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CS4FN

Computer Science for Fun

Issue 19

Touch it, feel it, hear it!

HapticWave: Feel the sound

Josephine's Tactful watch

Designing robots that care

Queen Mary University of London

Touch it, feel it, hear it!

by Paul Curzon

This issue is devoted to multimodal design, showcasing technology designed to help us experience the world using computers, but through more than one sense at once. Multimodal design is also a great way to support people with limited senses who can't hear, or see, or smell, or taste or touch. Some people find lots of sounds, sights, textures, tastes just too much, and we look at how computer science might one day help them too.

With the HapticWave you can hear and feel a sound wave, with the oPhone you smell a coffee and see a coffee even when there's no coffee anywhere near, the baby birthing monitor lets mums know when to push based on a beep and a graph. We focus on a research project called DePIC ('Design Patterns for Inclusive Collaboration') that is looking for the best ways of using combinations of senses. It is finding the best ways to help people with different senses available work together.

Touch the air

by Peter McOwan

Air is quite useful stuff, but we tend to think of it as light and fluffy, rather than sharp and pointy. Researchers at Bristol have found a way to create shapes out of thin air that we can actually feel.

Sound occurs when waves of pressure move through the air. Normally these waves have low power, like conversation or music. It takes the clever delicate structures of our inner ears to detect them. Our ears convert the waves into brain signals that let us hear. Really loud sounds, high intensity pressure waves, can actually be felt too. Pressure receptors in our skin can pick them up. Hearing an aircraft take off or being at the front at a rock concert both sound and feel loud. It's like being hit by a big wave. Listening to sound this loud for long can cause hearing problems precisely because our ears are fragile so that they can pick up the normal sounds.

So, is there a form of sound powerful enough to be felt by the pressure sensors on our fingers but safe? To allow us to feel shapes, it needs to be precise enough that different parts of the air next to each other feel different, just like pixels in a picture change colour from place to place.

The breakthrough for the Bristol team came when they created a small grid of tiny sound cannons able to launch their signals under computer control. The sound they use is ultrasound: sound at a frequency high above what the human ear can detect, so it does no harm. It has lots of uses like creating medical scans – that picture of your baby sister or brother in the womb was taken using ultrasound. Ultrasound can also clean dirty jewellery, shaking off the grime. At the right level the pressure that it creates in the air can be felt by our fingers.

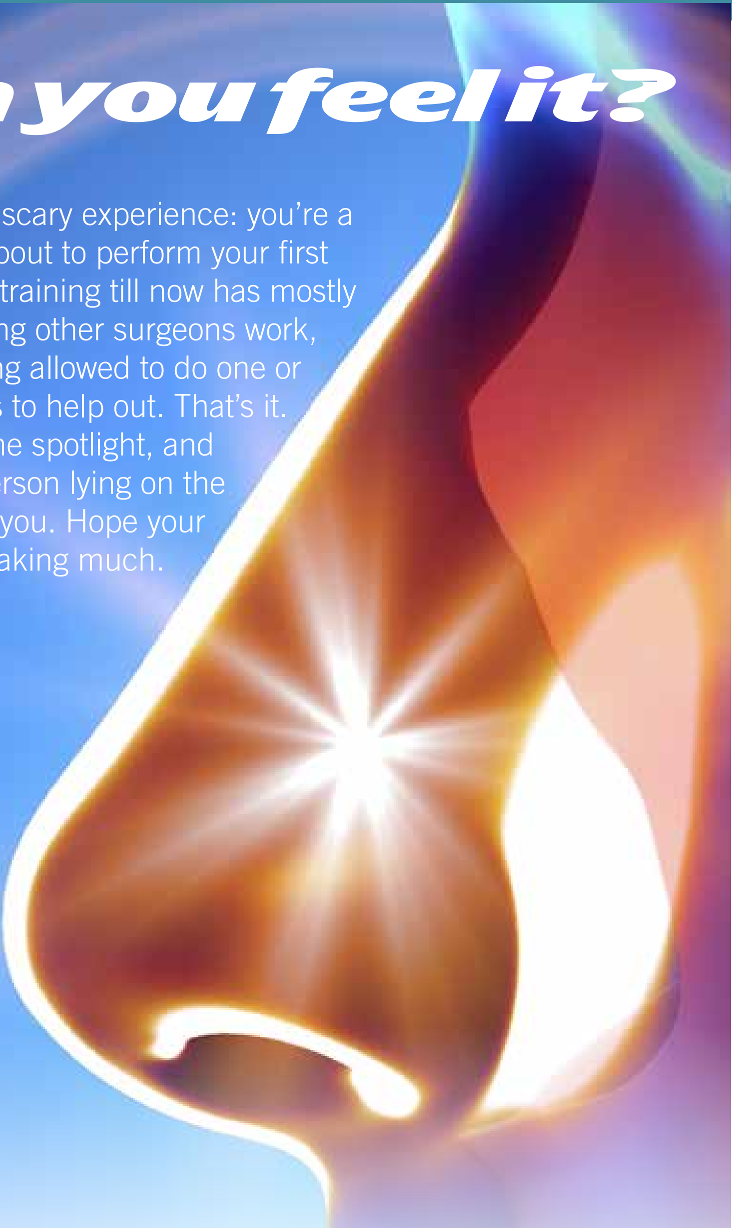
Using their ultrasound array the Bristol researchers can produce pressure patterns in the air that make it feel like you are touching an actual object: a cone or a sphere, for example. It's still early days but they hope to combine this haptic, touch interface with augmented reality. Graphical objects will be placed into the scene in the field of view of people wearing a special head visor. Once it works, we will be able to both see and touch objects that only really exist in the memory of a computer. The feel will seem real thanks to the right sound in the right place.

a grid of tiny sound cannons launch their signals

Can you feel it?

by Jonathan Black

How's this for a scary experience: you're a new surgeon, about to perform your first operation. Your training till now has mostly involved watching other surgeons work, and maybe being allowed to do one or two small things to help out. That's it. Now you're in the spotlight, and there's a real person lying on the table in front of you. Hope your hands aren't shaking much.



Fortunately, training simulators are being used more and more to give medical students something to practise on. They're finally getting cheap and powerful enough to allow more medical schools to buy them. Many modern simulators can even make it feel like you're working on the real thing by giving you feedback through your sense of touch: haptics. The simulator gives back the same movement and resistance you might get if you were genuinely suctioning blood or drilling into bone.

One of the newest simulators, developed at Stanford University, goes one better. It doesn't just have you practise on a made-up, model patient: you can actually upload real patient data into the simulator and practise for a real surgery you're just about to do! The Stanford folks practise sinus surgery, so their simulator is a mannequin's head attached to a haptics system. The surgeon's job is to insert a small camera in a tube, called an endoscope, into the patient's nose. Based on how far the scope goes down the sinus cavity, the haptics system figures out the amount of resistance the student should feel. It won't be just for students though. Senior doctors might want to upload data from patients to practise for a particularly difficult surgery.

Ada Lovelace competition

This year marks the 200th anniversary of the birth of Ada Lovelace so the next issue of cs4fn will be inspired by Ada. In the meantime enter a competition about her at **www.tnmoc.org/ada** run by the National Museum of Computing and Oxford University.

Putting your hand up a cow's bottom

by Jonathan Black

Haptics can help not just doctors, but veterinarians training – and it can help not just in the head but, errr, at the other end too.

Trainee vets have to learn how to feel for animals' organs. In small animals like dogs and cats you can do that just by feeling the outside of their tummies, but in larger animals like cows or horses you have to actually put your hands inside them. That's right, up there. Now the thing is, this is a very difficult thing to learn how to do properly. A teacher can't demonstrate it, because the student can't see what they're doing. Likewise when the student tries it, the teacher can't see to know if they're doing it right. Usually they just rely on describing what they're doing (and how the animal reacts, of course).

Fortunately for teacher, student and especially animal, Sarah Baillie and her colleagues at the Royal Veterinary College invented a simulator called the Haptic Cow. It's a haptic model of a cow's rear end, complete with 'Ouchometer' – a graph that shows whether the student's movements are too gentle to be effective, just right, or too rough to be safe. By using the Haptic Cow, students get an accurate idea of what they'll be doing in their real jobs, the teachers can see better feedback of how well the student's doing, and real cows don't have to worry about being practised on. For doctors, vets and their patients, haptics are helping to make sure that practice doesn't have to mean petrifying.

The Tactful Watch

by Paul Curzon

Jewellery and high technology don't mix much. Personal gadgets are one thing, jewellery quite another. That hasn't always been the case though.

In the 18th century there was a mobile revolution like the current one. Back then the technology wasn't the smart phone but the pocket watch. The 18th century watchmakers weren't just innovators though they were also artists and craftspeople. The result was exquisite jewellery that was also highly functional.

One of the absolute masters was Abraham Louis Breguet. Born in Switzerland, he set up business in Paris and was to become one of the greatest innovators ever. His clients included the likes of Marie-Antoinette, King George IV of Britain, the Sultan of the Ottoman Empire and Tsar Alexander I of Russia. Rather than build lots of identical watches he constantly tinkered with the designs. The result was that he is responsible for some of the most important innovations in clock technology. Many of his inventions were technical advances such as the first self-winding watch. He realised the importance of making his designs easy to use too though. A Breguet watch, made for the Queen of Naples, for example, was the first to be worn on the wrist!

In the 21st century we are just getting to grips with new ways of interacting with our personal gadgets. People have realised that basing mobile device designs on what works for a desktop PC is not so sensible. When on the move it's not that convenient to look at a screen. Consequentially we are undergoing a revolution in multimodal computing. It involves finding ways of using our other senses not just sight to interact with our mobile tech. The way your phone vibrates in your pocket is one simple example - tactile computing, delivering information through your sense of touch.

Clever as we are Breguet was way ahead of us though. At the turn of the 18th century it was not considered polite to look at your watch in public. Breguet's solution was the tact watch: a watch that allowed you to check the time without taking it out of your pocket. Tactile and tactful computing! His solution was of course (in all senses) incredibly elegant.

It was not considered polite to look at your watch in public

Round the edge were 12 evenly spaced diamond studs, with larger ones at the 3, 6, 9 and 12 positions. On the outside was an arrow. It did not move on its own like a normal clock hand, though. That wouldn't really work inside a pocket without a glass case and then it couldn't be touched. Hidden inside the case was an actual clock. When the owner wanted to tactfully check the time they would just spin the arrow until they felt resistance. That meant the arrow was now back in synchrony with the real hour hand. They could then count round the diamond studs to work out its position and so the time.

One of the most stunningly beautiful tact watches was made for Josephine Bonaparte, Empress of France in 1800. Two centuries later it sold at Chrysties for over $1.3 million. The best we've done in the 21st century is to just dip an iPod in gold and coat it with diamonds. The result: not 18th century elegance, but very expensive 21st century bling.

Artists and jewellers are starting to work with scientists and engineers again though so maybe our modern gadgets can follow the path of the watch and become elegant jewellery too.

Clapping Music

by Marcus Pearce and Samantha Duffy

"Get rhythm when you get the blues" – as Country legend Johnny Cash's lyrics suggest, rhythm cheers people up. We can all hear, feel and see it. We can clap, tap or beatbox. It comes naturally, but how? We don't really know. Now you can help find out by playing a game based on some music that involves nothing but clapping. If you are one of the best you could be invited to play live with a London orchestra.

We can all play a rhythm both using our bodies and instruments, though maybe for most of us with only a single cowbell, rather than a full drum kit. By performing simple rhythms with other people we can make really complex sounds, both playing music and playing traditional clapping games. Rhythm matters. It plays a part in social gatherings and performance in cultures and traditions across the world. It even defines different types of music from jazz to classical, from folk to pop and rock.

Lots of people with a great sense of rhythm, whether musicians or children playing complex clapping games in the playground, have never actually studied how to do it though. So how do we learn rhythm? We teamed up with the London Sinfonietta chamber orchestra and app developers Touch Press, to find out, using music called Clapping Music.

Clapping Music is a 4-minute piece by the minimalist composer Steve Reich. The whole thing is based on one rhythmic pattern that two people clap together. One person claps the pattern without changing it - known as the static pattern. The other changes the pattern, shifting the rhythm by one beat every twelve repetitions. The result is an ever-changing cycle of surprisingly complicated rhythms. In spite of it's apparent simplicity, it's really challenging to play and has inspired all sorts of people from rock legend David Bowie to the virtuoso, deaf percussionist Dame Evelyn Glennie. Now you can learn to play Clapping Music and help us to understand how we learn rhythm at the same time.

Our team have created a free game for the iPhone and iPad also called Clapping Music. You play for real against the static pattern. To get the best score you must keep tapping accurately as the pattern changes, but stay in step with the static rhythm. It's harder than it sounds!

We will analyse the anonymous gameplay data, together with basic information about the people playing like their age and musical experience. By looking at how people progress though the game we will explore how people of different ages and experience develop rhythmic skills.

It has led to some interesting computer science to design the algorithms that measure how accurate a person's tapping is. It sounds easy but actually is quite challenging. For example, we don't want to penalise someone playing the right pattern slightly delayed more than another person playing completely the wrong pattern. It has also thrown up questions about game design. How do we set and change how difficult the game is? Players, however skillful, must feel challenged to improve, but it must not be so difficult that they can't do it.

You don't need to be a musician to play, in fact we would love as many people as possible to download it and get tapping and clapping! High scorers will even be invited to take part in live performance events on stage with members of the London Sinfonietta.

Get the app, get tapping, get rhythm (and have some fun - you won't get the blues)!

Details of how to get the app or get involved in the research are in the magazine+ section of cs4fn: www.cs4fn.org/magazine/

Dancing Robots: Speed on the Dance floor

by Paul Curzon

England football star Peter Crouch became famous for his robotic dances to celebrate goals. He promised to only repeat it if England wins the World Cup, so it probably won't happen again! What about robots dancing like humans instead then? Could a robot ever understand the music they were dancing to in the way a human does? To start with it would need to perceive the music like we do. It turns out even that it isn't so simple. We don't always hear sounds as they really are.

One experiment that showed this explored what people believe they hear when a percussionist plays an instrument. Justin London of Carleton College in the US showed it depends not just on the sound itself but also on how the musician moves as they strike the instrument. He recorded musicians playing notes on Marimbas:instruments a bit like a xylophone where the percussionist hits wooden bars with a mallet. Justin created stick figure animations of the musicians' arm movements as they made the sounds to use as the basis of the experiment.

Volunteers listened to these sound recordings. Sometimes they heard the sounds with and sometimes without the animations. They then rated how long the notes lasted. When people only heard the sounds, they could judge their length fairly accurately. Watching the animations changed their perceptions though. When the stick figure's arm movement stopped abruptly after a sound was played the volunteers thought the sound stopped quickly too. When they heard the same sound while watching an animation where a longer arm movement was made they tended to think that the sound lasted longer. What they saw affected what they thought they heard!

Justin wondered if a similar thing might happen with the way we perceive how fast a track is being played – its tempo. Perhaps on a dance floor the speed of others dancing changes the tempo a person thinks they hear. He set up a new experiment with a team from Finland to find out. First they needed some music people could dance to. They chose a series of really danceable Motown songs from Wilson Pickett, The Temptations and The Supremes. They created both a faster and a slower version of each song to go with the normal one. They then got people to dance to the tracks, asking them to separately dance vigorously and then slowly to each. These dances were filmed and turned into moving stick figure animations as with the marimba playing. A new set of people listened to the tracks, both with sound alone and while they watched the stick figures dancing to the track. For each they were asked to judge how fast the tempo of the music danced to was.

The prediction was right. What people saw did affect the tempo of music they thought they were listening to. When they just heard the music they could tell which versions were faster and which slower. But when they were watching the stick figures dancing their brains started to get confused. When they watched a dancer dancing vigorously they thought the tempo was faster, for example. That was even though the dancers were still

jerkiness of movement makes it hard to judge a sound's tempo.

keeping time to the music. Their movements were just fast and jerky rather than slow and smooth. It seems to be the jerkiness of movement that made it hard for the volunteers to judge the tempo.

So on the dance floor we don't just perceive the music as it is. It depends on the way people are dancing around us too. If a robot were really to dance like a human, then for it to also feel the same to the robot, that robot would need our quirkiness in the way it perceived the world.

Understanding our multimodal brain

Justin London's aim is really to uncover fundamental things about how our brains work. The experiments show that the way we hear sound is about more than just the sound waves that hit our ears. Our perception of sound is different to the actual sound. That's important for people who design multimodal computer systems that present information for us to sense in more than one way. If they are to work well, it matters how we perceive the things we see, hear and feel. In Justin's experiments sight interferes with sounds. For an interface that uses sound and sight together to work well, the information we perceive in the different ways has to work together not interfere like that. Experiments like Justin's can help designer's understand how to get interfaces like that right.

On from Smell-O-Vision

by Jane Waite

A phone that smells has just come up roses! You don't need to smell a rat - this is the real deal! A scent creating phone and an aroma app hits the market in 2015!

Since the early 1900's pioneers of scent technology have sought the extra dimension of smell as part of the experience of plays and films. As early as 1906 electric fans wafted scent over theatre goers. A few years later a theatre sprayed perfume from ceilings. In the 1960's the Smell-o-Vision film experience and Aromarama process used scents such as tobacco, grass and horses to accompany particular films. Sadly, the idea wasn't popular and was stopped in its scented tracks.

Then in 2013, Haruka Matsukura of Tokyo University of Agriculture and Technology demonstrated her prototype 'smelling screen'. The image of a peach smelled, well, just like a peach! Tiny fans wafted scent from 'aroma flasks' hidden in odour releasing vents to pinpoint accuracy in front of an image. It looks like chocolate and it smells like it, too. As yet, Haruka's invention hasn't gone on to be sold but research started at Harvard University has!

In 2012, Harvard professor, David Edwards, encouraged his class to 'create a virtual world of aroma'. Three years later, he and his former student Rachel Field, are launching the oPhone.

Do you smell something fishy? No, this is how the oPhone works! You smell something delicious and see a piping hot pizza, you snap a pic and use your oPhone app to figure out the 'aroma recipe'. Tag your photo and send scent. Your friend gets the pizza picture and the 'aroma recipe' that can be recreated with their oPhone! Just how does the oPhone do it? It contains 8 cartridges of scents, oChips, each with 4 scents. The latest oPhone Duo can create over 300,000 unique aromas. The oPhone translates the pizza aroma recipe into a scent using combinations of heated oChips.

Field and her team are planning to launch oPhone hotspots, in Paris, France and Cambridge, Massachusetts so you can try out the aromatic experience. Can you imagine sharing a smell with a friend who is hundreds of miles away, there must be some responsible use issues here, only nice smells please!

Smells can evoke memories, help us learn, change our mood, even change what we do! Think of a peeled orange, how does it make you feel? Does the scent of the sea remind you of a place, or a particular perfume of a person. If you smell fire, what do you do!

Why not make a scent diary, or ask your parents about memorable scents from their childhood. Perhaps make a scent jar (for example, mix coffee beans in a jam jar with a dozen or so drops of an essential oil like Orange and Cinnamon Bark).

Patterns for Sharing

by Paul Curzon and Jane Waite

Computer Scientists like to share: share in a way that means less work for all. Why make people work if you can help them avoid it with some computational thinking. Don't make them do the same thing over and over - write a program and a computer can do it in future. Invent an algorithm and everyone can use it whenever that problem crops up for them. The same idea applies to inclusive design: making sure designs can be used by anyone, impairments or not. Why make people reinvent the same things over and over. Let others build on your experience of designing accessible things in the past. That is where the idea of Design Patterns and a team called DePIC come in.

The DePIC research team are a group of people from Queen Mary University of London, Goldsmiths and Bath Universities with a mission to solve problems that involve the senses, and they are drawing on their inner desire to share! The team unlock situations where individuals with sensory impairments are disadvantaged in their use of computers. For example, if you are blind how can you 'see' a graph on a screen, and so work with others on it or the data it represents. DePIC want to make things easier for those with sensory impairments, whether it be at home, leisure or at work, they want to level the playing field so that everyone can take part in our amazing technological world. Why shouldn't a blind musician feel a sound wave and not be restricted because they can't see it (see 'Blind driver filches funky feely sound machine!' overleaf). DePIC, it turns out, is all about generalisation.

Generalise it!

Generalisation is the computational thinking idea that once you've solved a problem, with a bit of tweaking you can use the solution for lots of other similar problems too. Written some software to put names and scores in order for a high score table? Generalise the algorithm so it can sort anything in to order: names and addresses, tracks in a music collection, or whatever. Generalisation is a powerful computational thinking idea and it doesn't just apply to algorithms, it applies to design too. That is the way the DePIC team are working.

Anyone can work with information using whatever sense is convenient

DePIC actually stands for Design Patterns for Inclusive Collaboration. Design Patterns are a kind of generalisation: so design ideas that work can be used again and again. A Design Pattern describes the problem it solves, including the context it works in, and the way it can be solved. For example, when using computers people often need to find something of interest amongst information on a screen. It might, for example, be to find a point where a graph reaches it's highest point, find numbers in a spreadsheet of figures that are unusually low, or locate the hour hand on a watch to tell the time. But what if you aren't in a position to see the screen?

Make good sense

One solution to all these problems is to use sound. You can play a sound and then distort it when the cursor is at the point of interest. The design pattern for this would make clear what features of the sound would work well, its pitch say, and how it should be changed. Experiments are run to find out what works best. Inclusive design patterns make clear how different senses can be used to solve the same problem. For example, another solution is to use touch and mark the point with a distinctive feel like an increase in resistance (see the 18th century 'Tactful Watch'!).

The idea is that designers can then use these patterns in their own designs knowing they work. The patterns help them design inclusively rather then ignoring other senses. Suddenly anyone can work on that screen of information, using whatever senses are most convenient for them at the time. And it all boils down to computer scientists wanting to share.

For more on DePIC see depic.eecs.qmul.ac.uk

Blind driver filches funky feely sound machine?

by Jane Waite

The blind musician Joey Stuckey in his recent music video commandeers then drives off in a car, and yes he is blind. How can a blind person drive a car, and what has that got to do with him trying to filch a sound machine? So maybe taking the car was just a stunt, but he really did try and run off with a novel sound machine!

As well as fronting his band Joey is an audio engineer. Unlike driving a car, which is all about seeing things around you - signs, cars pedestrians - being an audio engineer seems a natural job for someone who is blind. Its about recording, mixing and editing music, speech and sound effects. What matters most is that the person has a good ear. Having the right skills could easily lead to a job in the music industry, in TV and films, or even in the games industry. It's also an important job. Getting the sound right is critical to the experience of a film or game. You don't want to be struggling to hear mumbling actors, or the sound effects to drown out a key piece of information in a game.

Mixing desks

Once upon a time Audio engineers used massive physical mixing desks. That was largely ok for a blind person as they could remember the positions of the controls as well as feel the buttons. As the digital age has marched on, mixing desks have been replaced by Digital Audio Workstations. They are computer programs and the trouble is that despite being about sound, they are based on vision.

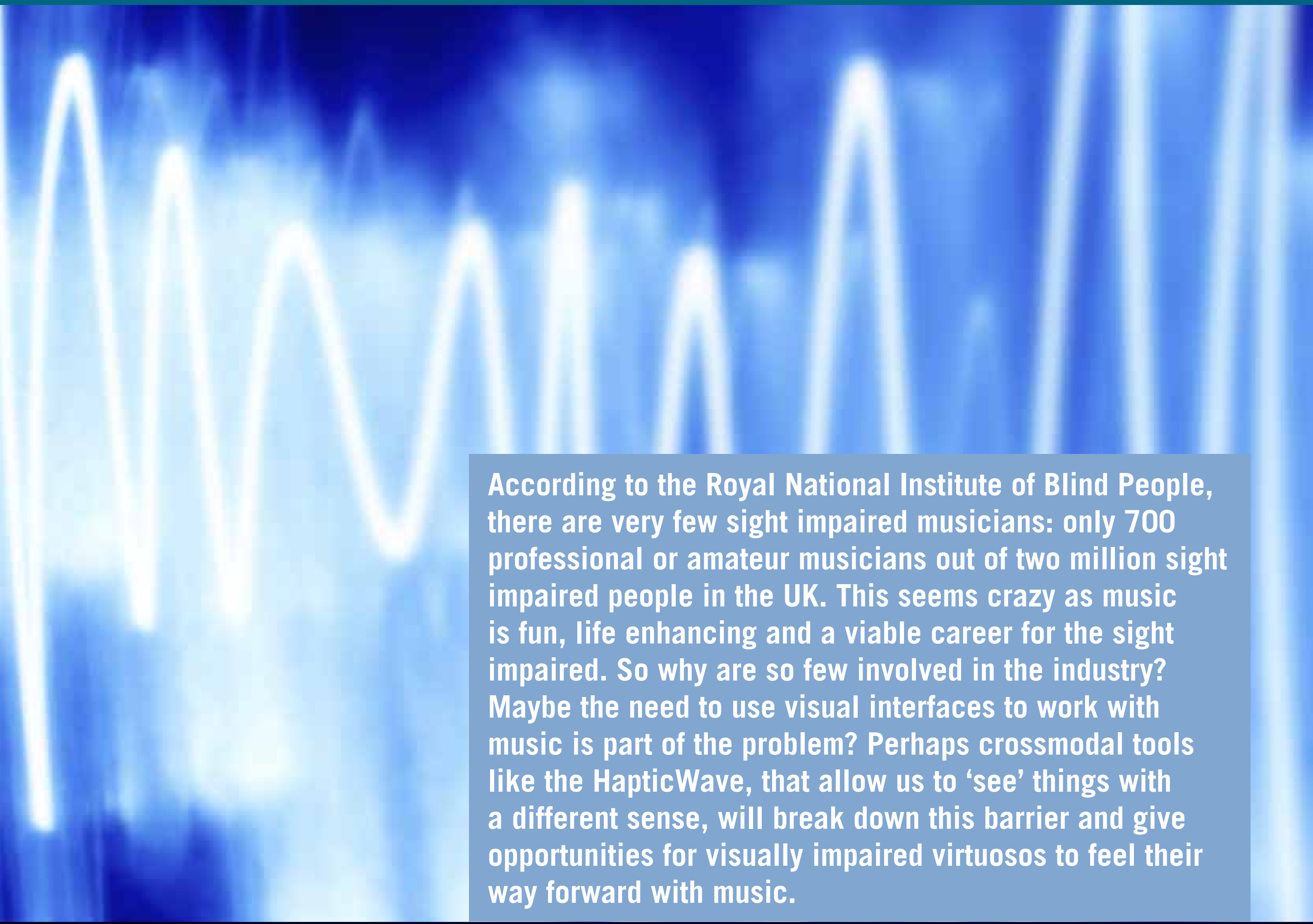
When we learn about sound we are shown pictures of wavy lines: sound waves. Later, we might use an oscilloscope or music editing software, and see how, if we make a louder sound, the curves get taller on the screen: the amplitude. We get to hear the sound and see the sound wave at the same time. That's this multimodal idea again, two ways of sensing the same thing.

But hang on, sound isn't really a load of wavy lines curling out of our mouths, and shooting away from guitar strings. Sound is energy and atoms pushing up against each other. But we think of sound as a sound wave to help us understand it. That's what a computer scientist calls abstraction: representing things in a simpler way. Sound waves are an abstraction, a simplified representation, of sound itself.

The representation of sound as sound waves, as a waveform, helps us work with sound, and with Digital Audio Workstations it is now essential for audio engineers. The engineer works with lines, colors, blinks and particularly sound waves on a screen as they listen to the sound. They can see the peaks and troughs of the waves, helping them find the quiet, loud and distinctive moments of a piece of music, at a glance, for example. That's great as it makes the job much easier…but only if you are fully sighted. It makes things impossible for someone with a visual impairment. You can't see the sound waves on the editing screen. Touching a screen tells you nothing. Even though it's ultimately about sounds, doing your job has been made as hard as driving a car. This is rather sad given computers have the potential to make many kinds of work much more accessible to all.

Feel the sound

The DePIC team (see 'Patterns for Sharing' overleaf) decided to fix the problems. They brought together Computer Scientists, Design experts, and Cognitive Scientists and most importantly of all audio engineers who have visual impairments. Working together over two years in workshops sharing their experiences and ideas, developing, testing and improving prototypes to figure out how a visually impaired engineer might 'see'



According to the Royal National Institute of Blind People, there are very few sight impaired musicians: only 700 professional or amateur musicians out of two million sight impaired people in the UK. This seems crazy as music is fun, life enhancing and a viable career for the sight impaired. So why are so few involved in the industry? Maybe the need to use visual interfaces to work with music is part of the problem? Perhaps crossmodal tools like the HapticWave, that allow us to 'see' things with a different sense, will break down this barrier and give opportunities for visually impaired virtuosos to feel their way forward with music.

soundwaves. They created the HapticWave, a device that enables a user to feel rather than see a sound wave.

The Haptic Wave

The HapticWave combines novel hardware and software to provide a new interface to the traditional Digital Audio Workstation. The hardware includes a long wooden box with a plastic slider. As you move the slider right and left you move forward and backwards through the music. On the slider there is a small brass button, called a fader. Tiny embossed stripes on the side of the slider let you know where the fader is relative to the middle and ends of the slider. It moves up and down in sync with the height of the sound wave. So in a quiet moment the fader returns to the centre of the slider. When the music is loud, the fader zooms to the top of the handle. As you slide forwards and backwards through the music the little button shoots up and down, up and down tracing the waveform. You feel its volume changing. Music with heavy banging beats has your brass button zooming up and down, so mind your fingers!

So back to the title of the article! Joey trialled the HapticWave at a research workshop and rather wanted to take one home, he loved it so much he jokingly tried distracting the researchers to get one. But he didn't get away with it - maybe his getaway car just wasn't fast enough!

Dreams, sticky tape and pass me a soldering iron!

by Jane Waite

Making the HapticWave (see 'Blind driver filches funky feely sound machine!' overleaf) was fun: mixing performing, experimenting and hacking! Here is how it happened...

Who made the HapticWave? Not just one person. No one did just one thing. It was a team effort. Researchers from Goldsmiths, Queen Mary University of London, and Bath University, audio engineers, music producers and musicians with visual impairments, designers and makers worked together making, hacking and modifying instruments,music and gadgets was their thing.

They didn't make the HapticWave in one go.They held lots of workshops, generated lots of ideas, designs and makes. They used participatory design, a way of designing where the ultimate users help decide what the problem is, what is needed and help come up with the design itself.

The team videoed each workshop, so they could look back at things people said and did, using a shared design notebook to write up their work, with photos, notes and diagrams, like a huge multimedia scrapbook. Everyone added their ideas and made comments. No idea was unimportant. Nothing was lost.

At first they worked to understand the problems audio engineers with visual impairments had when working with sound. They designed 'dream boxes' of ideas of how to overcome the problems, inspiring everyone to come up with even more ideas. The big idea they hit on was to 'touch a waveform', and they took that idea forward.

Their big idea was being able to touch a waveform

Next they made a prototype. They didn't spend ages working things out, they just got stuck in. It was a DIY prototype. They used second hand things like, old mixing desk parts, old computers and old scanners. They even used sticky tape to hold it together.

Then they had another workshop, where the audio engineers tried using it and again they were videoed and their ideas recorded. More people were then called in to help make the next version. Materials experts helped decide what to make it from. Specialists in human computer interaction helped to design the best possible interface between the technology and the users. This is a crucial part of developing computer solutions, people just won't use technology if it's too complicated or tricky to use.

It was a truly collaborative project, where problems, ideas, dreams, prototypes and expertise was shared. Prototypes were made, trialled and changed over and over again until the solution was just right for the users. Everyone was involved, every voice heard.

Beep, beep mummy here I come!

by Jane Waite

Babies about to be born are letting their mums know just how near they are to appearing in the big wide world thanks to a monitor from a team in Louisiana, USA. Electrodes on the baby's head and mum's body send data to a laptop that tells the mum what to do. It displays a graph showing a spike when it's time to push. It also creates a musical tone with a tempo that matches the baby's arrival.

Multimodal interaction is all about finding the most natural ways for humans and machines to talk to each other.

Here, the computer is communicating with the mother and baby in several ways and none of it involves pushing buttons! The baby-to-be can't tell the computer when its coming – no one has taught it to use a computer after all. Instead the computer picks up both its and the mother's natural movements via the electrodes – a natural movement-based, or gestural, interface – and works it out for itself. The graph gives the midwife the bigger picture of what is happening so she can help. It may help the mum too, but she isn't in a position to easily focus on a screen. It's hard to concentrate when you are screaming! Humans are very good at following the tempo in music though – it is what dancing is all about. Music is a very natural way for the mum to lock in to the rhythm of the baby, telling her what's happening in her body, motivating the next push. This moment by moment feedback from the baby lets the mum-about-to-be hear and see just how close she is to meeting her beautiful new baby.

Knowing when to push is very important! Mums often spend hours, even days in labour. That means wave after wave of extreme pain. It not only hurts, it's exhausting and many mothers need drugs to endure it. But the drugs mean she can't feel what is going on as well, so she doesn't know when to push. That means the labour can take longer and the longer the pushing time the greater the risks to mother and baby. The monitor can really help as the change in tone and the peak in the graph tell mum it is time to push now! Yes now!

When the musical monitor was trialled, it dramatically reduced the length of pushing time, on average from 77 minutes to 58 minutes. Fewer drugs were needed to safely deliver these new tiny people into the world and the risks associated with longer labours was reduced for mum and baby.

Using gadgets isn't always about people pushing buttons. Get the interaction design right and it can make pushing babies less painful too.

Peak levels:

Anyone can get the sound right

by Paul Curzon

The 'Peak level meter' is an essential tool of an audio engineer. It's used to adjust volume levels. For example, there may be odd moments when a recording is far, far louder than the rest of the track. So loud that the sound will distort when played. The engineer therefore tones it down a bit. Small nudges here and there make a massive difference to the quality of the final sound. A peak level meter is just a gauge that helps. It shows the sound level in real time as the engineer listens to the audio, blinking if the sound even momentarily reaches a critical level where something must be done. It's completely visual though so is completely inaccessible to a blind person.

The DePIC team decided to fix the problem. They've created the first ever plug-in software for professional Digital Audio Workstations that makes peak level meters completely accessible. It uses 'sonification': it turns those visual signals in to sound!

But hang on, the whole idea was that the meters were visualising sound in the first place! How can sonification be better than listening to the original sound? It isn't the original sound that matters to the engineer just a particular feature of it - the level of the signal. A peak level meter presents that abstraction of the sound to the engineer. An accessible version must do the same. Choosing the right abstraction for the job is an important part of computational thinking. The team's peak level meter sounds a beep whenever the meter flashes. It also changes the pitch of the beep according to how much too high the level is. This new signal is played over the top of the original and the engineer listens to both at the same time. The team are now getting feedback on it from audio engineers and will improve it as a result.

So far the feedback has been good. Sometimes two sounds are better than one!

Digital lollipop
no calories, just electronics!

by Jane Waite

Can a computer create a taste in your mouth? Imagine scrolling down a list of flavours and then savouring your sweet choice from a digital lollipop. Not keen on that flavour, just click and choose a different one, and another and another. No calories, just the taste.

The Singapore team are exploring how to send tastes over the Internet. They have suggested rules to send 'taste' messages between computers, called the Taste Over Internet Protocol, including a messaging format called TasteXML They've also outlined the design for a mobile phone with electrodes to deliver the flavour! Sweet or salt anyone?

Nimesha Ranasinghe, a researcher at the National University of Singapore is developing a Tongue Mounted Digital Taste Interface, or digital lollipop. It sends tiny electrical signals to the very tip of your tongue to stimulate your taste buds and create a virtual taste!

One of UNESCO's 2014 '10 best innovations in the world', the prototype doesn't quite look like a lollipop (yet). There are two parts to this sweet sensation, the wearable tongue interface and the control system. The bit you put in your mouth, the tongue interface, has two small silver electrodes. You touch them to the tip of your tongue to get the taste hit. The control system creates a tiny electrical current and a minuscule temperature change, creating a taste as it activates your taste buds.

The prototype lollipop can create sour, salty, bitter, sweet, minty, and spicy sensations but it's not just a bit of food fun. What if you had to avoid sweet foods or had a limited sense of taste? Perhaps the lollipop can help people with food addictions, just like the e-cigarette has helped those trying to give up smoking?

But eating is more than just a flavour on your tongue, it is a multi-modal experience, you see the red of a ripe strawberry, hear the crunch of a carrot, feel sticky salt on chippy fingers, smell the Sunday roast, anticipate that satisfied snooze afterwards. How might computers simulate all that? Does it start with a digital lollipop? We will have to wait and see, hear, taste, smell, touch and feel!

Magic: Holding a card to your heart

by Paul Curzon

A volunteer chooses a card at random to predict how rich the person they marry will be. Without seeing what the chosen card is they hold it against their heart and link it to their one true love. Amazingly they choose the only Joker in the pack - they will marry a fool! Even more amazingly, on the table in a sealed envelope is the calling card of a Joker asking the volunteer to marry them. It just shows how easy it is for your heart to make a fool of you!

Magician's use lots of different techniques to make sure their tricks seem magical. One of the most important is misdirection. It involves making the audience miss things that are there to be seen. It's all about controlling their attention and the way magician's do it includes some lessons for designers of interactive systems.

For example, magicians often make use of the fact that we can easily be distracted by sounds. When someone talks we naturally look at their face, for example, and when we are looking at their face we don't see what the magician's hands are doing. They also make use of the fact that information coming in from our different senses can interfere and that we don't always perceive what is really out there, because of this confusion. Software engineers need to draw on the same cognitive science to design good multimodal systems. Magicians find combinations of effects that interfere so we make mistakes whereas software engineers have to find combinations that reinforce one another.

To find out how to do this trick go to www.cs4fn.org/magic/ and look for 'Holding a card to your heart'.

I see where you run

By Pollie Barden

Lots of Smartphone apps help you track the exercise you do: running, walking, cycling, rowing and even swimming. How many help prevent older people getting lonely, though? I've helped design one that does!

The app was for GoodGym, a London running club with a difference. It pairs runners who need motivation with isolated older people (called the 'coaches') who would like someone to visit them. Rather than my acting the prima donna designer though, I worked with the runners and coaches to create it. We all helped come up with the idea and we designed and tested it together.

Design for us

This way of designing is called Participatory Design: a way to design that involves working really closely with the people you are designing for. They are in on it from the start and together you develop the design step-by-step. Your participants use it as it is improved, giving you feedback on each improvement. This 'rapid prototyping' is far better than waiting until you are finished to find out if it's useful. It increases the chances that you will come up with a design that really does work for those it is for. That's why more and more start up companies are designing this way.

We created two apps: one for the runners' phones and one for the coaches' tablets. The runner's app shows things like their speed, distance run, and time taken and also maps their progress. It also sends a signal to the coach's tablet, allowing the coach to watch their runner's progress on a map along with a countdown to their arrival. To keep things really simple for the coach, their tablet shows the map automatically as soon as the runner starts the run in their app.

What shall we talk about?

The runners and coaches trialled the system for six months, and it turned out that it did more than just allow the coaches to track their runners. It gave them things to chat about too.

Most of the coaches grew up in London and wanted to know more about the places the runners passed on their run. The app let them see the roads, parks and landmarks giving them new things to talk about when the runner arrived. They could share their history and knowledge of the places the runner had passed and it led to them chatting about their experiences living and working in London. Sometimes, the coaches even suggested places along the way for the runner to look out for, changing their route. At other times, the runners went a different way to share new areas of London with their coach.

Stop and chat

Sometimes the runners stopped for chats with people they knew. When this happened the estimate of when the runner would arrive began to increase instead of decrease and the coaches learned that this meant their runner had stopped. That led to conversations around the runner's friends.

The GoodGym apps ultimately did more than just help coaches keep track of their runners. They opened up new ways for the runners and coaches to share both their experiences and knowledge of London. Exactly what you need if you are living alone. Over time, some coaches became like a grandparent to their runner.

Designing robots that care

By Nicola Plant

Think of the perfect robot companion. A robot you can hang out with, chat to and who understands how you feel. Robots can already understand some of what we say and talk back. They can even respond to the emotions we express in the tone of our voice. But, what about body language? We also show how we feel by the way we stand, we describe things with our hands and we communicate with the expressions on our faces. Could a robot use body language to show that it understands how we feel? Could a robot show empathy?

If a robot companion did show this kind of empathetic body language we would likely feel that it understood us, and shared our feelings and experiences. For robots to be able to behave like this though, we first need to understand more about how humans use movement to show empathy with one another.

Think about how you react when a friend talks about their headache. You wouldn't stay perfectly still. But what would you do? We've used motion capture to track people's movements as they talk to each other. Motion capture is the technology used in films to make computer-animated creatures like Gollum in Lord of the Rings, or the Apes in the Planet of the Apes. Lots of cameras are used together to create a very precise computer model of the movements being recorded. Using motion capture, we've been able to see what people actually do when chatting about their experiences.

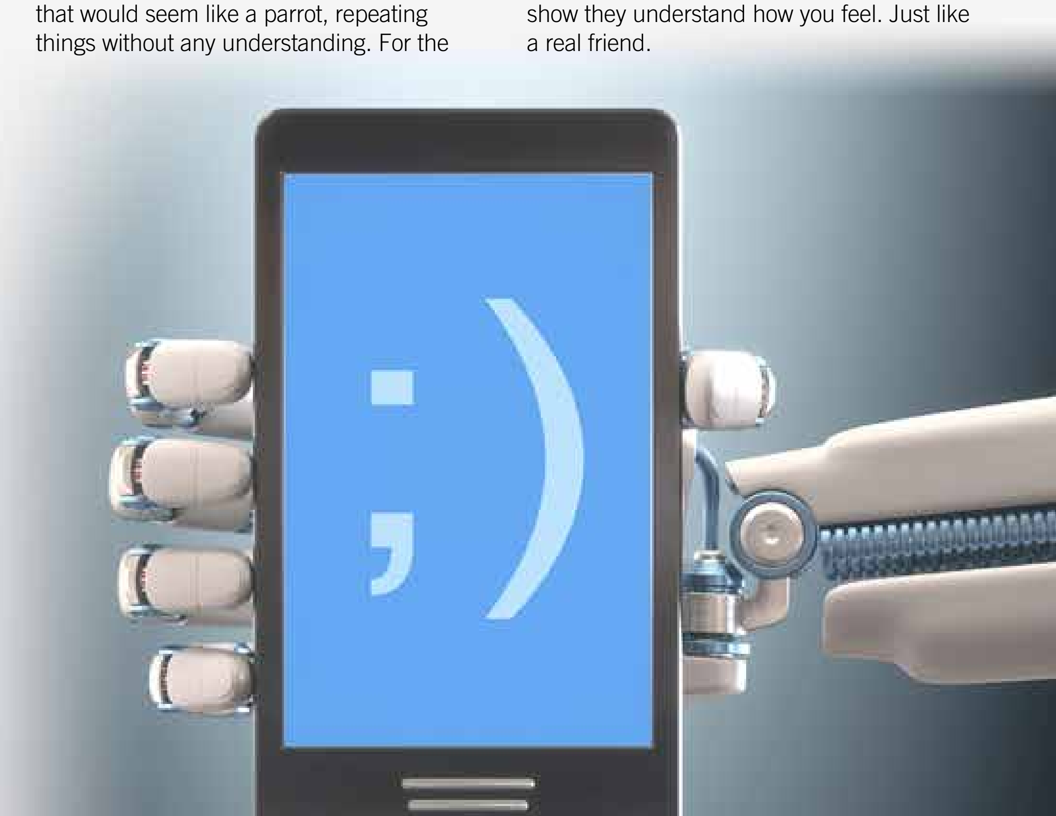
It turns out that we share our understanding of things like a headache by performing it together. We share the actions of the headache as if we have it ourselves. If I hit my head, wince and say 'ouch', you might wince and say 'ouch' too – you give a multimodal performance, with actions and words, to show me you understand how I feel.

So should we just program robots to copy us? It isn't as simple as that. We don't copy exactly. A perfect copy wouldn't show understanding of how we feel. A robot doing that would seem like a parrot, repeating things without any understanding. For the robot to show that it understands how you feel it must perform a headache like it owns it – as though it were really theirs! That means behaving in a similar way to you; but adapted to the unique type of headache it has.

Designing the way robots should behave in social situations isn't easy. If we work out exactly how humans interact with each other to share their experiences though, we can use that understanding to program robot companions. Then one day your robot friend will be able to hang out with you, chat and show they understand how you feel. Just like a real friend.

Talking Programs

One of the first talking programs was Alice (Artificial Linguistic Internet Computer Entity), a language processing chatterbot that chats with people. The person types in their half of the conversation, then, by applying computational rules to what was written, she comes up with appropriate responses and talks back, tricking them into thinking they are speaking to a real person.



A Telescopic lens for Mothers day

by Jane Waite

Written on Mothers Day. My lovely old mum had macular degeneration, a horrible condition that robs millions of people worldwide of their sight. If only she could have lived another 80 years, maybe she could have worn a pair of telescopic contact lenses to help her see. She would have laughed her old Yorkshire socks off and said 'Bye heck that's amazing!'

Macular degeneration is a leading cause of blindness in the world, it's like having a blurry black hole follow you around sitting right in the middle of whatever you look at. Faces are hard to recognise, reading and driving becomes impossible, colours and detail disappear.

A team in Switzerland have developed a prototype telescopic contact lens that, worn with special computerised electronic glasses, help people with sight problems, just like my old mum.

The contact lenses have miniscule concentric circles of tiny, light-bouncing mirrors cleverly set inside them.The electronic glasses redirect light onto the right part of the contact lenses so that they can do their telescopic magic. Objects are magnified to nearly three times their original size. To switch the magnification on and off, you have to wink. The sensors in the electronic glasses ignore your normal blinking, but can detect a wink.

Macular degeneration affects hundreds of thousands of people in Britain, and causes half of all blindness in the western world. As we live longer so we expect more people to suffer from this horrible age-related condition, but maybe these computer controlled spectacles and magnifying lenses give us a glimpse of hope.

Scratching when next board

by Peter McOwan

The next time you are near a blackboard with some chalk you can explore the strange way that our senses interact. Write a few words on the board then rub them out. Now write them again, but this time wear a pair of noise cancelling earplugs: your iPod or phone earplugs will do. You will find that the board feels smoother to write on, because you can't hear the scratching sound. This is an example of a cross modal interaction, what you feel depends on what you hear because of the way our brain combines information from all of the senses to produce your understanding of the world.

Wanting to scream and scream and scream

by Jane Waite and Paul Curzon

Here's a horror story. Your familiar, friendly home suddenly becomes alien and overwhelming. Everything around you moves and is menacing. Wall paper patterns spin and change. The light is too bright to bear. Sounds are magnified. Background noises fill your hearing. A dripping tap thuds, a tapping finger cracks like a whip by your ear, over and over again, the cat flap slaps, the sofa drums (bang, bang, bang, ...) it's never stopping, all beating together against you. Sirens go off all around, the clock is so loud and repetitive it makes you feel sick. Your senses are being attacked and you can't escape. It just makes you want to scream for it to go away, so you scream and scream and scream...

It isn't just a nightmare. Many people with autism spectrum disorder (ASD) suffer from 'sensory sensitivity' which in its worst cases is something like that. They process everyday sights, sounds, smells and touch differently. It varies a lot from person to person. They might see an object as blurred, magnified or fragmented. They might hear a sound only in one ear, not be able to cut out background sounds or not hear some sounds. Touch might be desensitised or hypersensitive. Tastes and smells might be either overpowering or dampened. We don't all sense the world the same.

The more we understand what its like, the greater chance we have of helping: of designing for people with autism. A human computer interface expert's job is to focus on the way we use a system, the way we sense it, experience it, working out how best to display information, how best to capture what is needed to make it work for people. They don't have to just design for the majority though, if the people who might use the gadget or software they are designing have special needs then they need to design for those needs too. And sometimes those designs turn out to be wonderful for everyone else too. Drop kerbs were introduced to help people with wheelchairs, but they help people with pushchairs too. Car central locking was invented for people with mobility problems but we all love it now. Perhaps we can design with and for people with autism.

Virtual fish

Many children with autism are calmed by watching the fish in an aquarium. The fish have the opposite effect to sensory overload. Unfortunately you can't take an aquarium out with you though. Perhaps, computer scientists can help. Augmented reality is the idea of projecting the virtual world on to the real world. Many cars now have head-up displays, superimposing information like directions on the road ahead. More futuristic versions involve goggles or contact lenses that add information to the world you see, telling you more about the things you look at. Want to know the way to the Emerald City? Then follow the yellow brick road that appears when you wear your glasses.

Maybe someone can make some cool augmented reality glasses for children with autism, not to give them more information but to help them cope. Perhaps something as simple as having glasses that place a virtual fishtank in the corner of every room would help...or maybe having fish swimming around the room as if you are in a fish tank would be better still? Perhaps having glasses that sense stress and automatically darken to cut problems out would help better. Who knows... unless someone works with the children who need the help, does the evaluation and builds something that works for them. Perhaps that person is you.

Go to the cs4fn website to watch a video showing what sensory sensitivity is like

Tickle my rubber hand

by Jane Waite

Take a rubber hand, two tickling sticks, a box and two people, one the 'tickler' the other the 'ticklee'. The 'ticklee' hides both hands in the box. But above their left hand, the tickler puts a rubber left hand so that it looks like it has replaced the real left hand. The ticklee can see their rubber left hand but not their own hands. The tickler then sets to work and tickles both the rubber left hand, in plain sight, and the hidden right hand. What do you think happens?

Might the ticklee think they now have a rubber hand that is being tickled?

The rubber hand illusion was created in 1990 by researchers looking at how our brains predict whether what they see or feel is right. The rubber hand gives our brains a multimodal conundrum. We can see a rubber hand being tickled, and we can feel our other hand being tickled. Logically we know our left hand is not being tickled, but our senses seem to be telling us otherwise.

Researchers have repeated this over and over and most people think, yep, they can feel the rubber hand being tickled. The way our brains make predictions based on combined information from the different senses leaves us with a powerful illusion. Freaky!

Illusion? What illusion?

An Australian team are using the rubber hand illusion to understand people with Autism. They found that they don't fall for the trick! Why? It might be that they don't associate this new strange experience of a rubber hand with what normally happens when you are tickled. Their brains therefore don't predict it will tickle.

With more experiments the researchers will get a better understanding of how autistic people make these subconscious predictions about the world. Ultimately this could help people with Autism make sense of the world. It might also help us change how things work so they are easier for those with Autism to predict.

Make it predictable

Good design is predictable. As you walk along the road lost in your headphone music, you feel bobbles under your feet and stop, looking around: you realised you were at a road. You are standing at a pelican crossing and see a red man flashing. You predict, without much thought, that the lights you can't see won't stop the approaching cars, so you wait. A green man and bleeps lead you to predict the cars will stop, even though the drivers can't see your light and you can't see theirs. You predict you can step out in to the road and won't get splattered over a car bonnet.

A crossing is a multimodal system. The bumpy ground and beeps are designed to help the partially sighted, though they often help the rest of us too.

Now think! Suppose you have autism. What do these different sounds, sights even textures of the buttons and the floor near the crossing mean? What will you predict will happen? How will you respond? Do these multimodal cues work for people with autism given they sense the world in a different way? Perhaps we could design them even better and help even more people.

A pelican crossing is fairly simple, but as computer scientists make ever more complex multimodal systems, they need to be sure they understand how our brains will react, autistic or otherwise. The rubber hand illusion shows it isn't always obvious. One person's surefire prediction might be another's bafflement. The more we know of how our brains really work the more chance we will think of ways to design everyday machines so they work well for everyone.

People with Autism don't fall for the trick!

The Australian rubber hand gang's findings might seem to be a trick, but actually the magic is in what they find out about our senses, and how that might one day lead to ideas for better design.

Back (page) in the groove

by Peter McOwan

Touching, seeing, hearing, tasting and smelling are the main ways we sense the world around us, but when we start to mix and match sensations in humans or machines, finding new ways to produce new experiences, the results can be groovy.

The Historical Record

Before the digital music download, and even before the CD, music came from scratches. The gramophone record was a disc of plastic vinyl with a spiral groove running round its surface. As the record rotated on the turntable a stylus, a sharp needle on an arm, tracked along this groove, from the outside to the centre of the record. Music was coded through the wiggles and bumps on the side of the groove. As the needle ran along it jiggled from side to side feeling the groove like a very thin finger, and this movement was turned into an electronic signal that went, via an amplifier to a loud speaker, and music was made.

These days music is coded directly as a set of computer instructions telling the music player exactly what sounds to produce, leading to high quality reproduction, though the familiar background hiss and crackle and the physicality of the record and turntable means that vinyl has lots of fans even now.

Reach out... make music in stylus

The Hysterical record

American film director William Castle made his name in the 1950s through a series of horror films with bizarre interactive gimmicks. He wanted new ways to make the cinema experience unique. After all, he was up against that new fangled home TV craze.

To create these unique experiences he filmed his movie 'House on Haunted Hill' in what he called 'Emergo'. The process involved a normal movie but with a rubber skeleton on a wire dangling over the audience that moved in time with the skeleton on screen in the final scenes. Sadly as word spread people came to the cinema to throw things at the skeleton rather than be terrified.

His film 'The Tingler', about a creature that attaches itself to the spinal cord and can only be killed by screaming was filmed in 'Percepto'. That involved attaching aircraft wing de-icer motors to the underside of random cinema seats that buzzed at the right time during the film.

Finally the film '13 Ghosts' was a triumph filmed in 'Illusion-O'. The audience were given a hand held ghost viewer (actually red/blue cellophane glasses). They could look through the red plastic to see the ghosts, or make them vanish by looking through the blue plastic if they were too frightened. The technique exploited complementary colours in the same way as early 3D movies, but like all Castle's ideas it was the showmanship that made it work.

Reach out ... and scare somebody's friend

Growing the grooves for coffee in space

A grumble that crew on the International Space Station have, along with the toilets, is that they can't drink coffee from a cup. They do have a special expresso coffee-making machine, the ISSpresso, developed by the Italian space agency. But micro gravity means that liquids, like coffee, must be held in pouches with a quick release straw type attachment. Otherwise the contents float out and cause problems for the electronics. Not ideal for enjoying a cuppa, especially since that lovely coffee aroma is trapped in a plastic bag.

Enter 3D printing. American researchers working with a high school student have come up with a cup which, while still enclosed, uses surface tension and other simple fluid properties to move the coffee along the cup's surfaces. It comes out in a controlled way without pumps of other mechanics. The clever shape can be 3D printed from a computer-generated plan. In future, the science behind it might also improve the efficiency of other fluid transport systems in space, like life support and fuel tanks.

Reach out ... float free, and relax with a cuppa

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