# chi+med
making medical devices safer

# Update 6

22 June 2012

## Introduction

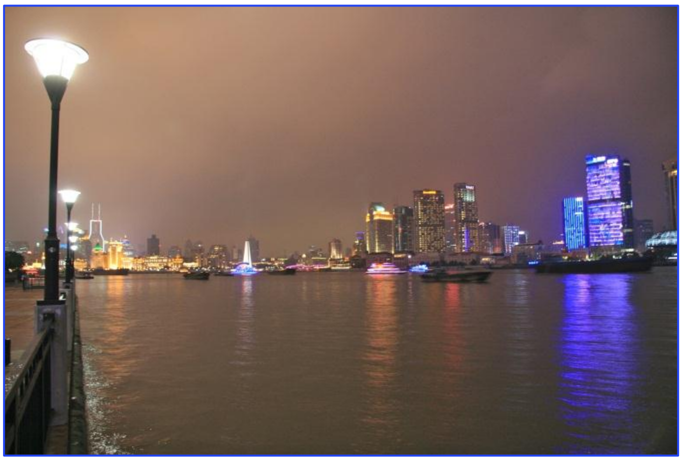
**Welcome** to the sixth CHI+MED newsletter, in which we focus on the **number entry research** that has been going on within the programme, with short summaries from members of the research team who are working on this topic. Future newsletters will highlight other themes.

The CHI+MED team is now almost at full strength, and we have hosted several international visitors, including Professors Wayne Gray, Andreas Holzinger, Jenny Preece and Ben Shneiderman. Team members are working increasingly closely with researchers and practitioners elsewhere, particularly in North America and China. But more on that in a future newsletter. In this one, we will introduce new staff, give a quick overview of some recent activity, and then focus on the science of number entry.

Ann Blandford, a.blandford@ucl.ac.uk

## CHI+MED in China

CHI+MED recently hosted its first international workshop on 7 June in Shanghai. Representatives from Chinese higher education institutes, China State Food and Drug Administration and Smiths Medical enjoyed a useful exchange of information with CHI+MED researchers and a strengthening of connections between research and industry. Issues of usability were discussed and opportunities for further knowledge transfer were developed.



*Picture credit: Shanghai, by Harold Thimbleby*

## New staff

***City University***

*Jonathan Day* is a PhD student working on cognitive resilience.

***Queen Mary, University of London***

*Michael Harrison* is working as a Research Fellow on integration and formal modelling, and *Sinan Halilbeyoglu* is a PhD student working on the use of vision techniques as an analytical tool for evaluating interfaces.

***Swansea University***

MRes student *Julie Webster* is working on number entry, comparing direct and indirect input devices (for examples knobs and sliders versus touchscreen keypads). *Gerrit Niezen* will be joining the team soon, to work on innovative technology designs.

***UCL***

Post-doctoral Research Assistant *Jo Iacovides* is investigating the usability of medical devices and PhD student *Aisling O'Kane* is looking at patients' experiences of mobile medical devices. *Erik Berndt* is an intern this summer, studying device use in anaesthesiology

## Staff awards

*Peter McOwan* (QMUL) became Vice Principal and won the Mountbatten Medal from the BCS and *Paul Curzon* (QMUL) won the Drapers Award for teaching.

*Jonathan Back*'s paper "Choosing to interleave: human error and information access cost" won a best paper award at the CHI2012 conference.

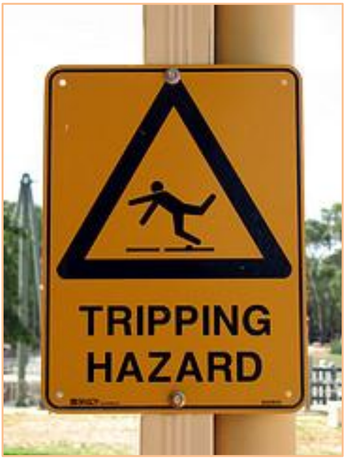
## CHI+MED research masterclass in Nottingham

On 24 and 25 March, a group of CHI+MED researchers shared a masterclass experience with a number of leading researchers in relevant fields. During the two-day masterclass, CHI+MEDers demonstrated their research outcomes and enjoyed in-depth discussion with experts in clinical practice and education, psychology and Human Computer Interaction including Prof. Andrew Howes, Prof. Mark Sujan, Prof. Russell Beale, Dr Peter Gardner and Bridget Malkin.

Topics ranged from research subjects, methodology to potential applications and publications. Following up this masterclass, dialogues are being established to facilitate future collaboration.
*Karen Li, Yunqiu.Li@swansea.ac.uk*

## New papers published in number entry

*"Just like an infected wound can appear misleadingly healthy until it goes nasty, bug-ridden devices look fine until things go wrong."*




*Picture credit: jcolman on Flickr*

If you see a trailing wire it's easy to spot that someone might trip over it but the potential for mistakes when using medical devices can often lie unseen within the user interfaces and underlying algorithms.

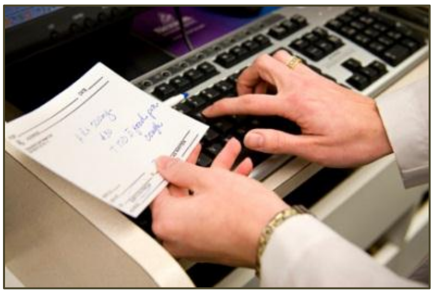
Entering numbers on a drug infusion pump is a safety critical task where errors can cause injury and death. When an error occurs the temptation is often to retrain, or remove, the person who 'made' the error assuming that this has fixed the problem but perhaps missing other underlying causes of error that will continue to resurface because nothing is learned from them.

Hidden or 'latent' error can be present in machines themselves but also in the systems in which they're used **(1)**.

UCL | Swansea University Prifysgol Abertawe | Queen Mary University of London | City University London | EPSRC Engineering and Physical Sciences Research Council

A wrongly entered drug infusion rate might be due to human error but it could also be due to poor pump design, poorly designed processes, incorrect identification of the patient and wrong or confusing information from the pharmacy. In other words poor human-computer system design (either of the devices themselves or of the socio-technical system in which the devices and their users are embedded) can lead to error.

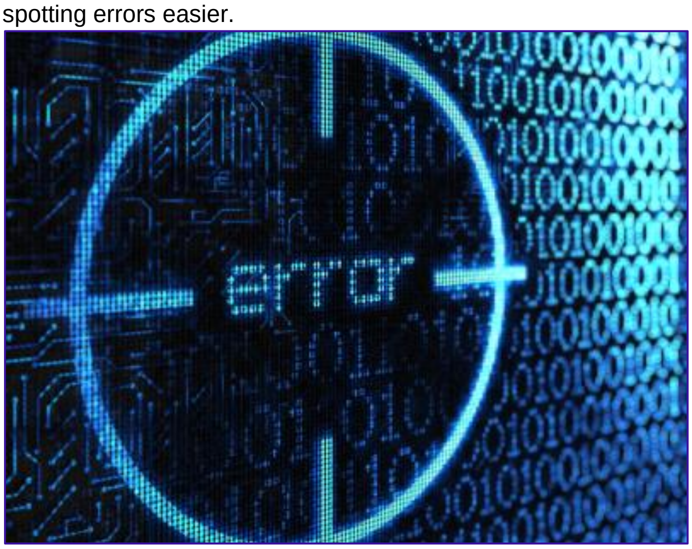
If a nurse needs to calculate a dose from information on the prescription instructions then he or she needs a minimum amount of information to do to that (or, even better, for the correct dose to be provided by the pharmacy). Adding irrelevant detail, and forcing the nurse to pick out the correct details, can cause confusion and may increase the risk of error.



Despite being a potential source of multiple interaction errors the way in which numbers are used has been under-explored in human computer interaction (HCI) research. This means we know very little about how numbers are transferred from a prescription pad into the medical device that will deliver the drug. Guidelines exist for the way numbers are written down (for example writing 2 and never 2.0 with a trailing zero, because 2.0 may be misread as 20) these are routinely ignored and so wrong numbers may be entered into the devices.


*Picture credit: Dom Furniss*

Even correctly-written numbers can still be entered wrongly and understanding more about the different styles of number entry systems may help. For example one study **(2)** indicated that in a laboratory setting the use of up/down arrows tended to direct the user's attention towards the display screen, but in contrast people using a number entry keypad tended to look at that, rather than at the screen. This difference translated into a lower rate of unnoticed and uncorrected errors in users of the up/down system. However the difference may not be entirely up (or down!) to where the user is looking. Up/down arrows generally require the user to introduce (and correct) error as part of normal use - to enter 95 the user might need to enter 100 and decrease to 95 - a strategy that perhaps makes spotting errors easier.




The underlying device algorithms are a source of hidden errors too. Most devices don't check that the entered numbers make sense and will arbitrarily interpret 1.2.3 as an assumed 1.23 rather than checking with the user. In cases where this type of error translates to patient harm the machine log will be silent on the true reason for the error (the device ignores the human error and then mishandles it), shifting the blame onto the unwitting user. These errors can be reduced by the use of safety locks.

For example, guns are dangerous **(3)**, and even expert users make slips sometimes; the effect of an error in shooting the gun is drastic and difficult (or impossible) to undo, so a blocking mechanism (the safety lock) is put in place, which must be deactivated before use. In the example given above it would be safer to reject outright any number that didn't make sense (1.2.3) and ask the user to re-enter it. Simulations show that blocking these 'malformed' entries can reduce the potential for adverse errors considerably.

Errors in using medical devices can result from a combination of latent conditions (such as the device being designed with the buttons too closely together) and 'active' failures (which occur at the time of the error for example pressing the wrong button). Detecting and preventing latent conditions can contribute greatly to safer device design.

Discovery tools **(4)** let device manufacturers easily and exhaustively check that such requirements are being met in their user interfaces. These UI discovery tools complement conventional user testing techniques which, although not exhaustive, provide basic insights into device use.

User error is often systematic. General guidelines about how to design resilient systems that prevent systematic human error are provided by a set of rules or `design principles'. An example of a design principle for interactive devices is *predictability*. This concerns the ability of a user to determine the outcome of a future interaction. Other examples include consistency of labelling and visibility (obviousness) of the different modes in which a device can be operated.

In CHI+MED, we are using computer programs **(5, 6)** to help us determine whether interaction design principles have been consistently implemented in the user interface of drug infusion pumps. When an interface does not comply with a design principle we can ask:
(i) What design changes could be applied to make the design compliant?
(ii) Under what conditions does the design become compliant to the design principle?

An answer to the first question may provide useful insights to device manufacturers about the effect of different features in interaction design and an answer to the second could be useful in training, for example we can check whether there's a reasonably simple strategy (other than resetting the device for example) that allows a user to avoid predictable problems.

## My PhD – Sarah Wiseman, UCL

"I'm trying to understand more about how we transcribe numbers, how we read a number in one place, and then enter it in to a device, be it a mobile phone, an ATM or a medical device. We already know a lot about how people transcribe text and can say things about how likely they are to make an error depending on which fingers are involved in the word they are typing, or how quickly they can type, or how much of the text they need to be able to see to type at optimum speeds. I want to find these things out, but focussing on numbers **(7)**.

*Picture credit: artnoose on Flickr*

With this information, we have been able to build keyboards that allow us to type more accurately, and faster. Increasing the accuracy of number entry systems in the same way would be fantastic. So far I have collated a list of number entry errors **(8)**, looked at the numbers people are really entering on these devices **(9)**, and have begun looking at how we read numbers: do we just see lists of unrelated digits, or do we group them together into longer numbers?"

*Sarah Wiseman, sarah.wiseman.10@ucl.ac.uk*

You can find out more about Sarah's work on our blog.

**Number entry game**

*Patrick Oladimeji, Sarah Wiseman, Abi Cauchi, Rimvydas Ruksenas*


As part of our last annual meeting, the number entry group designed a fun game where users could assume the role of a nurse on a busy ward who raced against time to setup infusion pumps for a number of patients.

Various number entry interfaces are in use in hospitals across several different devices. Nurses and healthcare practitioners have to interact with all these different interfaces often under pressure and stress of taking care of patients with different health priorities.

The aim of the game is to show the various performance differences between different number entry interfaces. The game will go live on 1 August 2012 and can be played at http://tinyurl.com/NumberEntryGame

## References

Our full list of publications can be found here.

1. *Harold Thimbleby* (Swansea) Errors + bugs needn't mean death (CHI+MED public paper #51) in Public Service Review: UK Science + Technology, 2:18-19.

2. *Harold Thimbleby* Interactive numbers: a grand challenge (#52) In Blashki, K., editor, Proceedings of the IADIS International Conference on Interfaces and Human Computer Interaction, xxviii-xxxv. IADIS.

3. *Harold Thimbleby* Interactive systems need safety locks (#47) in the Proceedings of the IEEE 32nd International Conference on Information Technology Interfaces ITI (7 October 2011) and Think! interactive systems need safety locks (#46) Journal of Computing and Information Technology, 18 (4): 349-3607.

4. *Harold Thimbleby* Avoiding latent design conditions using UI discovery tools (#45) International Journal of Human-Computer Interaction, 26 (2-3): 120-131.

5. *Paolo Masci* (QMUL), Rimvydas Ruksenas (QMUL), Patrick Oladimeji (Swansea), Abigail Cauchi (Swansea), Andy Gimblett (Swansea), Yunqiu Li (Swansea), Paul Curzon (QMUL) & Harold Thimbleby (Swansea) The benefits of formalising interactive number entry (#50) in the Proceedings of the 4th International Workshop on Formal Methods for Interactive Systems (FMIS2011), volume 45 of Electronic Communications of the EASST.

6. *Paolo Masci*, Rimvydas Ruksenas, Patrick Oladimeji, Abigail Cauchi, Yunqiu Li, Paul Curzon & Harold Thimbleby On formalising interactive number entry on infusion pumps (#21) in the Proceedings of the 4th International Workshop on Formal Methods for Interactive Systems (FMIS2011), volume 45 of Electronic Communications of the EASST.

7. *Sarah Wiseman*, Anna Cox and Duncan Brumby A case for number entry CHI 2012: the 30th ACM Conference on Human Factors in Computing Systems: workshop paper.

8. *Sarah Wiseman*, Paul Cairns (York) and Anna Cox A taxonomy of number entry error (#29) BCS HCI conference June 2011.

9. *Sarah* Wiseman (UCL) Anna Cox (UCL) and Duncan Brumby (UCL) Designing for the task: What numbers are really used in hospitals? In: (Proceedings) CHI 2012: the 30th ACM Conference on Human Factors in Computing Systems: Work In Progress (poster).

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