or possible otherwise.

Additional Achievements

In addition to achieving the tasks as outlined above, several extra accomplishments can be reported:

- A modified version of the oscillopsia simulation has enabled an undergraduate project for an orthoptics BMedSci student to be supported. The project aims to use the oscillopsia simulation to measure the effects of severity of oscillopsia on visual acuity. This is the first attempt to determine the effects of oscillopsia on visual acuity in the literature and it is anticipated to form the basis of a peer reviewed publication.

- We have sought to assess how representative of oscillopsia the simulation is. To do so we applied and obtained ethical approval to record eye movements of infantile nystagmus sufferers who have previously experienced oscillopsia. The eye recordings of the infantile nystagmus sufferer were then recreated in VR and they were asked to fill in a questionnaire to determine how similar the experience is to their previous experience of oscillopsia. This provides a form of validation for the VR oscillopsia simulation and also delivers data to support a publication in the form of a technical note detailing the concept of oscillopsia simulation.

Reflection

This 6-month project has predominantly run to schedule throughout and culminated in a virtual reality app to simulate oscillopsia as described in the original application. Feedback from SHC was incorporated and permission to publish was granted. The publication routes for both iPhone and Android phones were successfully navigated and feedback on Google Play has been unanimously positive – receiving six 5-star reviews.

A version of the oscillopsia simulation was developed for the Oculus Rift to provide a high fidelity simulator. However, the unforeseen removal of the Oculus Share website has meant this has not been published for public consumption. However, it is still valuable as a high fidelity resource for the clinic and attracts much interest at outreach events.

Frequently, at multiple stages of development throughout the project, the app was demonstrated to the public, professionals and individuals suffering from nystagmus. The response from all participants was one of overwhelming support. Value was added by observations of how different individuals interacted with the app and individual feedback informing the apps' development and features.

The goal of creating a personalised app for patients suffering from oscillopsia has been successful. This process is highly automated requiring only minimal human intervention. The current implementation means personalised eye tracking data can be incorporated into the app within 15 minutes. The power of such an app cannot be underestimated. It permits the oscillopsia sufferer to effectively and accurately communicate their condition to others at their discretion.

Additionally, work beyond the project continues to validate the authenticity of the app and such an exercise will provide the data necessary to complete a manuscript for scientific publication.

Conclusion

This project has not only delivered the principal objectives laid out in the original application but opened doors to new collaborations and possibilities. The reaction to our work from a wide range of backgrounds has been universally positive and has led us to propose an expansion of this project to create a suite of VR simulations of different visual impairments in collaboration with the SRSB – an avenue which was inconceivable prior to this project.

VR is still an unknown quantity, but this project has demonstrated that it has relevance beyond the gaming industry and, through the use of accessible VR technologies (Google Cardboard + smartphone), VR can positively influence patient quality of life. We thank SHC for its forward looking stance at promoting such developments for patient benefit.

References

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Appendix 1: Protocol to produce personalised nystagmus app

The procedure to create a personalised app when a patient with nystagmus has their eyes tracked.

1. Complete eye tracking fixation protocol on Eyelink 100 Plus
2. Output a ‘Sample Report’ from Eyelink’s Data Viewer software:
    a. Analysis -> Reports -> Sample Report
    b. Choose the following to include in the report (the order is not important):
        i. LEFT_GAZE_X
        ii. LEFT_GAZE_Y
        iii. LEFT_IN_BLINK
        iv. RESOLUTION_X
        v. RESOLUTION_Y
        vi. RECORDING_SESSION_LABEL
        vii. RIGHT_GAZE_X
        viii. RIGHT_GAZE_Y
        ix. RIGHT_IN_BLINK
        x. TIMESTAMP
    c. Save as .xls file
3. Run the computer program: ‘Eyelink2VR.exe’. Follow the steps as instructed:
    a. If tracking data for both eyes exists a popup asks the user which eye data to use
    b. The waveforms of both the horizontal and vertical components are displayed and the user is asked to choose one.
    c. The selected component of the waveform is then displayed and the user must select a suitable region (a typical region and without blinks) to use in VR.
    d. The selected region is displayed to the user and the user can OK this region or try again.
    e. The program then completes and the user is asked to select a directory in which to put the .txt file containing eye rotations over time.
4. The file named ‘NystagmusPersonalised.txt’ is then ready to be placed in the ‘resources’ directory of the Unity project. It should replace any existing text file called ‘NystagmusPersonalised.txt’.
5. Within Unity the ‘Your Personalised Nystagmus’ button should be made active in the inspector.
6. The app can then be re-built for Android (File -> Build Settings -> Android -> Build).
7. The .apk file can then be loaded onto the patient’s Android phone by (preferably) connecting it via USB (although other mechanisms could be used e.g. Google Drive, Dropbox).
8. The patient can then install the app by finding it in the phones file structure and pressing the logo.
9. The app is then ready to be used and will appear on the apps page on the phone.

Appendix 2: Summary of outreach events

1. & 2. Festival of Life – Sheffield (20/04/2016 & 23/04/2016)

The Festival of Life is a week-long event organised by the University of Sheffield to engage with the public from the local area and showcase research at the university. David Randall contributed to two separate events during the week under the banner of the Sheffield Hospital's Charity and BRET (The Bardhan Research and Education Trust of Rotherham that funded David's PhD).

The first event was held in the Medical School on the 20/04/2016 which showcased work in the Medical Physics Section with a stall for virtual reality and a rough prototype nystagmus demonstration. The event was successful and saw approximately 50-70 members of the public attend over a 2-hour period.

The second event was held in the Moor Market in the city centre of Sheffield on 23/04/2016. The event saw hundreds of passers-by engage with the demonstrations on display. Our virtual reality stall was extremely well attended and was received with great enthusiasm from all ages – particularly families with young children. There was genuine interest in what we were trying to do with our nystagmus research and in particular there was great support and encouragement offered from the mother of a nystagmus sufferer.

Festival of Life event at the Moor Market

3. **Insigneo Showcase – Sheffield (05/05/2016)**

This is an internal event within the University of Sheffield organised by Insigneo. We were asked to set up a stall to disseminate virtual reality applications including the prototype nystagmus demonstration throughout the day. This was mainly to disseminate the work to other researchers and NHS staff within Sheffield.

4. **Nystagmus Network Open Day – Reading (07/05/2016)**

The Nystagmus Network is a small charity entirely dedicated to supporting nystagmus sufferers. Once a year they hold an 'Open Day' event which is attended primarily by people and families suffering from nystagmus. The event had over 100 attendants. We were one of 4 groups at the event with a stall to showcase research into nystagmus. The nystagmus research being performed by our group was highly relevant to the attendees of the event who related to the work enthusiastically. A couple of comments from the event were:

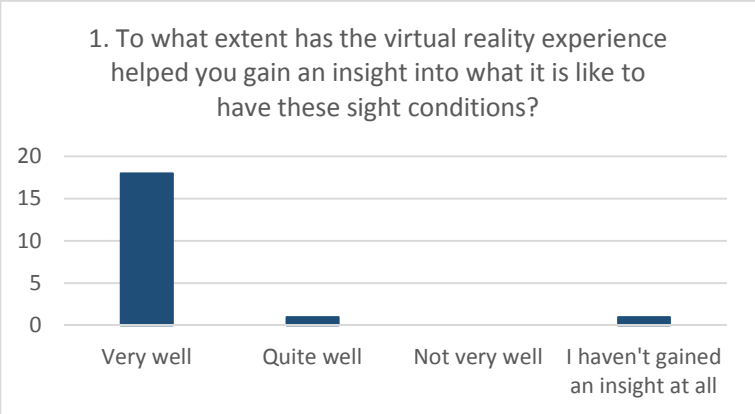
- With an interest to download the app one parent of a nystagmus sufferer said, "When will the app be available on the phone"
- More than one infantile nystagmus sufferer experienced the oscillopsia in virtual reality made comments such as, "This is representative of the oscillopsia I have experienced in the past"

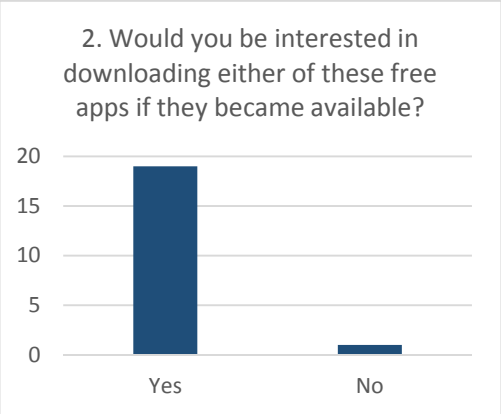
5. **Sheffield Teaching Hospitals 3D Day (01/07/2016)**

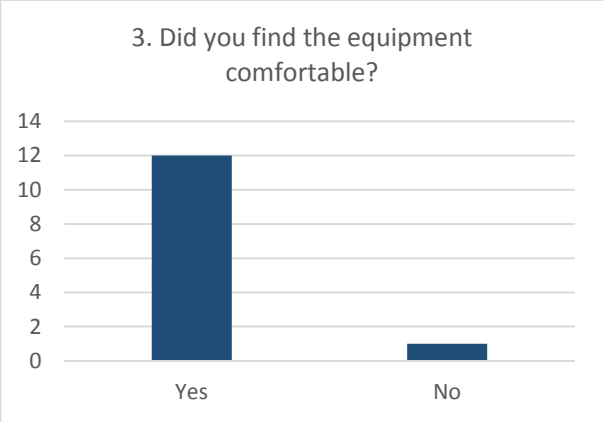
Dr John Fenner presented some of the virtual reality demonstrations under development in an oral presentation. During the lunch and tea breaks David Randall ran a demonstration station with 3 virtual reality headsets running the nystagmus oscillopsia simulation. Both components were well received and were the focal point of much interest over the day. Over 50 people saw the presentation and came to experience virtual reality over the day. The audience comprised primarily of researchers, clinicians and clinical scientists working in the local area. This has led to further discussions with local colleagues: one is a researcher in neuroscience (SiTRAN) and the other an ophthalmology surgeon interested in producing a patient specific virtual reality simulation of some of his gustatory oscillopsia patients to help decision making of whether to operate.

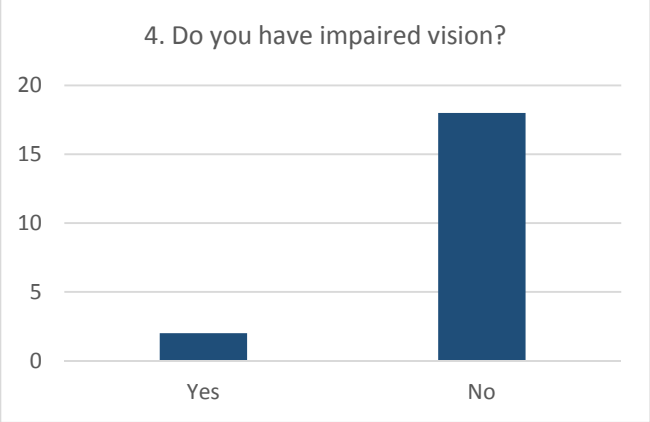
6. **Sheffield Royal Society for the Blind virtual reality demonstration event (14/07/2016)**

A stall to demonstrate the nystagmus virtual reality experience was set up in the foyer at the Sheffield Royal Society for the Blind's headquarters in Sheffield city centre. The event was well advertised on social media and other websites and received plenty of attention with several coming to the centre specifically to see the virtual reality demonstration. The reaction from every participant was extremely positive; many took our contact details with them, others left their contact details with us and most filled in a questionnaire evaluating the oscillopsia experience. See below for summary of responses to the questionnaire.









Specific highlights and feedback:

The parents of a child who had nystagmus came along with the child's teaching assistants to experience how the young boy may see the world. They were overwhelmingly encouraging of the work and very enthusiastic. They felt the simulation gave them a first-hand experience of nystagmus and oscillopsia which their son experiences. The family also informed the soon-to-be-teacher of the boy, requesting her to visit the demonstration. As well as showing the teacher the simulation, our orthoptics colleague, Anne Bjerre also provided the teacher with useful information on the special requirements the boy may need.

A man who worked at the SRSB had nystagmus and had experienced oscillopsia before (when he is anxious or in a busy environment), he tried the simulation and remarked that it was very similar to what he has experienced in the past.

Some who came to the demonstration had never heard of nystagmus or oscillopsia, so the demonstration also helped raise awareness of the condition. They were taken aback by the severity of the condition and realised that oscillopsia affects patients' day to day life massively.

When we showed the staff of the SRSB the Google Cardboard (which is only £9) and said that one potential aim was to produce an app simulating certain sight conditions to be viewed in the Google Cardboard – they were very keen to have discussions, citing that it could help their centre.

Several parents of children with the nystagmus were also interested in the development of the app so that the conditions can be simulated to others so they can form a clearer understanding.

The success of this event cannot be understated and a second virtual reality event was arranged for the end of the project to disseminate progress and advertise the app for public download.

An SRSB Tweet of the VR outreach event at their premises

7. Medical Physics and Engineering Conference – Manchester (12-14/09/2016)

An oral presentation was made to an audience of technical experts. Feedback was positive and our work was said to be "interesting". The conference also presented a chance to network with colleagues in medical physics. The VR simulation caught the attention of the editor of a medical physics journal who offered to look over an abstract of the forthcoming manuscript/technical note communicating the oscillopsia simulation app.

8. 50 & Moor Event – The Moor, Sheffield (29/09/2016)

We were invited to join the SRSB at The Moor, Sheffield city centre. Passers-by enjoyed interacting with the group and the VR oscillopsia simulator helped to get their attention. A member of local TV station/journalist was interested in the work and expressed a desire to meet up to talk about it further (though I have yet to hear from him).

An SRSB Tweet promoting the VR simulation at the '50 and More' event

9. World Sight Day – SRSB event (13/10/2016)

We were invited to demonstrate the VR simulation at the SRSB World Sight Day event in the foyer at the Sheffield Royal Society for the Blind headquarters. Clients of the centre and people passing by were invited to experience the VR oscillopsia simulation. This included staff from the University of Sheffield engineering department who were fascinated by the condition and were pleased to have the opportunity to experience the visual impairment. One commented that a colleague had nystagmus and this was a real 'eye-opener' to know the kind of challenges they must face on a daily basis.

The VR demonstration for World Sight Day at the SRSB premises

10. Invited to demonstration/present at teaching session for surgical registrars (Sachin Salvi)

Demonstrated the app to 15-20 surgeons at the invitation of Sachin Salvi a consultant surgeon interested in using the app for gustatory oscillopsia patients. It was well received and provoked much discussion among the surgeons.

11. Nystagmus Network, Wobbly Wednesday - Local (02/11/2016)

A stall was set up in the main entrance to the medical school. Students, porters and academics were given the chance to experience oscillopsia. The effects of the condition were well understood by some who commented "I couldn't live like that!".

A demonstration in the Foyer of the Medical School for Nystagmus Network's Wobbly Wednesday event

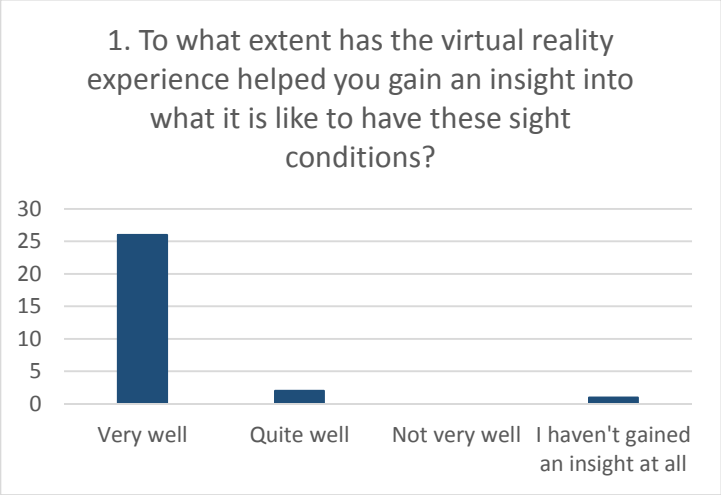
12. Final VR nystagmus app showcase demonstration SRSB HQ

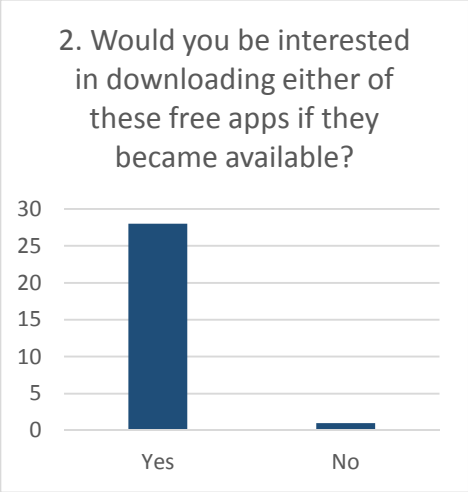
Following the success of the first demonstration at the SRSB this was planned as a continuation to showcase the latest developments towards the end of the project. The event was a huge success. A few comments were:

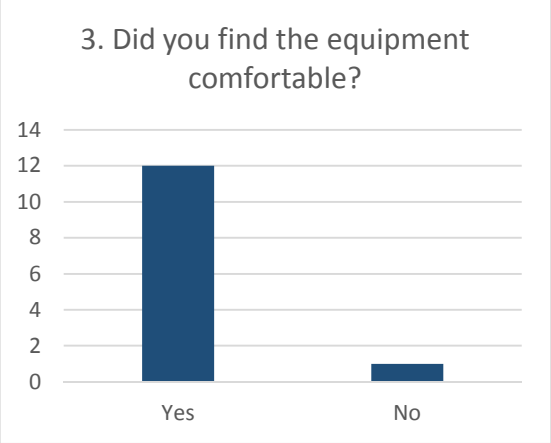
- Written on SRSB's Facebook page: "*Wow! We came along today to use the headset as my 4-year-old daughter has Nystagmus. It was amazing to be able to see how people with Nystagmus see. I have to say that I felt quite ill using it. People with Nystagmus are truly amazing! I feel very fortunate that we got the opportunity to use this and to speak to the people involved. Truly amazing. Thank you."*
- On the Questionnaires handed out after the demonstration:
  "This has been a great experience to help me understand my daughter's nystagmus"
  "Fantastic, should be available for all to see"
  "Amazing"

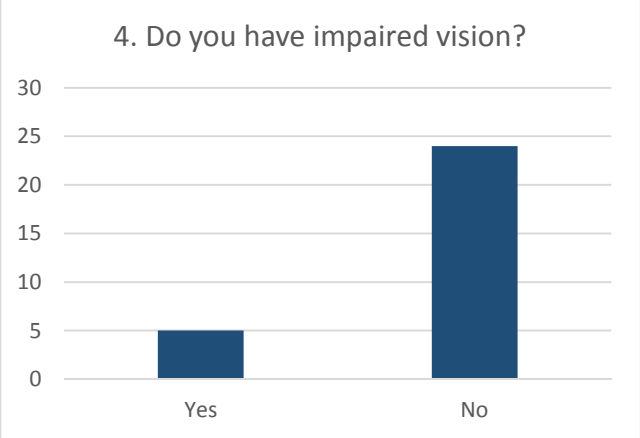
"I found it very interesting to see how individuals with visual impairments live. I would like to see more of this information about impairments"
"I would like to see this technology progressed"
"Great Technology, looking forward to the future, especially simulation of macular degeneration. It was a massive relief when the oscillopsia stopped and returned to normal, you could see how it could offer relief if you corrected for the eye motion"

Collection of all questionnaire feedback from both the event on 14/07/16 and on 14/11/16 produces the following statistics:









13. **British and Irish Orthoptic Society Northern Region Clinical Meeting (16/11/2016)**

A formal presentation on the virtual reality app was given at a clinical orthoptic meeting. There was significant interest from the audience and many approached afterwards to experience oscillopsia. In particular, colleagues in Liverpool were impressed and wanted to contact some patients with oscillopsia who may benefit from developments at Sheffield.

PPI Meetings

Nystagmus Participant 1, 15/07/2016

Feedback: Positive about the project – 'good idea', good for dissemination to and use by people with nystagmus SRSB and similar institutions – Michael thinks it would be very useful as a mobile phone app.

Suggestions: Better scenes (current scene being demonstrated is a video of a junction in Hillsborough), perhaps make a walking/moving scene, eventual goals beyond this funding could be towards a larger visual impairment app where lots of other conditions are also simulated. Go to another nystagmus network open day event once the apps and project is completed.

Nystagmus Participant 2, 22/08/2016

Feedback: Positive – The app looked good, demonstrated oscillopsia well. The participant thought the app was great to demonstrate and show to people at events such as that at the SRSB and for infantile nystagmus patients to understand the condition themselves. The participant questioned the use of the app for public consumption as he thought they would not generally be interested but agreed that for people affected by nystagmus, such as those with family members with nystagmus, it could be of great benefit.

Nystagmus Participant 2, 07/11/2016

Feedback: App looked good. For visually impaired it is difficult to read the writing on the pop up as it would take too long. It would be better to include the pop up within the scenes – not the main menu.

Nystagmus Participant 3, 02/11/2016

Feedback:

- Writing in main menu hard to read and too wide so have to move head quite a lot to read it
- Write "HOW TO USE" in big letters on the instructions to draw attention to it
- DR suggested popping up instructions at the start of every scene (how to return to main menu and toggle nystagmus) Lindsey thought this was a good idea

Actions:

- Make writing bigger in main menu
- Reduce writing so it is in a narrower column
- Add pop up instructions as you enter each scene

Healthy PPI group (3 people), 16/11/2016

Feedback:

- Good, very intuitive.
- Have to angle head very vertically to access ‘return to main menu’ button
- In the high quality, expensive headset the splash screen, writing etc. is fine but in the cheaper headset the field of view is insufficient to visualise all the information
- Bug spotted: Reticle visible on arrows in main menu

Actions:

- Make button larger to return to the main menu
- Make splash screen, loading screen and ‘return to main menu text’ smaller
- Hide the reticle when looking at the arrows

Appendix 3: Spending Summary

Note: As a summary report, the following provides approximate spend only. Researcher salary for 6 months FTE is not shown. For a detailed breakdown of costs please contact Dr Andrea King (a.r.king@sheffield.ac.uk) at the University of Sheffield.

- Ricoh Theta S 360° Camera: £300
- VR headset (Homido v2, Google Cardboard): £60
- Dedicated VR headset: £440
- App publishing fees: £80
- Travel + Outreach: £120

Total Spend: ~£1000