

# Lecture 5: Designing efficient systems

Measuring and optimising human performance through quantitative experimental methods.

# Overview of the course

- Theory driven approaches to HCI
- Design of visual displays
- Goal-oriented interaction
- Designing smart systems (guest lecturer)
- **Designing efficient systems**
- Designing meaningful systems (guest lecturer)
- Evaluating interactive system designs
- Designing complex systems

# Lessons from text entry - recap

- It's possible to model human action
- It's possible (in part) to predict human action
- Efficiency can be predicted, and also measured
- A really fundamental trade-off:
  - *Speed versus accuracy*

# Fitts' Law

# User actions are information-constrained

How many bits of information to select one of these choices?



How many bits of information to select one of these choices?



The human neuromotor system is limited by information rate - size of target relative to movement

# Demonstration of Fitts' Law

# Fitts' Law – the only equation in HCI!

- How long does it take to point at something?
- Proportional to the **D**istance to target
- Inversely proportional to **W**idth of target
- Like most human performance (and most things in information theory), it's a log function:
- Time =  $k \log (2D/W)$

# Speed-accuracy tradeoff

- Users are capable of doing things faster
- But making more mistakes as a result
- Did your application need speed, or accuracy?



By Anna Frodesiak - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=11443870>

## 1. State EOC

### 1. TEST Message

DRILL-PACOM (DEMO) STATE ONLY

False Alarm BMD (CEM) - STATE ONLY

Monthly Test (RMT) - STATE ONLY

PACOM (CDW) - STATE ONLY

<https://theoutline.com/post/2954/user-interface-designers-are-horrified-by-hawaii-s-missile-alert-system?zd=1>



# Hacking Fitt's Law: "semantic pointing"



Renaud Blanch, Yves Guiard and Michel Beaudouin-Lafon. **Semantic Pointing: Improving Target Acquisition with Control-Display Ratio Adaptation.** In *Proceedings of CHI 2004*, pages 519-526, Vienna - Austria, April 2004.

# Small changes can have a big effect (1972)

## Psychological Evaluation of Two Conditional Constructions Used in Computer Languages

M. E. SIME, T. R. G. GREEN AND D. J. GUEST

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NEST solution:

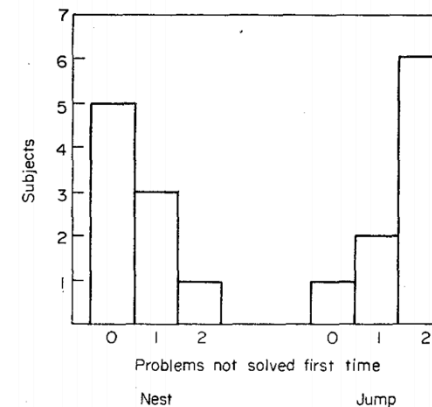
```
IF JUICY THEN
  IF LEAFY THEN
    IF GREEN THEN GRILL
    OTHERWISE BOIL
  OTHERWISE FRY
OTHERWISE
  IF HARD THEN ROAST
  OTHERWISE REJECT
```

vs

JUMP solution:

```
IF JUICY GOTO L1
IF HARD GOTO L2
REJECT
L2 ROAST
L1 IF LEAFY GOTO L3
  FRY
L3 IF GREEN GOTO L4
  BOIL
L4 GRILL
```

=>



KLM/GOMS: Predicting time

# Keystroke Level Model (KLM)

Model an interaction as series of operators, to predict the time an expert takes to do something

<b>Operator</b>	<b>Time/s</b>	<b>Description</b>
K	0.2	Key or button press
P	1.1	Pointing
H	0.4	Homing, switching hand between keyboard/mouse
M	1.35	Mental preparation
R	?	System response time

# Keystroke Level Model (KLM)

Rules for when you should insert operators (NOT EXAMINABLE)

1. Insert Ms in front of Ks and Ps that select commands
2. Remove any Ms that are fully anticipated
3. Remove all but the first M from runs of MK that are a single cognitive unit
4. Remove any Ms where the K is a redundant terminator
5. Remove Ms from terminate constant strings

# Example

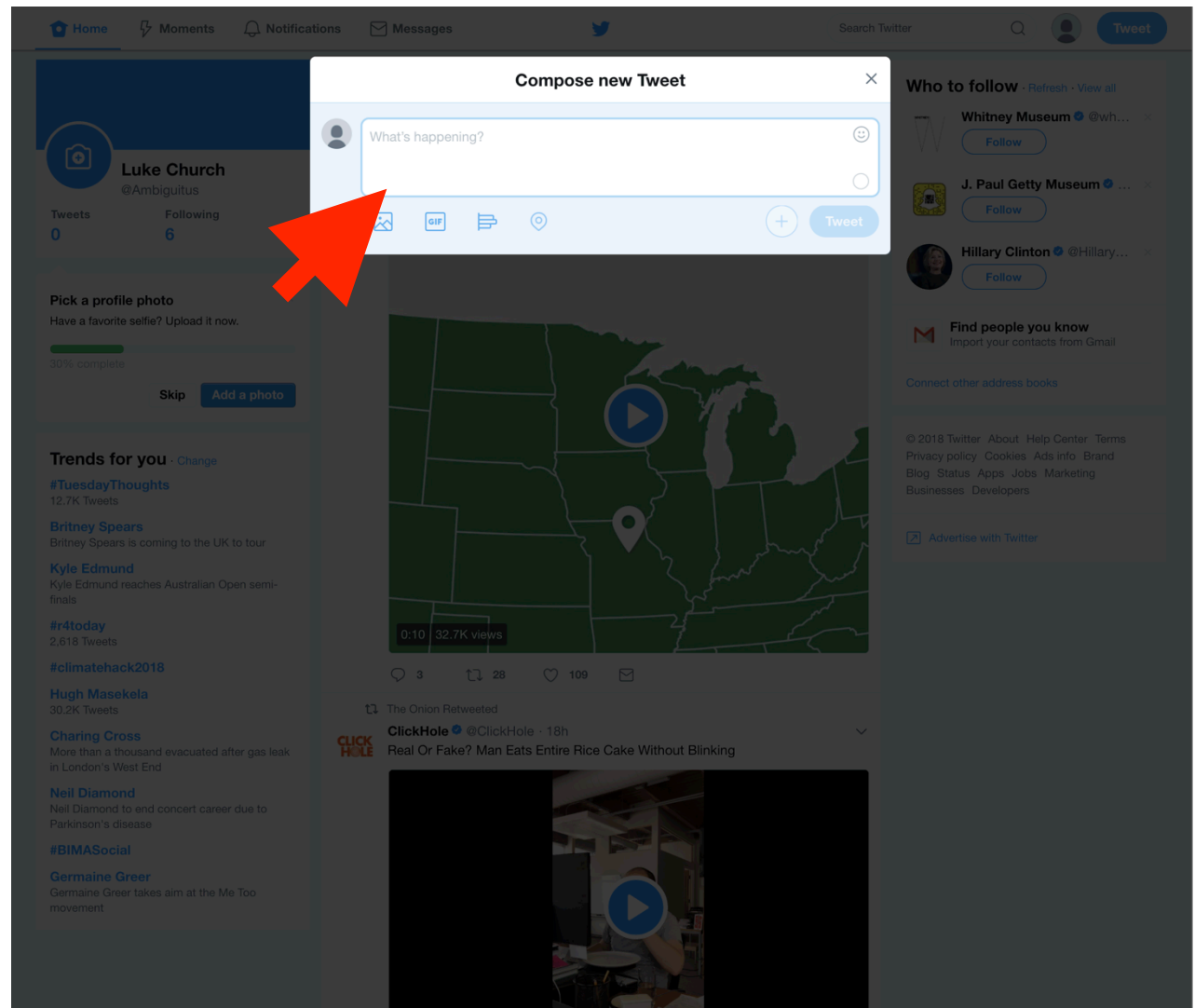
- M (before command)
- H (hand -> mouse)
- P (point at "Tweet")
- K (Click)
- R (wait for response)

The screenshot shows the Twitter interface with the following elements:

- Navigation Bar:** Home, Moments, Notifications, Messages, and a 'Tweet' button in the top right corner, which is highlighted by a red arrow.
- Profile Card:** Luke Church (@Ambiguitus) with 0 tweets and 6 following.
- Profile Photo Prompt:** "Pick a profile photo" with a progress bar at 30% complete and buttons for "Skip" and "Add a photo".
- Trends for you:** A list of trending topics including #TuesdayThoughts, Britney Spears, Kyle Edmund, #r4today, #climatehack2018, Hugh Masekela, Charing Cross, Neil Diamond, and #BIMASocial.
- Main Tweet:** From The Onion (@TheOnion) 4 hours ago, titled "National News Highlights". The tweet content is: "Columbia, MO Contractor Lewis Petersen, 46, felt guilty about installing floors in a new house on Doyle Street, as he knows good and well that floors are unnecessary and a scam." It includes a map of Missouri with a location pin and has 3 replies, 28 retweets, and 109 likes.
- Retweet:** The tweet is retweeted by ClickHole (@ClickHole) 18 hours ago with the text "Real Or Fake? Man Eats Entire Rice Cake Without Blinking" and a video thumbnail.
- Right Sidebar:** "Who to follow" section featuring Whitney Museum, J. Paul Getty Museum, and Hillary Clinton, along with a "Find people you know" section.

# Example

M (before command)  
P (point at “What’s  
happening?”)  
K (Click)



# Example

M (Prepare to type)

K

K

K

K

K

K

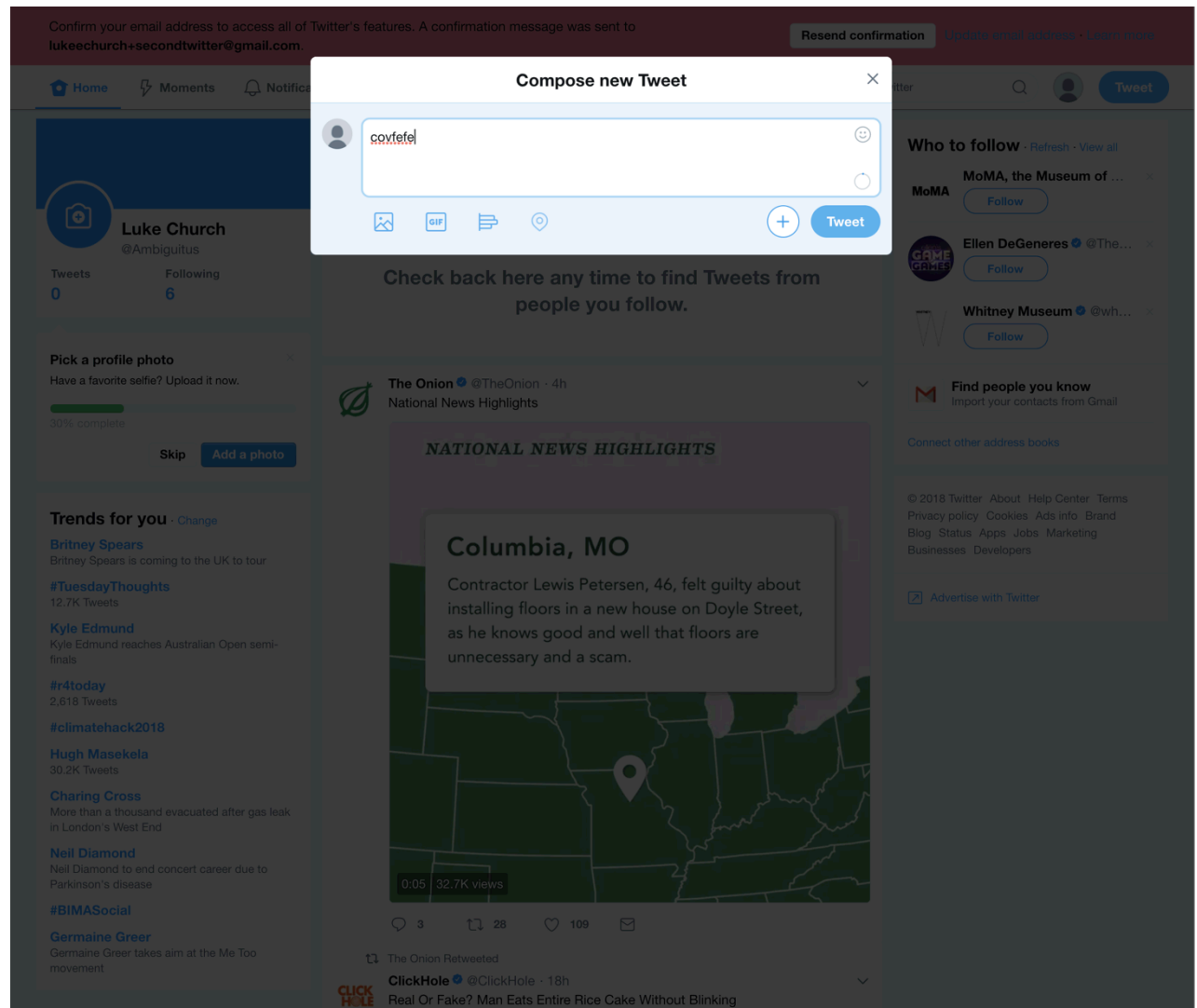
K

M (Prepare to click)

P (Point at "Tweet")

K (Click)

R (Wait for response)



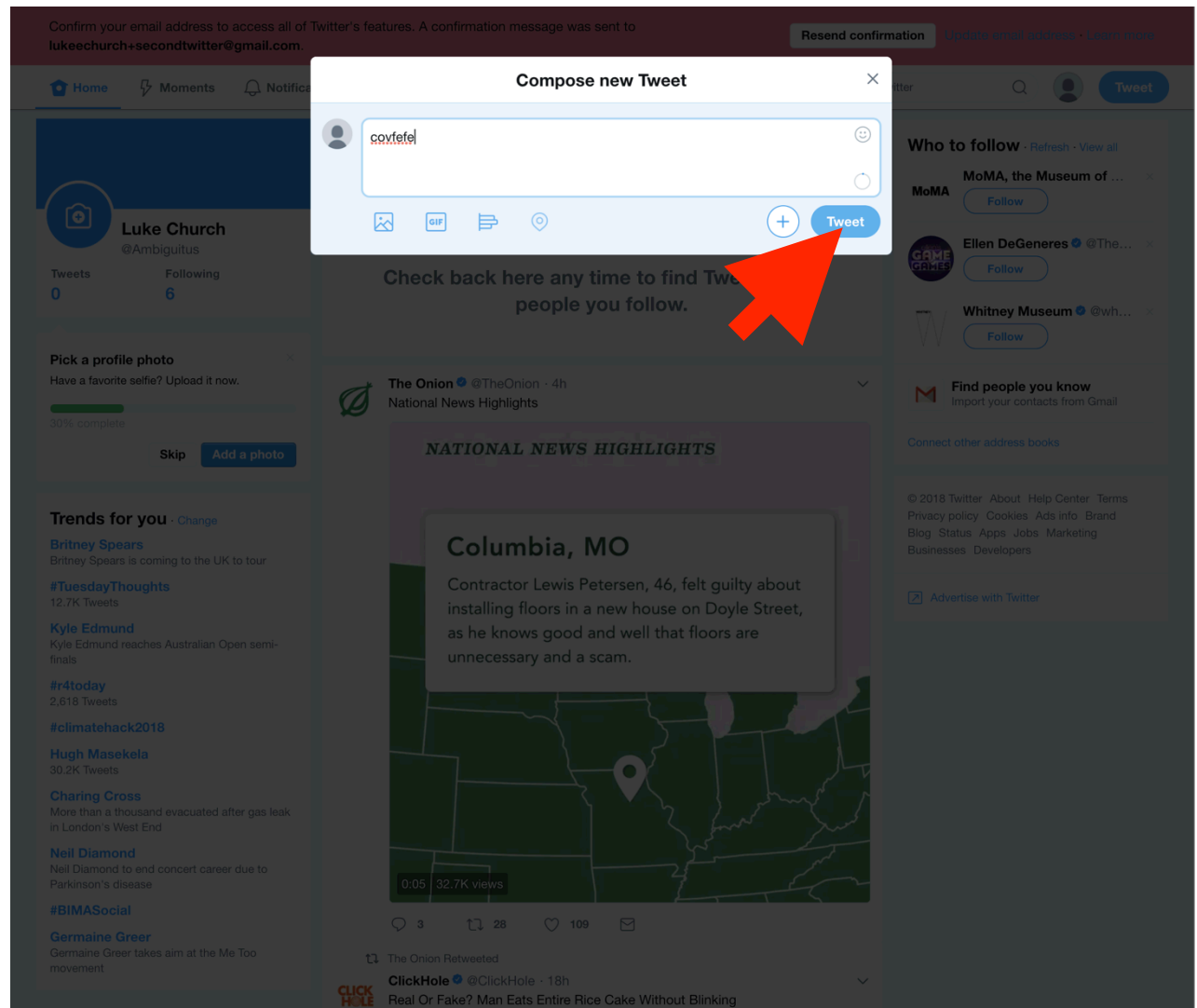


# Example

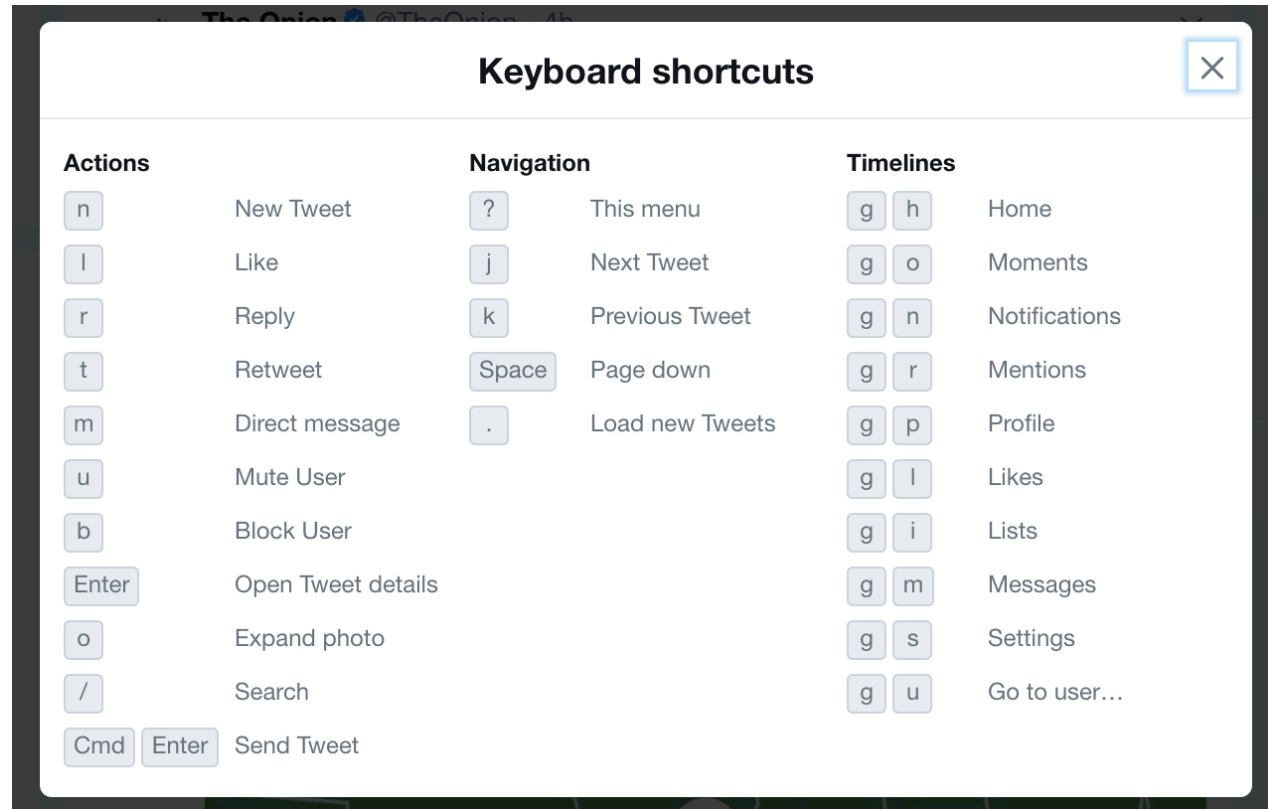
MHPKR  
MPK  
MKKKKKKKMPKR

$$1.35 + 0.4 + 1.1 + 0.2 + \sim 0.2$$
$$1.35 + 1.1 + 0.2$$
$$1.35 + 7 \cdot 0.2 + 1.35 + 1.1 + 0.2 + \sim 0.2$$

= 11.5s



# Keyboard shortcuts



The image shows a screenshot of the Twitter 'Keyboard shortcuts' modal window. The window has a title bar with the text 'Keyboard shortcuts' and a close button (X) in the top right corner. The content is organized into three columns: 'Actions', 'Navigation', and 'Timelines'. Each item consists of a keyboard shortcut icon followed by the action name.

Actions	Navigation	Timelines
<b>n</b> New Tweet	<b>?</b> This menu	<b>g h</b> Home
<b>l</b> Like	<b>j</b> Next Tweet	<b>g o</b> Moments
<b>r</b> Reply	<b>k</b> Previous Tweet	<b>g n</b> Notifications
<b>t</b> Retweet	<b>Space</b> Page down	<b>g r</b> Mentions
<b>m</b> Direct message	<b>.</b> Load new Tweets	<b>g p</b> Profile
<b>u</b> Mute User		<b>g l</b> Likes
<b>b</b> Block User		<b>g i</b> Lists
<b>Enter</b> Open Tweet details		<b>g m</b> Messages
<b>o</b> Expand photo		<b>g s</b> Settings
<b>/</b> Search		<b>g u</b> Go to user...
<b>Cmd Enter</b> Send Tweet		

# Example

M (become command)  
K ('n')  
R (wait for response)

The image shows a screenshot of a Twitter profile page for Luke Church (@Ambiguitus). The profile header includes the name, handle, and statistics: 0 tweets and 6 following. A 'Pick a profile photo' prompt is visible, showing a 30% completion progress bar and buttons for 'Skip' and 'Add a photo'. The 'Trends for you' section lists several trending topics with their respective tweet counts. The main content area features a tweet from 'The Onion' (@TheOnion) about 'National News Highlights' in Columbia, MO, with a video player showing a map and a text overlay. Below this is a retweeted video from 'ClickHole' (@ClickHole) titled 'Real Or Fake? Man Eats Entire Rice Cake Without Blinking'. The right sidebar contains a 'Who to follow' section with suggestions like Whitney Museum, J. Paul Getty Museum, and Hillary Clinton, along with a 'Find people you know' section and footer links for Twitter's policies and advertising options. A red arrow points to the 'Tweet' button in the top right corner of the interface.

# Example

M (Prepare to type)

K

K

K

K

K

K

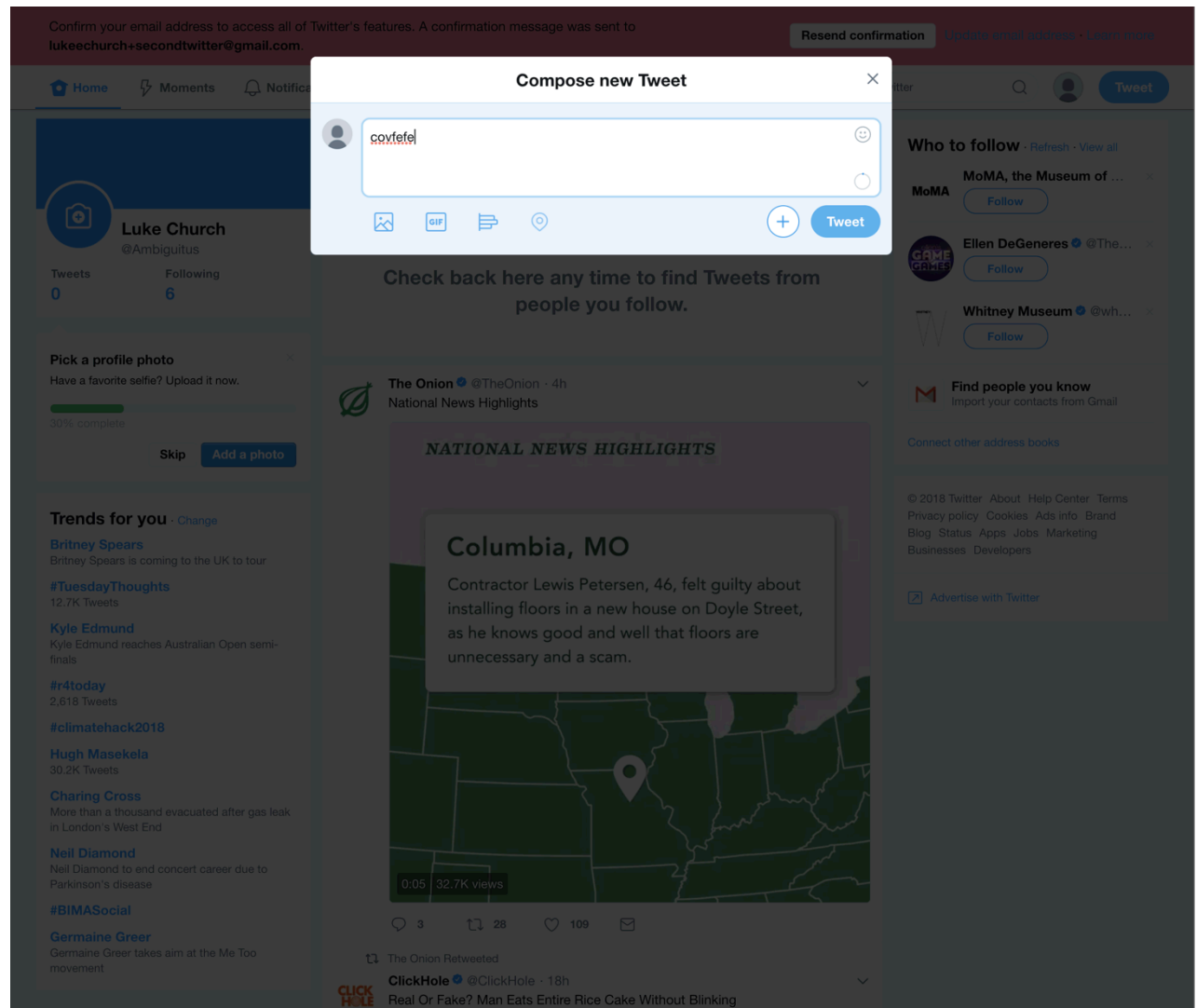
K

M (Prepare to click)

K (cmd)

K (enter)

R (Wait for response)



# Example

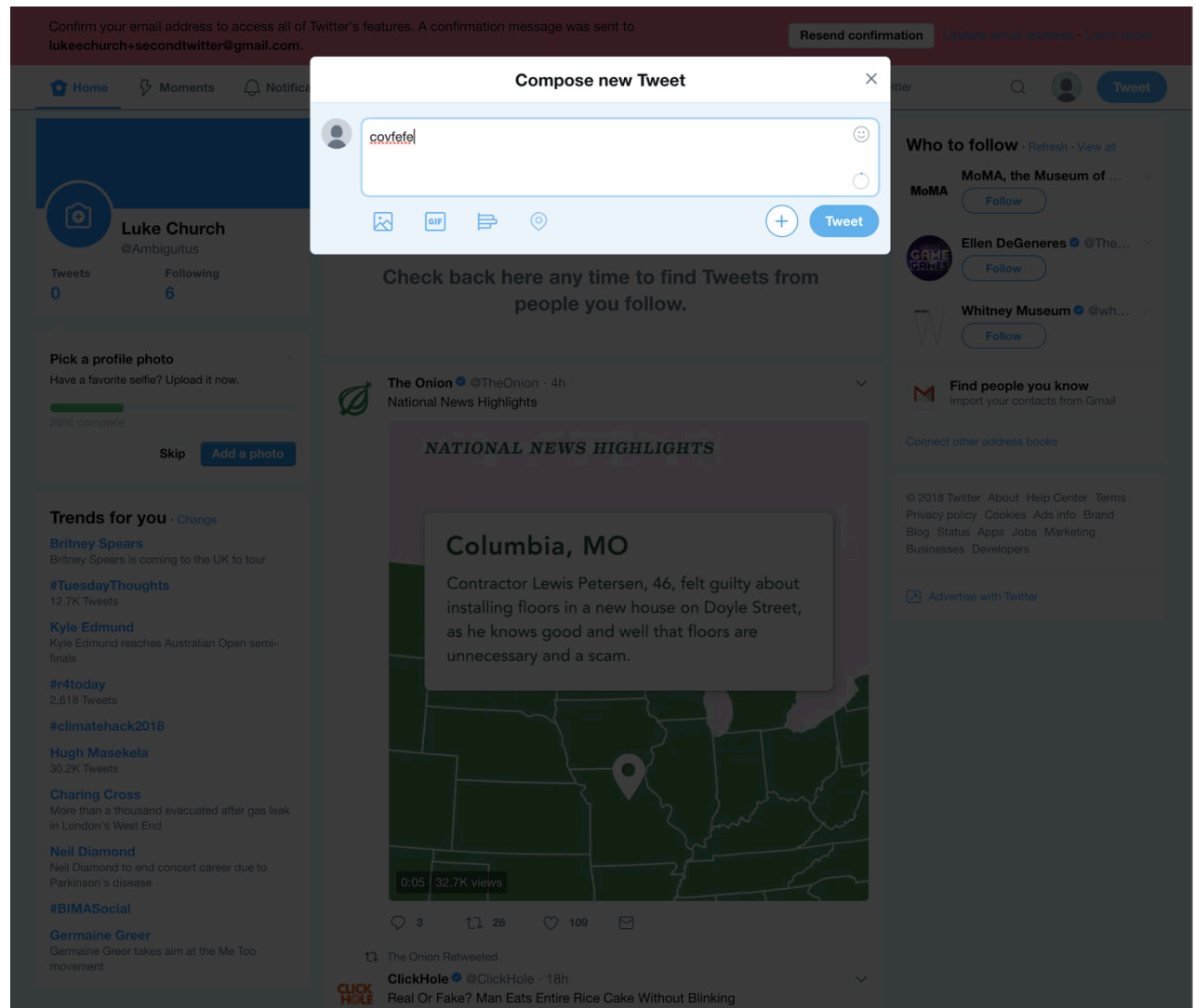
MKR  
MKKKKKKKMKKR

$$1.35 + 0.2 + \sim 0.2$$

$$1.35 + 7 \cdot 0.2 + 1.35 + 0.2 + 0.2 + \sim 0.2$$

$$= 6.45s$$

(Compared to 11.5s before)

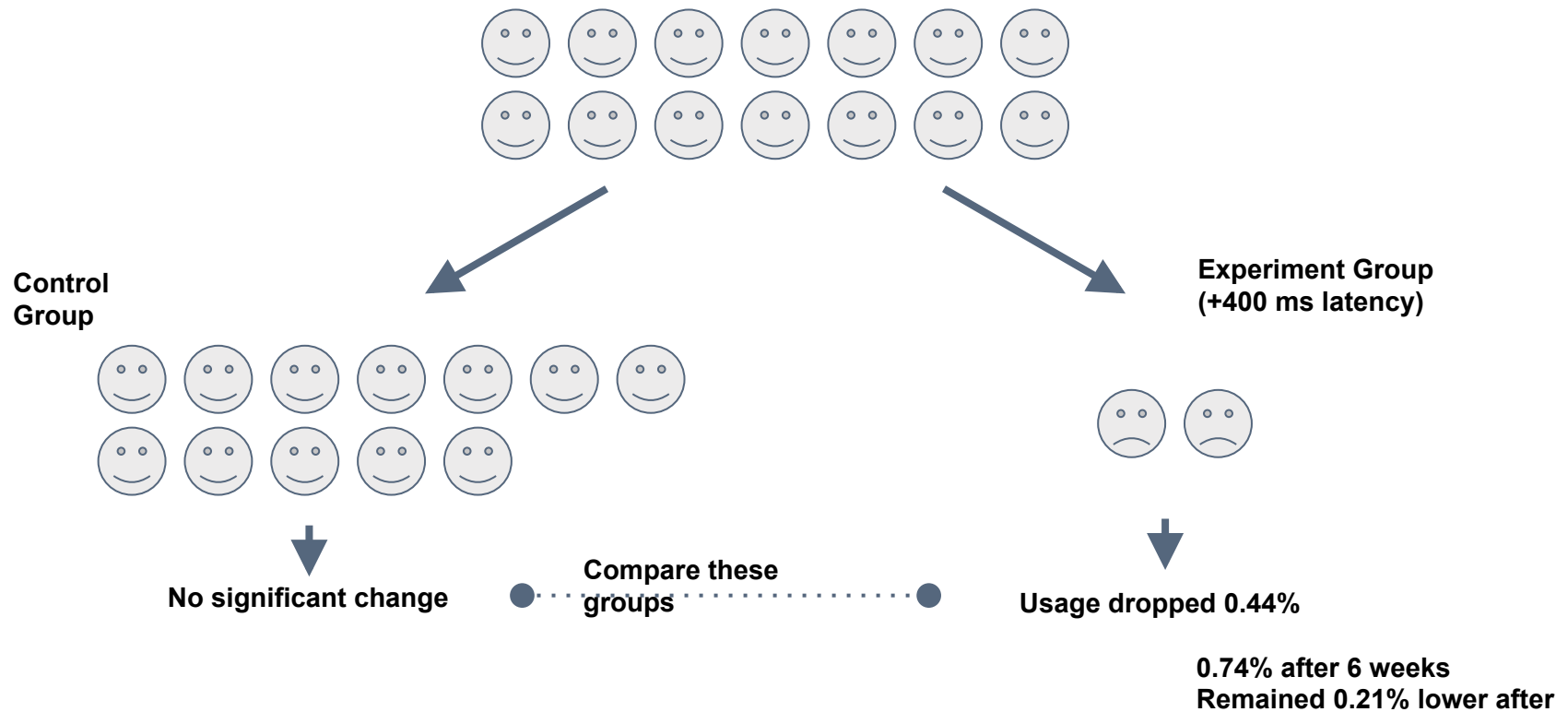


Experiments: Measuring time/usage

# How many links should be on a search result page? (10, 20 or 30?)

- User studies: More is better
- When given 30, usage fell - why?
  - Analysis showed 400ms extra latency

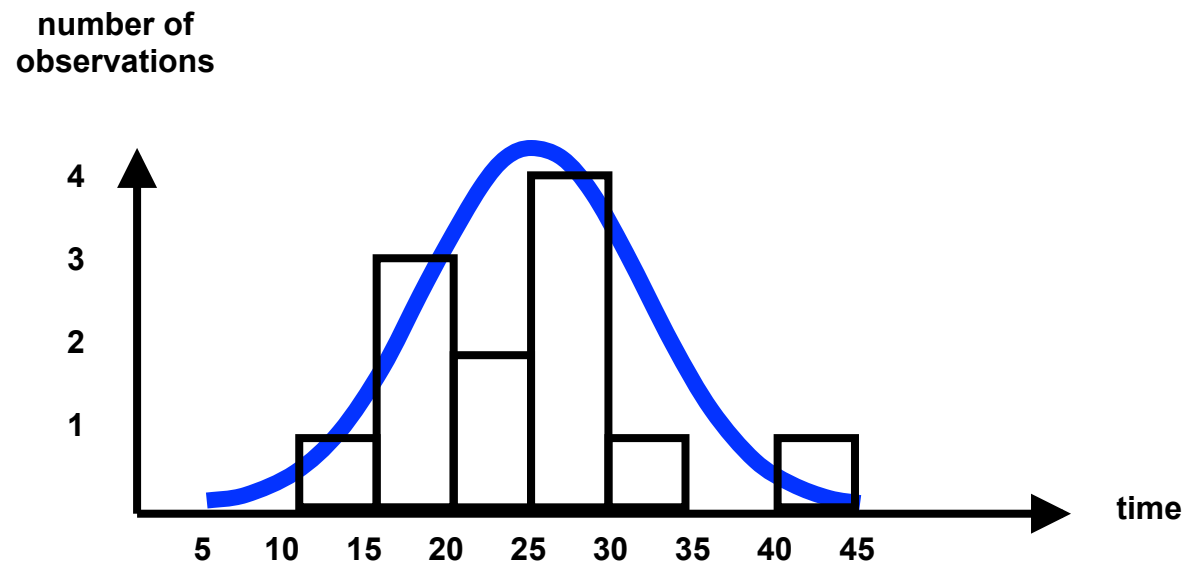
# Latency experiment





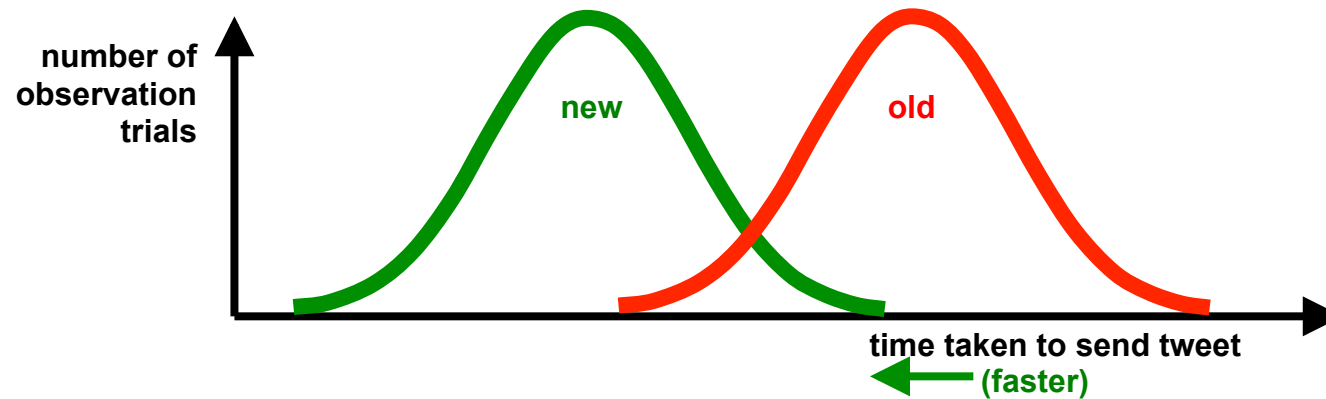
These are A/B experiments

(statistics: histograms & distributions)



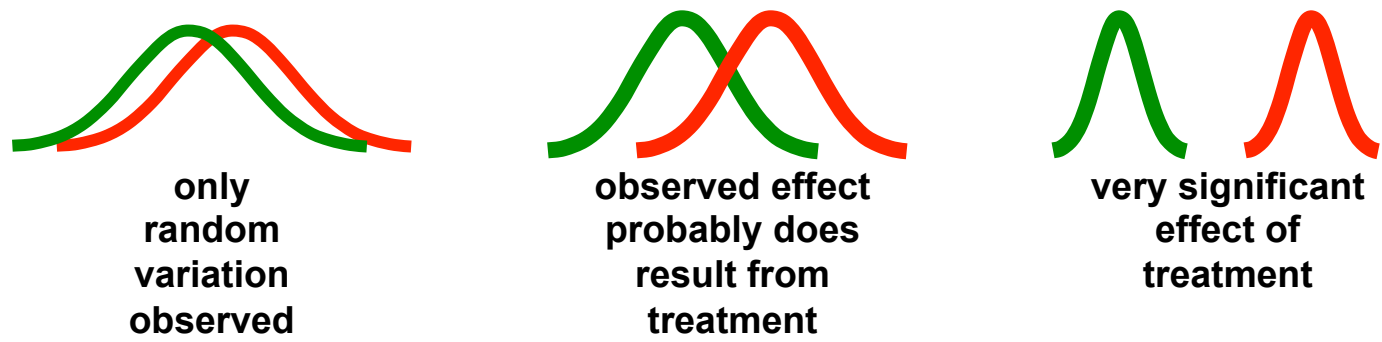
## Experimental treatments

- A *treatment* is some modification that we expect to have an effect on usability:
  - How long does Donald take to send his tweet using this great new interface, compared to the crummy old one?
  - Expected answer: *usually faster, but not always*



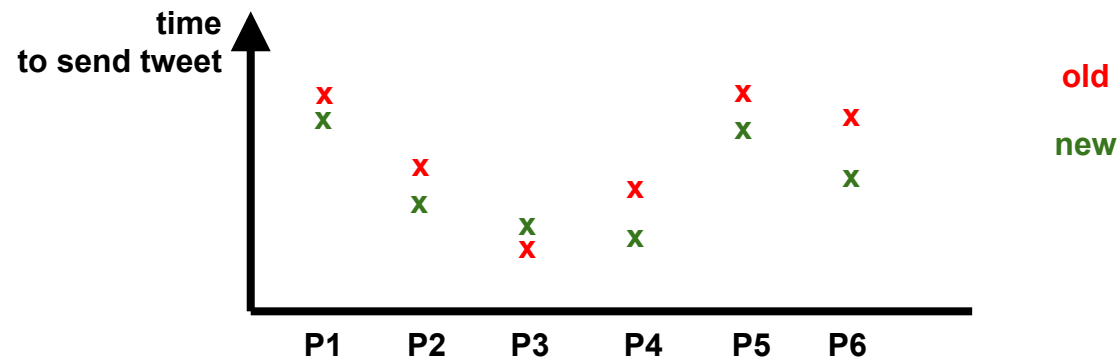
# Hypothesis testing

- *Null hypothesis:*
  - What is the probability that this amount of difference in means could be random variation between samples?
  - Hopefully very low ( $p < 0.01$ , or 1%)
  - Use a statistical *significance test*, such as the *t-test*.



## Sign tests

- In a within subjects experiment it's possible to compare the results
  - Explores the [null] hypothesis that the median of the pairs is zero
  - Means might not be significant, but the sign can be
  - This is a non-parametric test, so doesn't depend much on the data, but not very powerful (use a paired t-test, or Wilcoxon rank test instead)



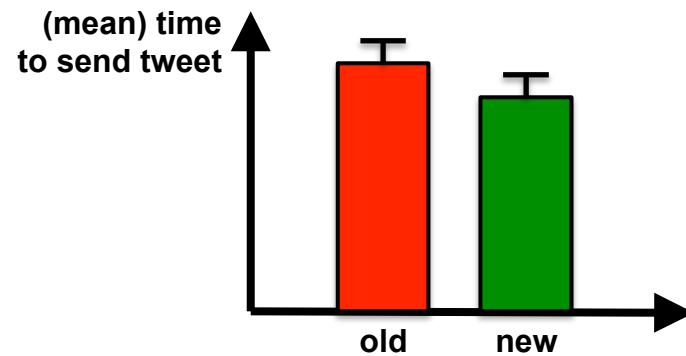
Experiment A: 'significant' but boring

## Sources of variation

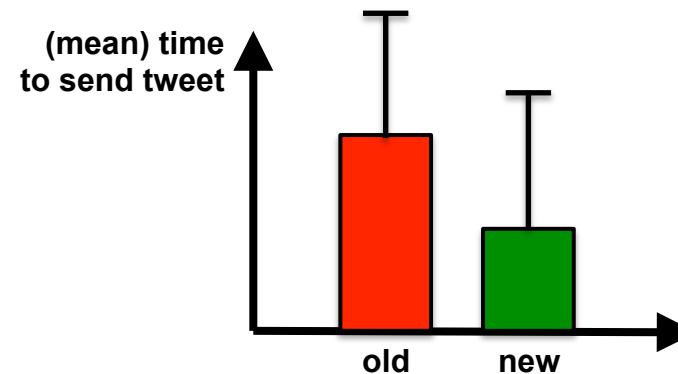
- People differ, so quantitative approaches to HCI must be statistical.
- We must distinguish sources of variation:
  - The effect of the treatment - what we want to measure.
  - Individual differences between subjects (e.g. IQ).
  - Distractions during the trial (e.g. sneezing).
  - Motivation of the subject (e.g. Mondays).
  - Accidental intervention by experimenter (e.g. hints).
  - Other random factors.
- Good experimental design and analysis isolates these.

## Effect size – means and error bars

- Difference of two means may be statistically significant (if sample has low variance), without being very interesting.
  - But mean differences must *always* be reported with a confidence interval, or plotted with 'error bars'



Experiment A: 'significant' but boring



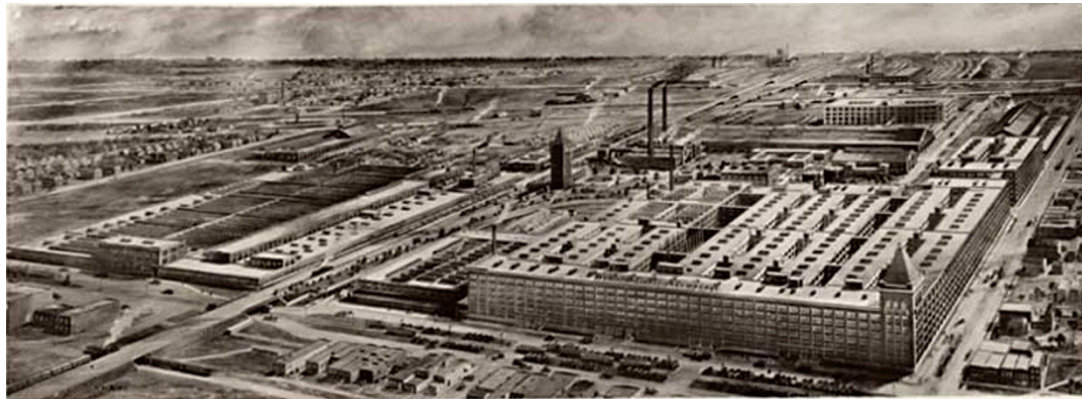
Experiment B: interesting, but treat with caution

## Problems with controlled experiments

- Huge variation between people (~200%)
- Mistakes mean huge variation in accuracy (~1000%)
- Improvements are often small (~20%)
- ... or even negative (because new & unfamiliar)
- ... and may result from something unrelated to your design!



# The Hawthorne Effect



- Studies on productivity in 1924-1932
  - Do lighting levels affect productivity?
  - Studies appeared to show improvements in both directions
  - Results show the motivational effect of being studied, not of the change

By Western Electric Company - Western Electric Company Photograph Album, 1925., Public Domain, <https://commons.wikimedia.org/w/index.php?curid=37704076>

Is efficiency always a design goal?

- What if you wanted to encourage thoughtfulness? Creativity?

# Taylorism

- F.W. Taylor (1856-1915)
  - Engineer who invented scientific management
  - Measure workers as if parts in a machine
  - Optimise by measurement and correction
- Not so popular with trade unions!
  - Note that 2nd wave HCI (the turn from human factors to social science) involved working closely with trade unions, especially in Sweden and Denmark



# Discretionary use systems

If you are not working to someone else's goal, you can decide whether or not to be efficient (or whether you want to use the system at all)



Simone Giertz: "Queen of Shitty Robots"

# Efficient creativity?

- What if there isn't a good measure of productivity?
  - Maximise output of poetry-lines?
  - Maximise musical notes played per second?
  - Maximise Cambridge graduates per year?
- Optimum User Experience
  - What if you wanted people to enjoy what they did?



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