Eye testing at home – developing an app for measuring vision

BY STEPHANIE CAMPBELL

COVID-19 has made home vision monitoring a necessity. **Stephanie Campbell** shares how her idea for a vision testing app that would engage patients became a reality.

Months before COVID-19 first began to mutate to its human host, there was a small team of software developers, vision scientists, optometrists and ophthalmologists working hard to build a system that would allow vision monitoring to take place at home. We all understood that the growing imbalance between demand and supply in ophthalmology was unsustainable, and we all knew that self-monitoring would ease that burden. I had a bold dream that 50% of follow-ups could be seen 'virtually', if only the correct information were in the right hands. While I knew this was an achievable target, it did seem ambitious every time I said it out loud.

Little did I know that, within months, our in-person appointments would have slashed and that my bold dream would be a practical and necessary goal within mainstream ophthalmology, and that across the world, we'd all be plugging away to make it a reality.

Since my very first hospital job (Queens Medical Centre, Nottingham, 2010), I've been steeped in a world that combined the clinical and the academic. When I went back to university to study research, I'd work in the hospital for part of the week and in the university research clinics for the rest. However, the gap between the equipment levels in academia and in real hospital clinics was profound, and it always felt ironic to me that the patients most in the need had access to the least equipment and the least time with specialists.

I've been fortunate to be inspired by the very best people who brought their research into their clinics – where their clinics felt alive with passion and with thought and purpose. They brought out the best in others, and a sense that the knowledge of today is only a small part of what will drive our clinical practice of the future (and that we have a responsibility to fill that gap). So, too, was the concept that we could tangibly impact the lives of our patients by the things we created. My PhD Supervisor Maggie Woodhouse created vision tests (Cardiff Cards) for toddlers and for people

of all ages with learning disabilities, bridging a gap that had gone ignored in clinical testing until then.

It was only when a patient of mine refused to have his eyes tested, whilst being completely pre-occupied with the iPad he'd spotted on my shelf that the idea came to mind. Why couldn't he test his own vision? Meanwhile, Ophthalmologist Luke Anderson believed the automation of vison measurement would increase precision of vision testing out-of-hours, when the orthoptic department was closed and when juniors were running the hospital. It wasn't a huge leap for us both to imagine that we could get patients to self-test at home and simply oversee the results.

Years of listening to patients read eye charts had taught me the first thing – this had to be self-administered for it to be efficient, and secondly – well, it had to be fun. I'd been a subject in enough vision science

experiments in my short time to know that the accurate measurement of vision took time, and that it was usually insanely boring for everyone involved.

Unlike most people who have developed apps to measure vision, we didn't want to compromise on the vision science – we wanted to bring it into people's homes. The answer was to gamify the experience (vision tests hidden behind simple video games), ideally so that the patient could forget they were having their vision measured at all, and so be keen to do it on a weekly basis. We knew gamification would lead to better engagement and compliance – but crucially, from a scientific perspective, we could keep the patient playing for much longer and gather more data toward a much more accurate result.

While I originally envisioned that we'd be developing apps to measure vision, we've ended up doing much more than
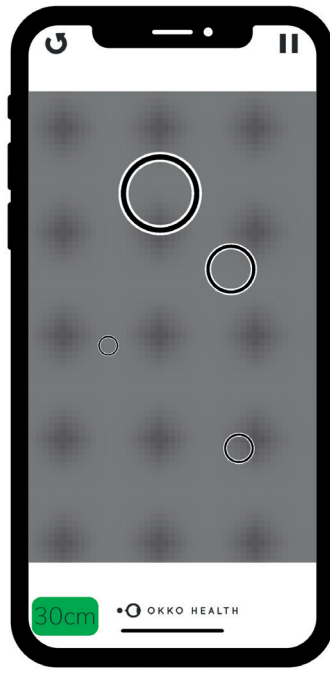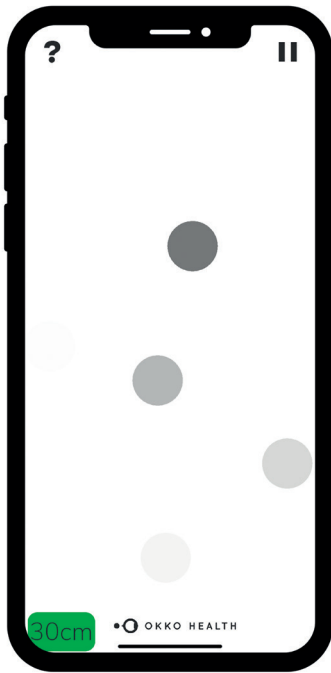
that – we've developed a system approach, that has a back-end that a clinician can log into to view results, with clever code that even adjusts the acuity score for the pixel size of the phone (and thus the size of the optotype). There are complex analytics developing that will soon get to know the pattern of gameplay for an individual and use artificial intelligence (AI) to identify deterioration at the earliest possible stage.

It's been 18 months since I took the plunge and went full time, and looking back, the comprehensive approach we took has allowed the team to develop the most user-friendly and scientifically robust remote monitoring system for the emerging self-testing market. For me, it's been an absolute pleasure to bring together the creative side I always had lurking inside of me, together with the scientific approach core to vision science and ophthalmology.

Being a non-ophthalmologist in a hospital, I have been so fortunate to have had much 'sitting in' with other professionals over the years, and this 'fly on the wall' time taught me patients' true reflections and fears when other professionals have left the room. This, combined with training from different aspects of eye care including areas like low vision assessments, has given me a deep understanding of patient need. A partnership with the Macular Society really highlighted to me support needs that simply weren't able to be given in hospital, no matter how well intended we hospital professionals are. Most importantly, I learnt that much supportive care would be better served outside of the hospital, where patients were more relaxed. Certainly, this will help us to use clinical time more

effectively. Therefore, a big component of our tech is to build in supportive information about eye care support services and reg flag symptoms, at the patients' fingertips.

I also have a part time role with a Health Board in Wales, wherein I support primary care to work more effectively and work to reduce geographical inequity in eye care. It's made me realise the potential of vision home-monitoring to reduce the travel burden on those with poor transport access, and for those who are working and who struggle to make set appointments.

As well as supporting patients through difficult times, home-monitoring has the potential to create manageable clinics for us all, helping us to spend more in-person time with the patients who need it, and reassuring those who do not need to be seen. When we move this service to be semi-automated through the use of AI, clinicians won't need to manually review all results, and we'll be able to look after more patients on waiting lists, more safely, and more effectively. This tech could be used to widen clinical trials, and to provide granular data several times a week on aspects of vision like contrast and colour, that we wouldn't usually have.

We want to drive down the cost of delivering great eye care at scale, providing a safety-net technology that makes clinicians and patients feel knowledgeable and safe. As such, our technology is a "software as a medical device" and is subject to much regulation and heavy clinical trials that we are now embarking on. We decided to become certified as a medical device manufacturer at an early stage, so that hospitals and patients would know we were serious about developing the best

home-monitoring software on the market. However, this has been a whole new world for me and the paperwork is enough to rival even NHS systems!

The most challenging part of having a tech start-up is learning a new language: that of software developers, teaching each other what's possible with vision science and coding respectively, and creating a shared knowledge base so that we can quickly iterate and bring new ideas to life. While it's tough work, it's also the most enjoyable aspect, and I delight in being able to incorporate the ideas of our growing scientific and clinical collaborators with the hard work of the team, to bring the ideas to life.

Right now we're focussing on paediatric amblyopia and on adult maculopathy monitoring. But my dream is that in the years to come, every patient will have a 'companion app' for their specific eye disease, helping them, and us, to track their vision and provide both early alerts and support when they need it. Perhaps it is a silver lining of COVID-19 that we have a unique chance to streamline our clinics and run them in the way that works for us and for patients too.

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