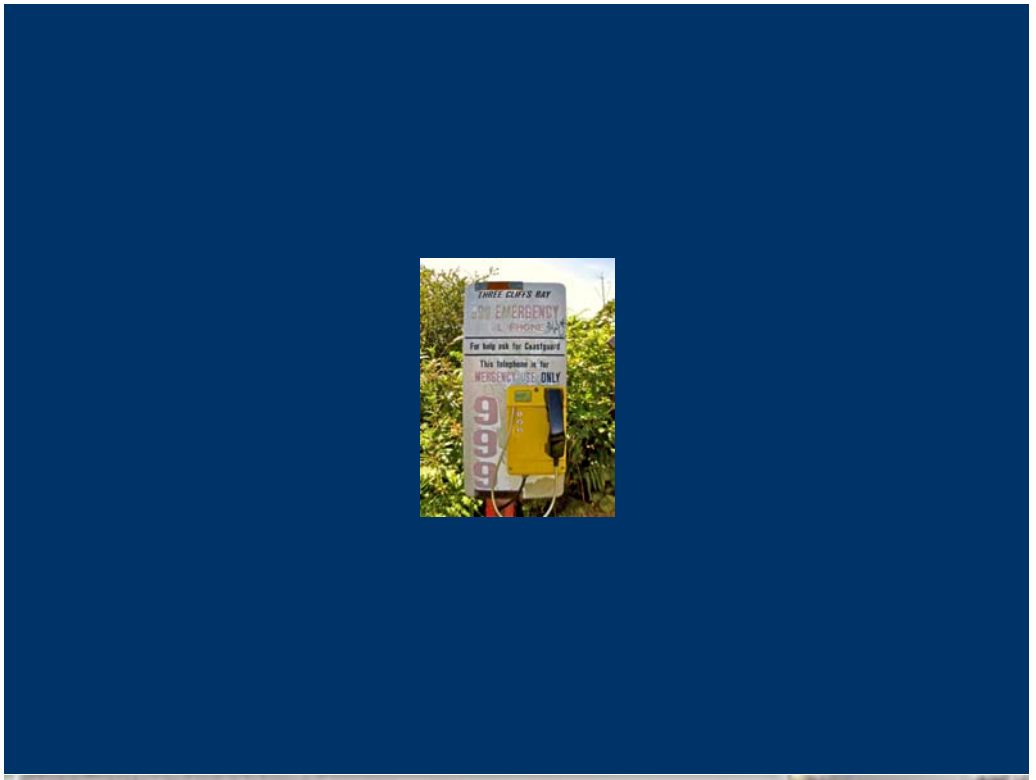
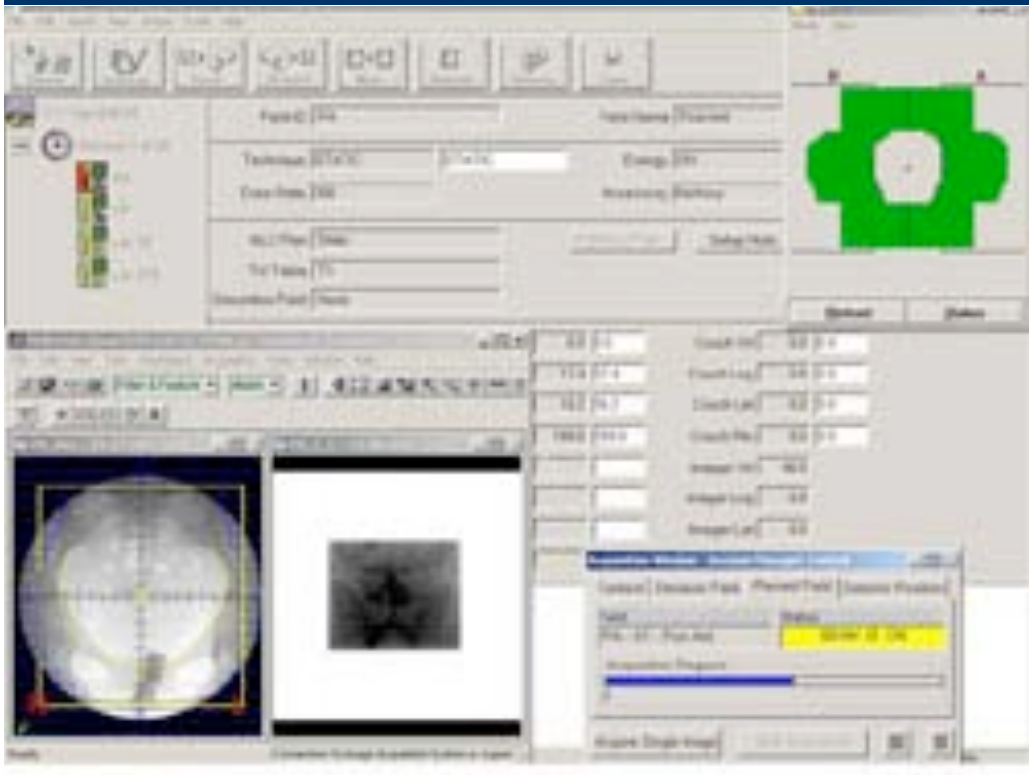
Interactive systems need safety locks

Harold Thimbleby
Swansea University


THREE CLIFFS BAY
EMERGENCY
PHONE
For help ask for Coastguard
This telephone is for
EMERGENCY USE ONLY
999

MERGENCY USE ONLY
999
BT
1
2
3

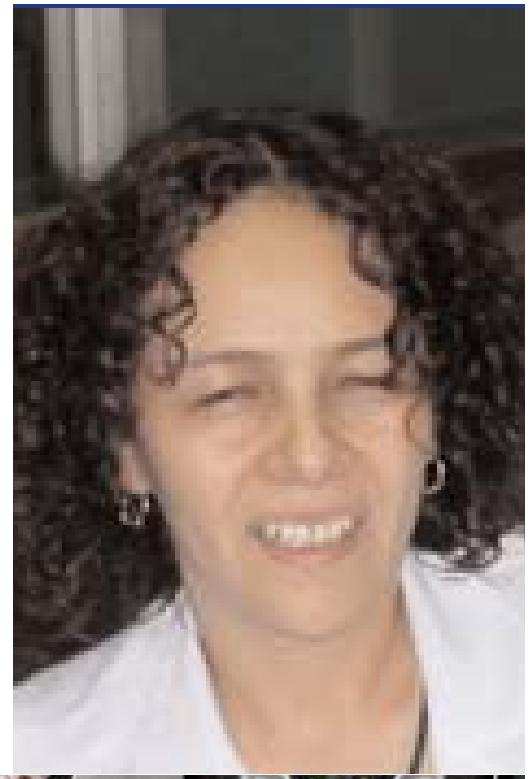


Panama incident, 2000–2001

18 patients died

2 radiologists imprisoned for manslaughter

Olivia Saldaña



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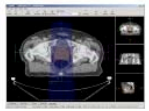
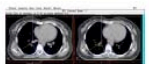


DSS Treatment Planning Hundreds of users worldwide rely on the DSS everyday the manage their patient loads.



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The user must CAREFULLY check if results are correct BEFORE using in treatment.

A USER SHOULD VERIFY THE RESULTS THROUGH INDEPENDENT MEANS until the USER’S PROFESSIONAL CRITERIA IS SATISFIED.

Paraphrased…

We make dangerous things.

There are no designed-in safety locks.

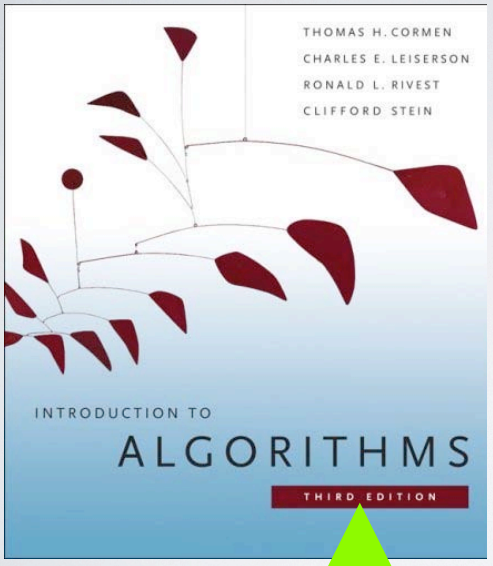
It’s your fault if anything goes wrong.

Interactive systems need safety locks

Harold Thimbleby
Swansea University

Why safety locks?

1. People make slips
2. Safety locks stop some slips causing harm
3. Bad design allows slips to cause harm



1292 pages

"beautifully written introduction to design of algorithms"

"the bible of the field"

"best textbook ever seen"

"We do not address error-handling"

Java

```
System.out.println(12345678
                   +8765432l)

                    21111110

System.out.println(12345678
                   +8765432)
```

Java

```
System.out.println(1111111111
                   +1111111111)

                    -2072745074
```

happens everywhere

Learned?

- Human slips get incorrect results
- Slips go undetected
- Applications do not provide “safety locks”
- *Bad design causes errors*

EXTERNAL BEAM PLANNING: Norm Point Off-axis Distances and Off-axis Ratios for OMP Plans

Name:
ID:
Prep:
Date: 19-Jun-10

Chkd:
Date:

Orientation of Patient: HFS Head First Supine / HFP Head First Prone / FFS Feet First Prone / FFP Feet First Prone

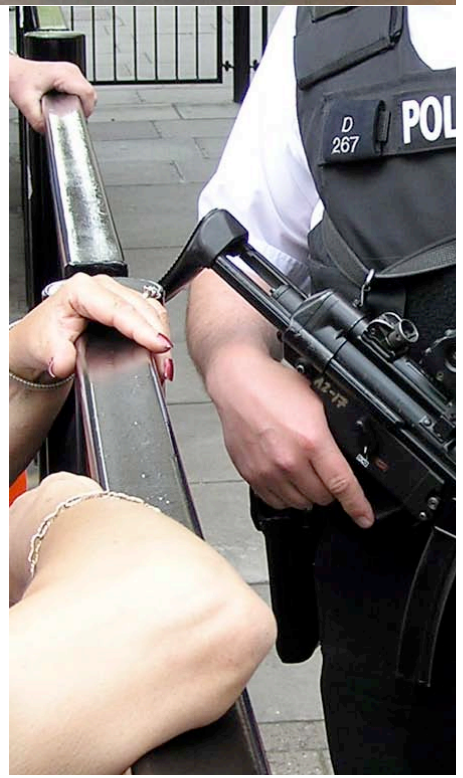
Modality: 6MV X-ray

	Field 1	Field 2	Field 3	Field 4	
Coordinates of Isocentre:	9.3	-0.3	-1.7		cm
Coordinates of Norm Point:	11.9	-0.3	-5.5		cm
Gantry Angle:	302	126	0	0	degree
Collimator Angle:	80	280	0	0	degree
Turntable Angle:	0	0	0	0	degree
Norm Point Depth:	5.0	5.0	5.0	5.0	cm
SSD for Norm Point:	99.2	90.7	98.8	98.8	cm
Open OAR_0:	1.018	1.017	1.026	1.026	
Radial Distance:	1.8	1.6	2.5	2.5	cm
In-plane Wedge OAR_{WY}:	1.183	1.168	1.000	1.000	
OAD in Y1-Y2 direction:	1.7	1.6	0.0	0.0	cm
Cross-plane Wedge OAR_{WX}:	1.002	1.002	1.014	1.014	
OAD in X1-X2 direction:	-0.3	0.3	2.5	2.5	cm
Combined Wedge OAR_W:	1.184	1.168	1.014	1.014	
Radial Distance:	1.8	1.6	2.5	2.5	cm

Y1 Y2 X1 X2

	Field 1		Field 2		Field 3		Field 4	
	Y	X	Y	X	Y	X	Y	X
Norm Point at Isocentre Level	1.7	-0.3	1.6	0.3	0.0	2.5	0.0	2.5
Off-axis Ratio OAR	1.184	1.018	1.168	1.017	1.014	1.026	1.014	1.026

- Errors **always** happen
- Safety locks **reduce** errors and their consequences



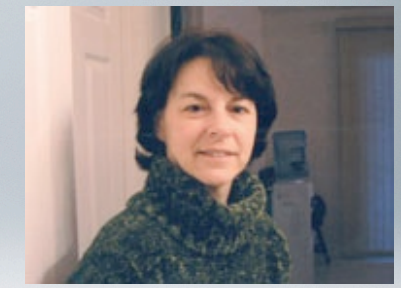
93% of nurses make numerical errors

I D Kapborg, "Calculation and administration of drug dosage by Swedish nurses, student nurses and physicians," *Int J Quality in Healthcare*, **6**(4):389-395, 1994.

If we know that, why aren't there safety locks?

Denise Melanson

22 August 2006



Root Cause Analysis

Fluorouracil Incident Root Cause Analysis

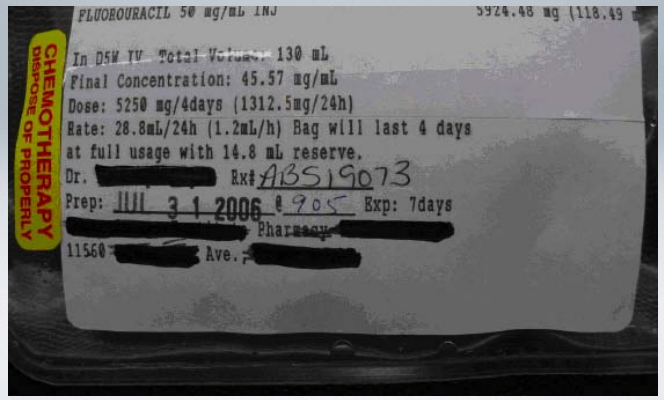
Final Draft: April 5, 2007
Final Formatted Report: April 30, 2007
Formatted for Web Posting: May 22, 2007

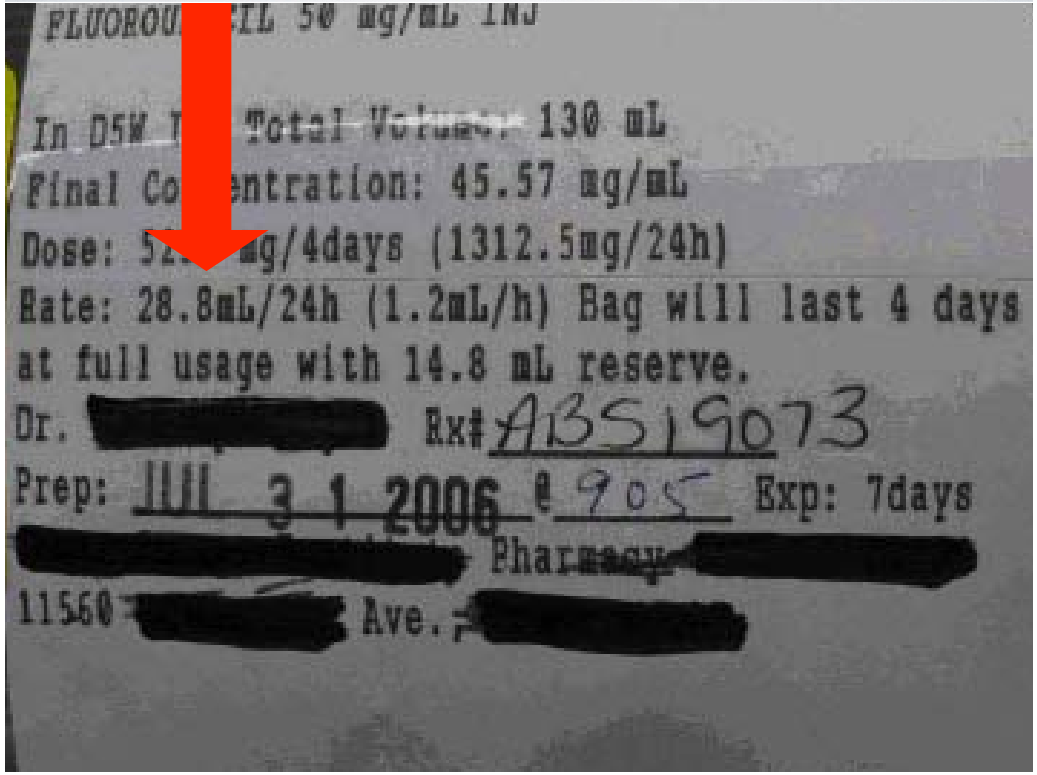
ismp Canada — Institute for Safe Medication Practices Canada® / Institut pour l'utilisation sécuritaire des médicaments du Canada®

5-Fluorouracil 5,250 mg (at 4,000 mg/m2) Intravenous once continuous over 4 days

Cis_5FU_Part2-HN-CC - Cycle - 1, Day - 1
Substitutions Allowed

Administration Instructions:
Continuous infusion via ambulatory infusion pump
(Baseline regimen dose = 1000 mg/m2/day = 4000 mg/m2/4 days)





5250 mg

45.57 mg/mL

4 days

$$\frac{5{,}250 \text{ mg}}{45.57 \text{ mg per mL}} \Big/ (4 \text{ days x } 24 \text{ hours per day})$$

AC	5	4	MRC
MRC	2	5	=
MRC	5	.	
4	0	5	
×	÷	7	
2		÷	
4			
M+			
AC			

22 keystrokes

Four problems

- Calculators are different
- People make slips
- Calculators don't detect or block errors
- Things **will** go wrong

only
blocks
2 errors

Safety locks block slips

Safety locks block slips

Press 1.2 3

Abbott **999**, **123**, **1.2**, **1:23AM**, **1:23PM**

Graseby 3400 **1.3**

Casio HS8V, HS85 **1.23**

Mathematica **0.36**

Excel **0**

Word **1.5**

Alpha **6**

Keys	Me	J1	J2	Gr	N1	N2	J3	J4
.00000001	1e-8	1e-8	1e-8	1e-8	1e-8	1e-8	true	true
.1	0.1	0.1	0.1	0.1	0.1	0.1	true	true
0.25	0.25	0.25	0.25	0.25	0.25	0.25	true	true
0666	666	666	666	666	666	666	true	true
8.0	8	8	8	8	8	8	true	true
87.23	87.23	87.23	87.23	87.23	87.23	87.23	true	true
99	99	99	99	99	99	99	true	true
1..23	error	1	NaN	1.23	1	1.23	true	false
1.2.3	error	1.2	NaN	1.3	1.2	1.5	true	false
.1.2.3.	error	0.1	NaN	0	0.1	0.6000000000000001	true	false
.1...	error	0.1	NaN	0	0.1	0.1	true	false
Text!	error	NaN	NaN	0	0	NaN	false	false
	error	NaN	0	0	0	0	true	true
+3	error	3	3	0	0	NaN	false	true

Patient dies

Log shows 55 mg

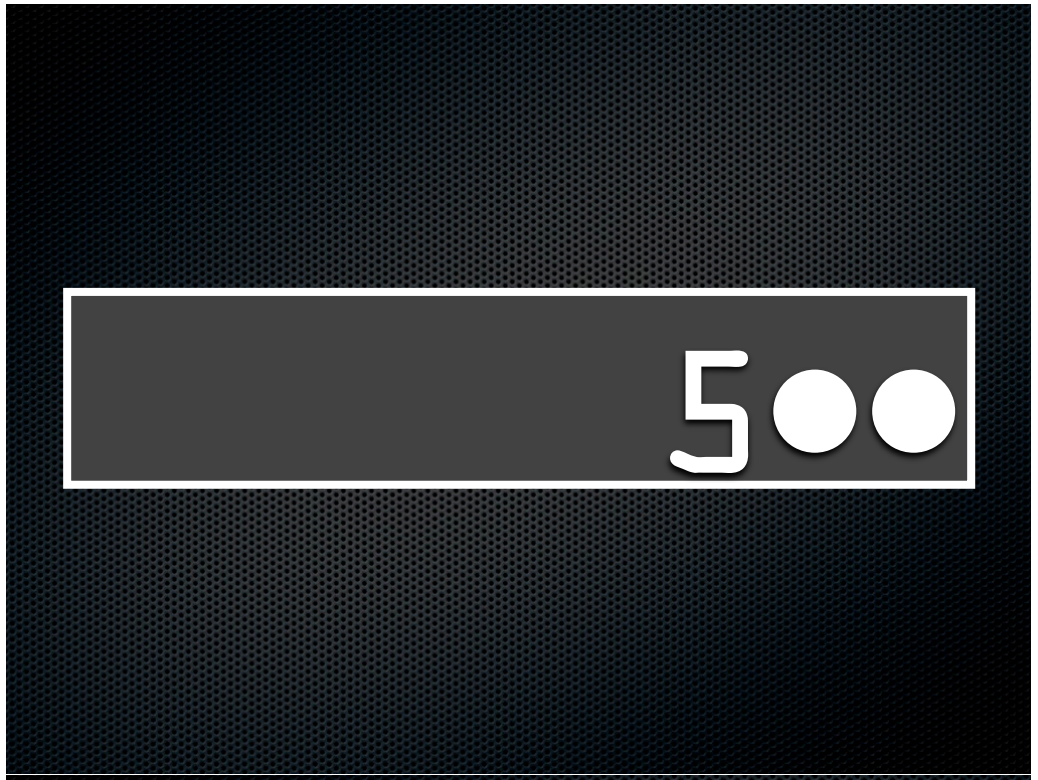
Should be 5.5 mg

Nurse at fault

Task — enter 5.5 mg

5

5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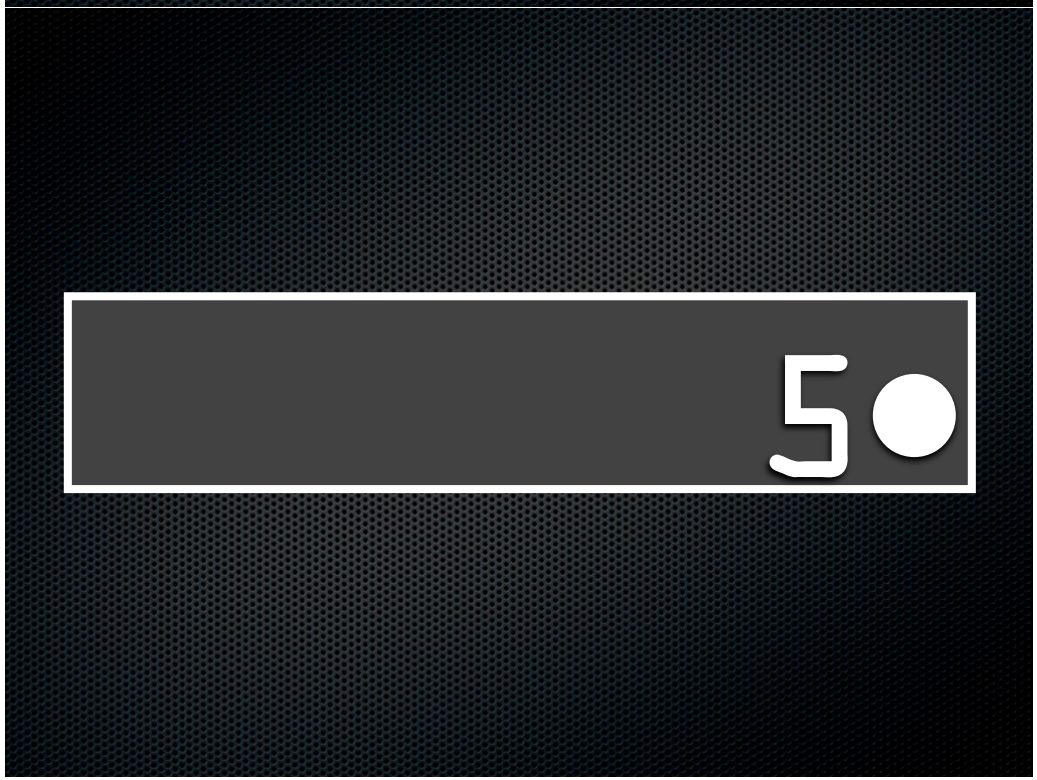
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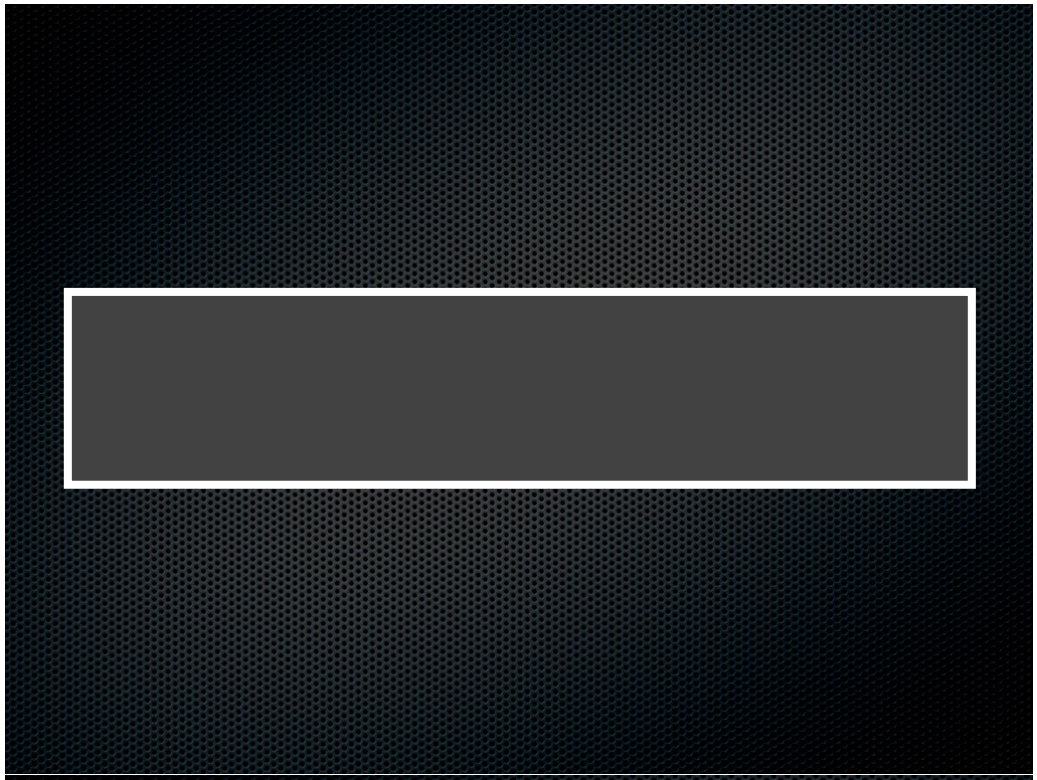
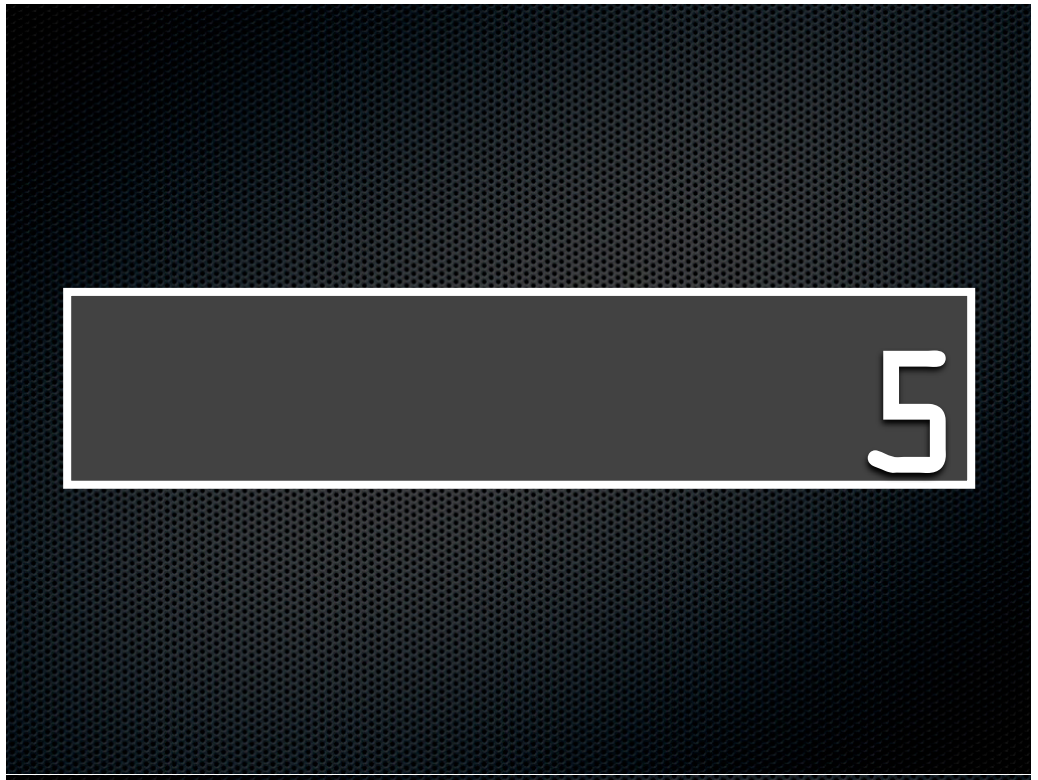
5 5

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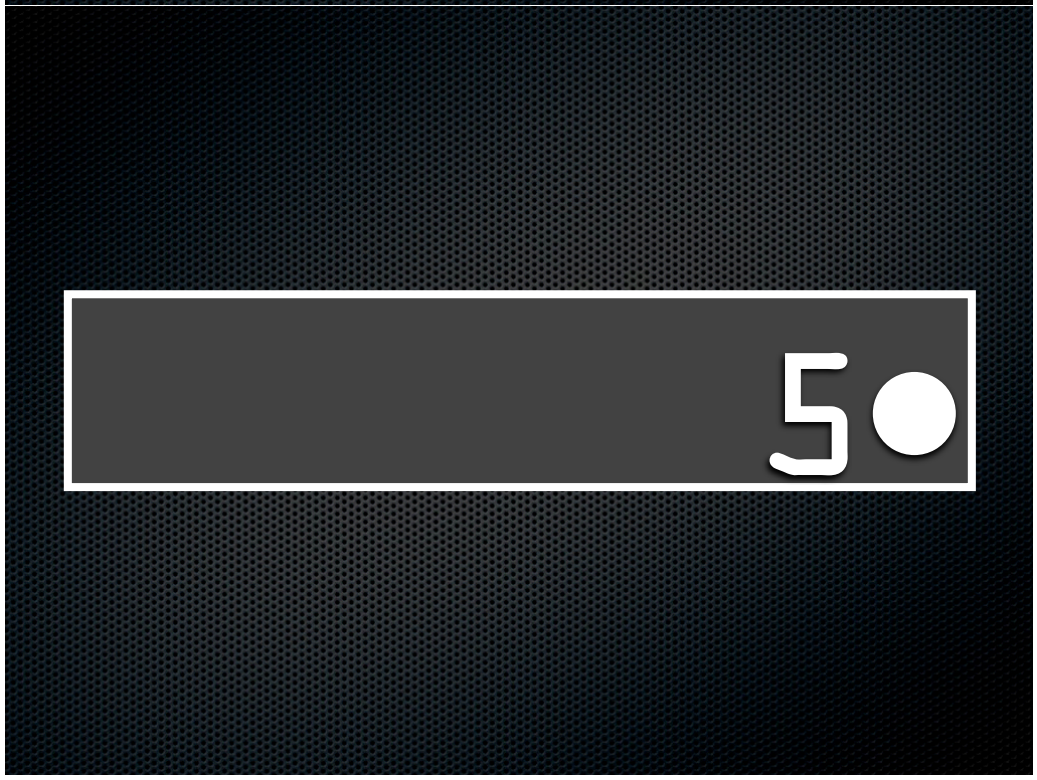
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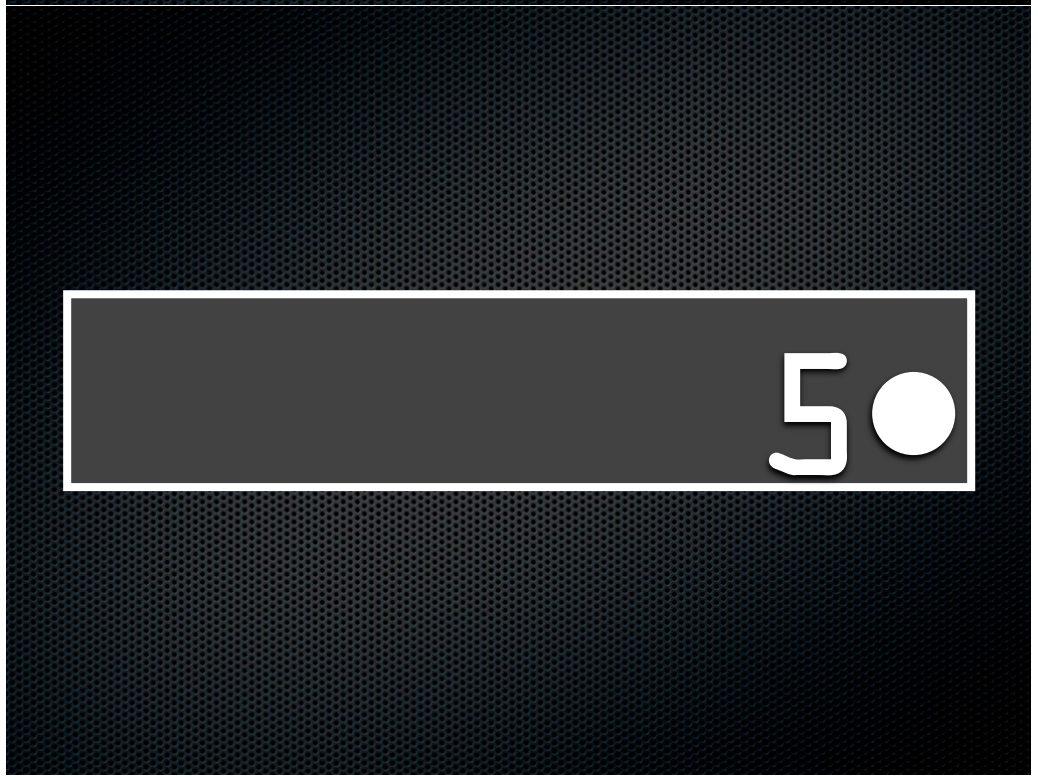
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5

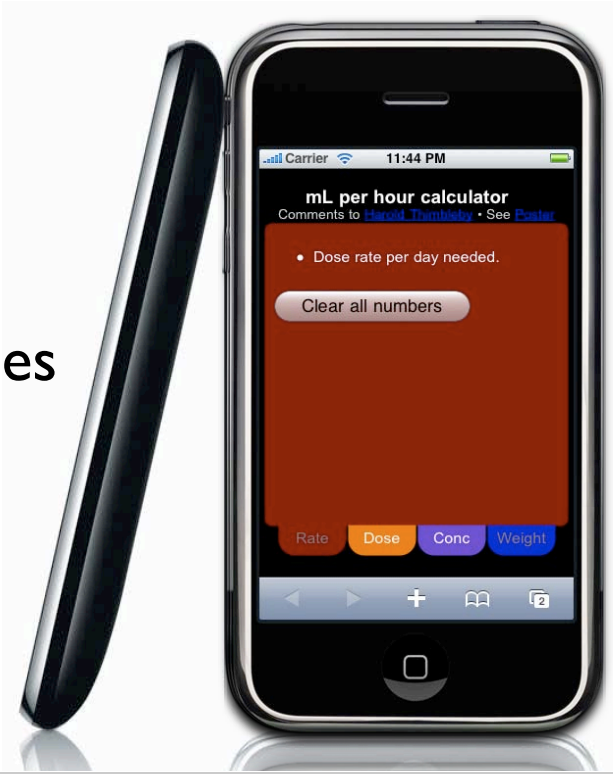
55

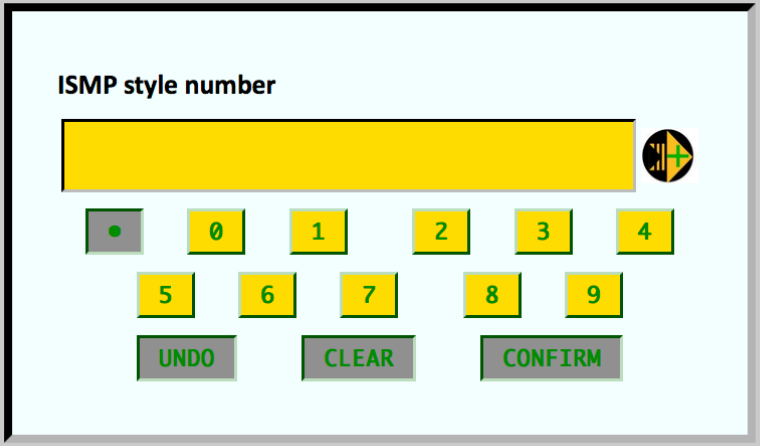
Nurse thinks 5•5

Log shows 55

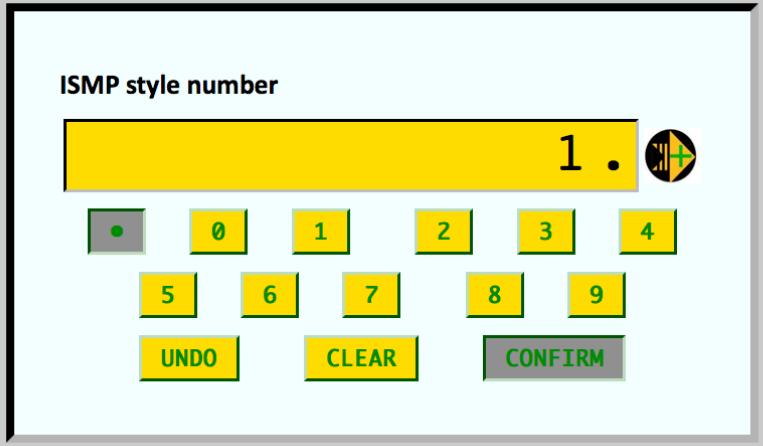
what can we achieve with safety locks?

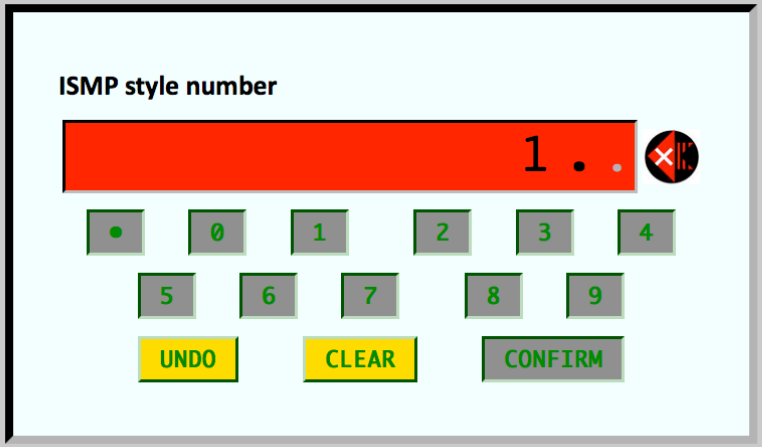
blocks **35** types of error

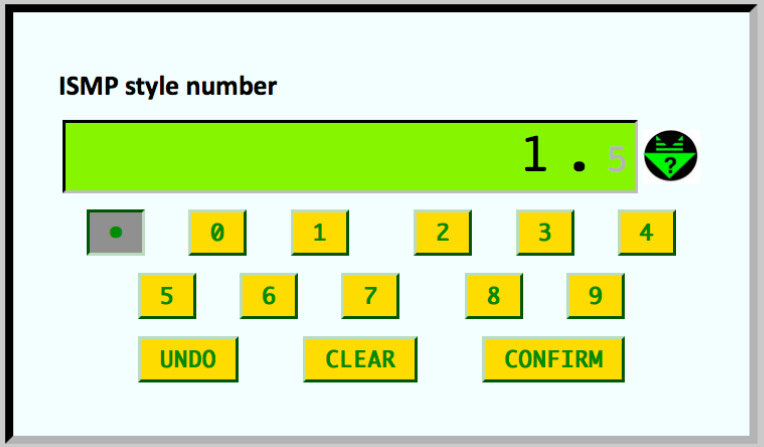




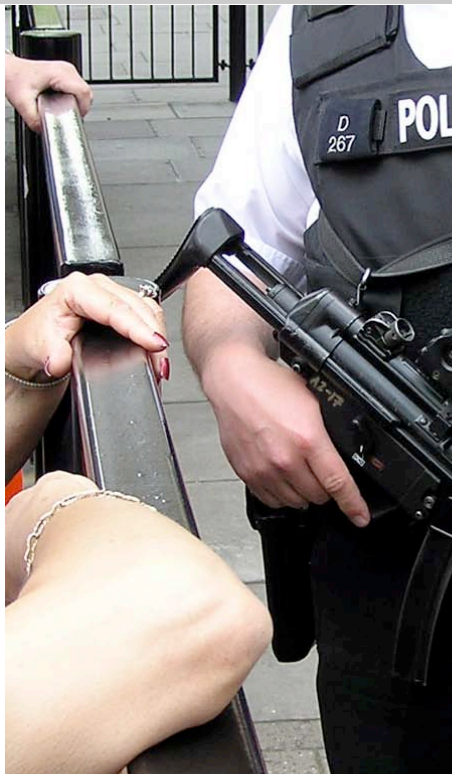
blocks **35** types of error

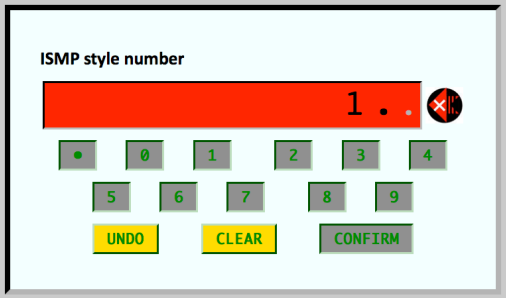






- Where's the safety lock?
- You cannot make data entry errors





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Reducing number entry errors: solving a widespread, serious problem

Harold Thimbleby[1,*] and Paul Cairns[2]

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[2]*Department of Computer Science, University of York, York YO10 5DD, UK*

Number entry is ubiquitous: it is required in many fields including science, healthcare, education, government, mathematics and finance. People entering numbers are to be expected to make errors, but shockingly few systems make any effort to detect, block or otherwise manage errors. Worse, errors may be ignored but processed in arbitrary ways, with unintended results. A standard class of error (defined in the paper) is an 'out by 10 error', which is easily made by miskeying a decimal point or a zero. In safety-critical domains, such as drug delivery, out by 10 errors generally have adverse consequences. Here, we expose the extent of the problem of numeric errors in a very wide range of systems. An analysis of better error management is presented: under reasonable assumptions, we show that the probability of out by 10 errors can be halved by better user interface design. We provide a demonstration user interface to show that the approach is practical.

death rate

> To kill an error is as good a service as, and sometimes even better than, the establishing of a new truth or fact.
>
> (Charles Darwin 1879 [2008], p. 229)

Interactive systems need safety locks

Harold Thimbleby
Swansea University

Why safety locks?

1. People make slips
2. Safety locks stop (some) slips causing harm
3. Bad design allows slips to cause harm

ideas

1. **Safety locks work**
2. **They aren't difficult to program**
3. **They save lives**
4. ***Go and put them in!***

Press On

Principles of interaction programming

MIT Press, 2007

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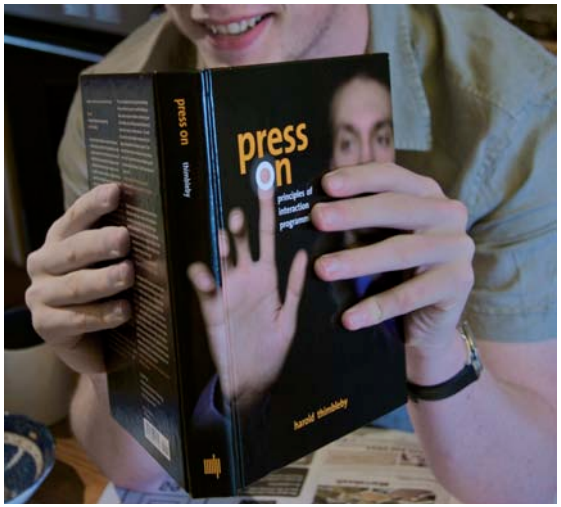

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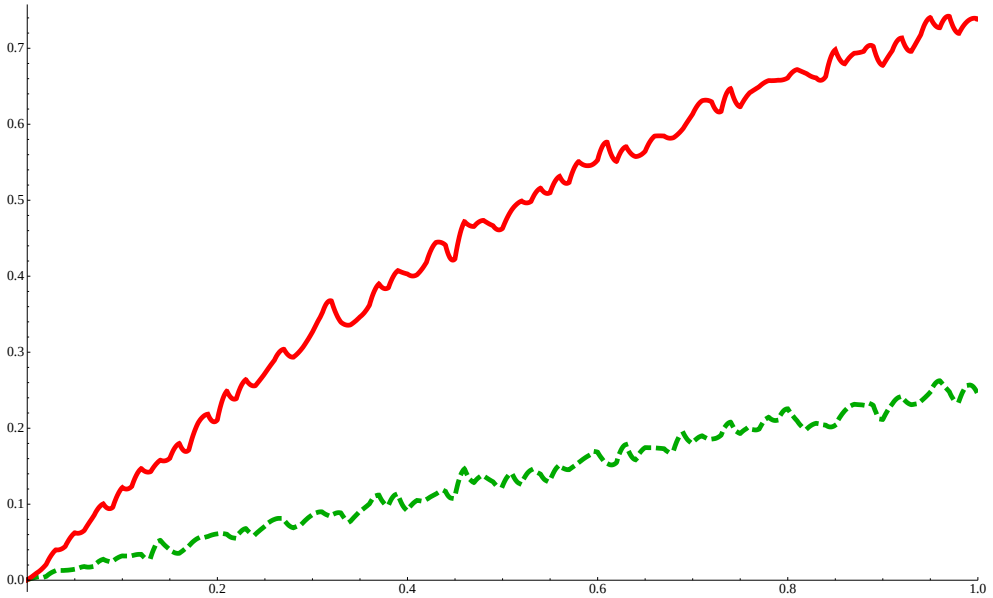
- Think of a dose
- Say, 5•5
- *Sometimes* make slips
- Enter 5•5 58 5••5 etc
- Classify out-by-ten errors