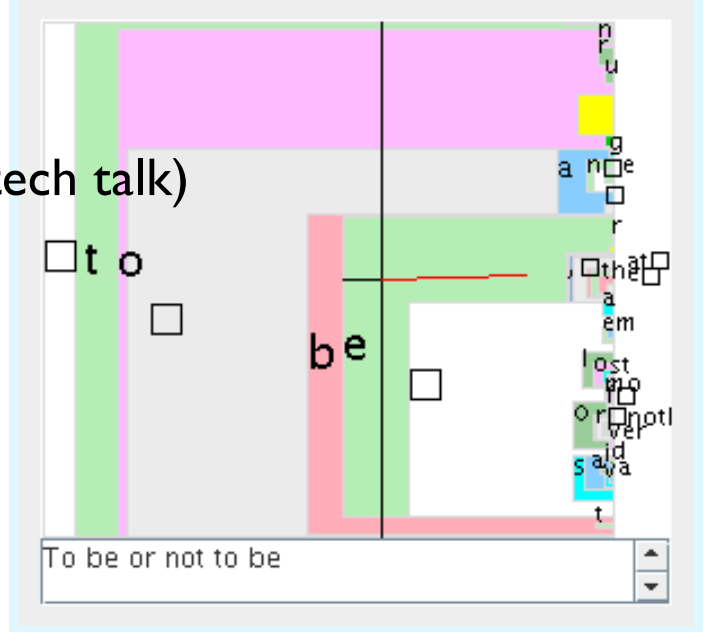
Mixed Initiative Interaction

MPhil ACS module P230 - Alan Blackwell

What is Mixed Initiative?

A classic illustration of mixed initiative – predictive text

- David MacKay's Dasher was the first ML-based predictive text system
  - turned a language model visualisation into an interactive controller
  - the driving/flying metaphor can appear 'autonomous'
    - Continues generating text unless you stop it – imagine if it used GPT3
    - Steers you toward most likely sequences from training data (plagiarism?)
    - Takes serious effort to say something unlikely
- Keith Vertanen's reimplementation
  - https://dasher-site.netlify.app
- David's language model explanation (extract from Google tech talk)
  - https://youtu.be/0d6yIquOKQ0
- Instructions on how to use Dasher by Keith Vertanen
  - https://youtu.be/nr3s4613DX8
- Testimonials by users (developer Ada Majorek at 1:15)
  - https://youtu.be/QxFEUk3J89Q



Principles of Mixed-Initiative User Interfaces

- Classic paper by Eric Horvitz:
  - Principles of mixed-initiative user interfaces.
  - In proceedings CHI 1999, pp. 159-166.
- Advocates elegant coupling of *automated services* with *direct manipulation*
- *Autonomous actions should be taken only when an agent believes that they will have greater expected value than inaction for the user.*
  - (note who controls this relationship – "when the agent believes" – and note Horvitz's current job as Chief Scientific Officer of Microsoft)

How to add value with automation

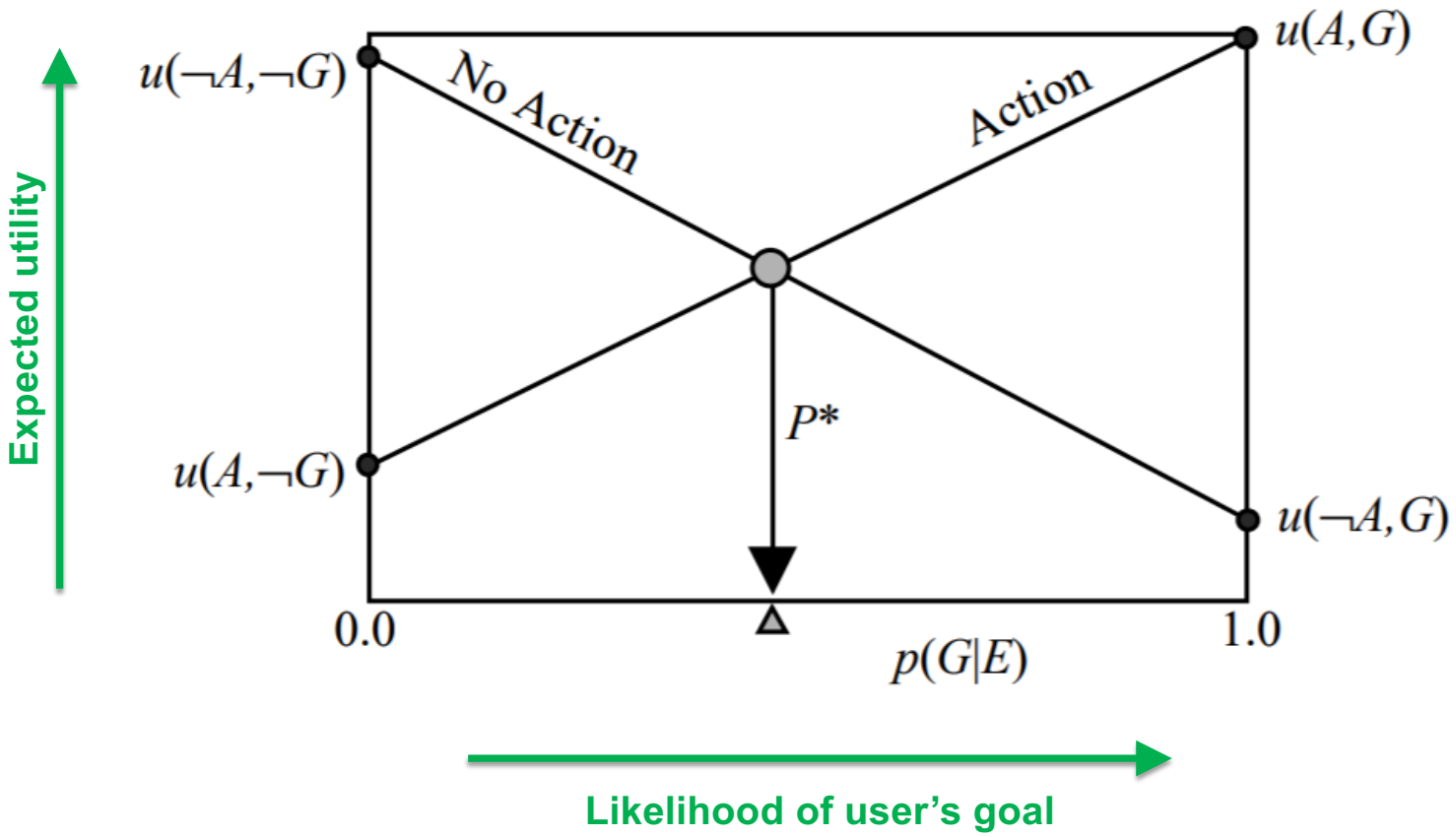
- Consider uncertainty about user's goals
- Consider status of user's attention in timing services
  - with cost/benefit of deferring action to a time when action will be less distracting.
- Infer ideal action in light of costs, benefits, and uncertainties
- Employ dialog to resolve key uncertainties
  - consider costs of bothering user needlessly
- Allow efficient direct invocation and termination
- Minimise cost of poor guesses about action and timing

Expected utility of automated action

- assume an agent can infer p(G|E)
  - likelihood of the user's goal being G
  - given the observed evidence E
- and decide whether to take action A, based on the utility that this action would have in achieving the desired goal G rather than other possible outcomes (not-G)

	Desired Goal	Not Desired
Action	$u(A,G)$	$u(A,\neg G)$
No Action	$u(\neg A,G)$	$u(\neg A,\neg G)$

Expected utility threshold for action vs no action



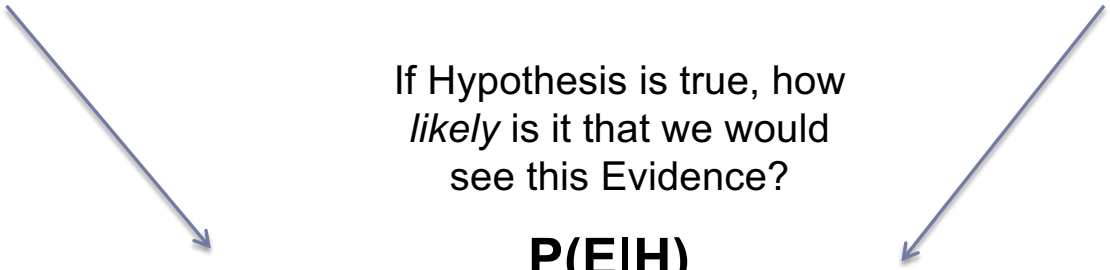
A probabilistic view of user interaction

- Machine:
  - I know how to do several things.
  - I wonder which one the user wants me to do? ***(a likelihood estimate)***
- User:
  - This machine can do a whole bunch of stuff.
  - What is most likely to make it do the right stuff? ***(a likelihood estimate)***
- Machine:
  - I think the user has ***(may have)*** made a mistake
- User:
  - I think the machine has ***(may have)*** made a mistake

Bayes theorem (for Bayesian inference)

Posterior probability of **H**ypothesis *after* taking new **E**vidence into account

Prior inferred probability of this **H**ypothesis *before* new **E**vidence became available.



If Hypothesis is true, how *likely* is it that we would see this Evidence?

$$P(H|E) = \frac{P(E|H)}{P(E)} P(H)$$

What is the probability of seeing E, under all possible hypotheses?

H: Hypothesis
E: Evidence

Bayesian inference inference of user intention

Probability that user wants to delete all files, given that they just typed ‘rm –rf’

(Prior) probability that user wanted to delete all files *before* we saw this.

If user does want to delete all files, how *likely* is it that they would type ‘rm –rf’?

$$P(D|R) = \frac{P(R|D)}{P(R)} P(D)$$

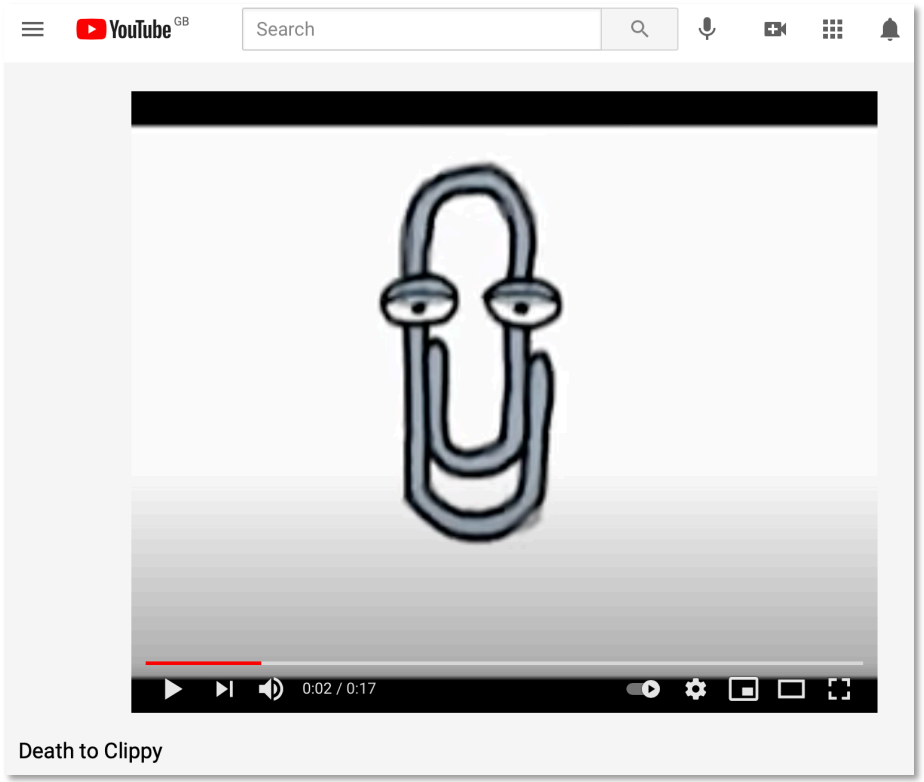
What is the probability user would type ‘rm –rf’, under all possible hypotheses?

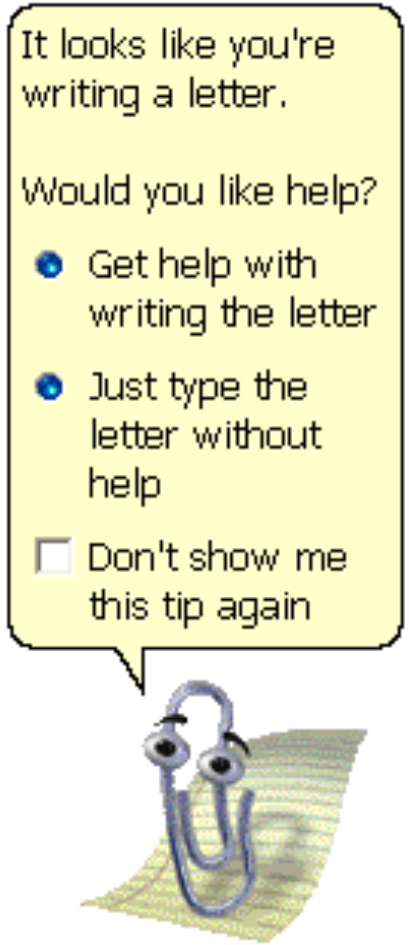
D: User wants to **D**elete all their files

R: User has typed ‘**r**m –rf’

Another classic (notorious) example of mixed initiative

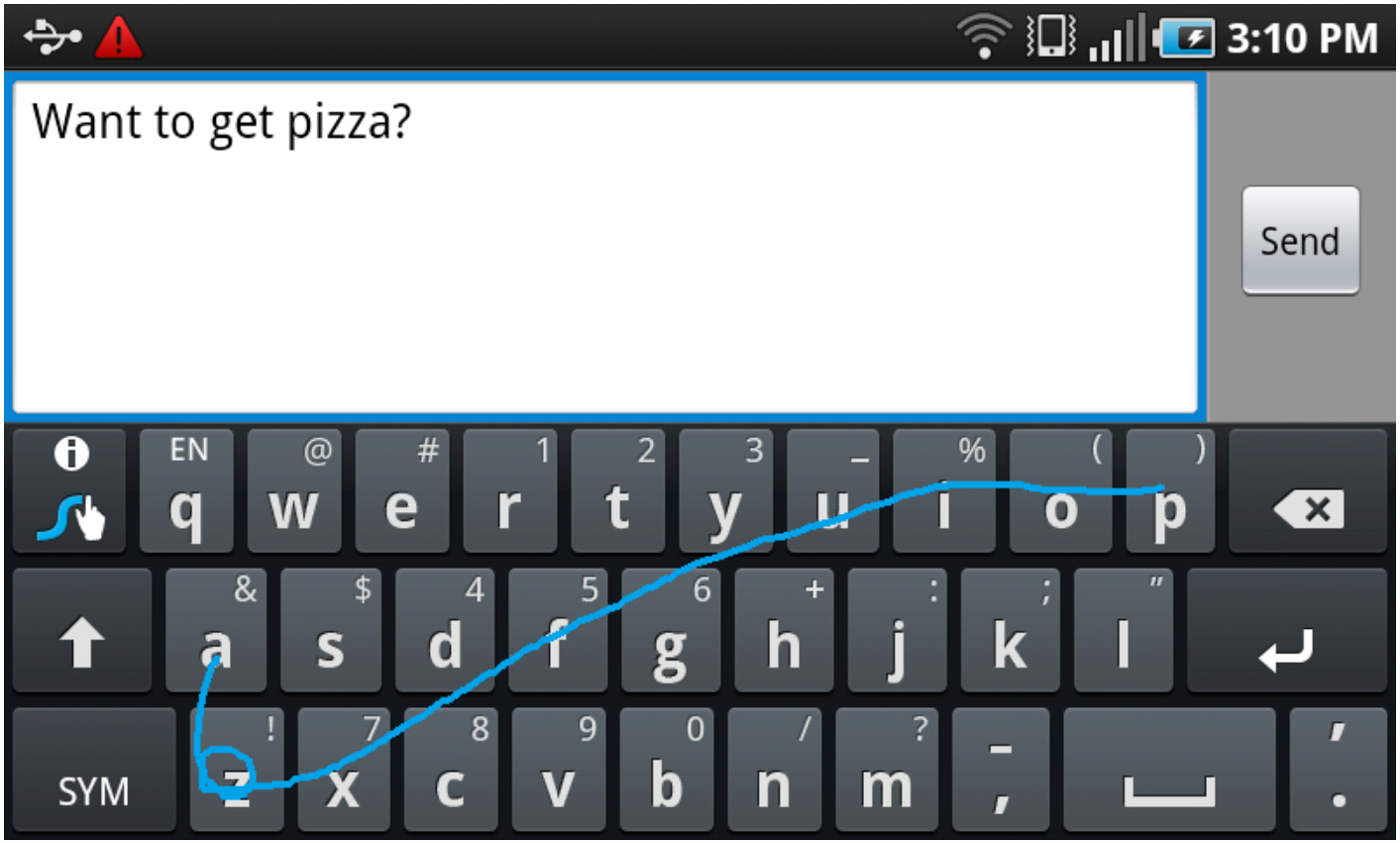
- https://www.youtube.com/watch?v=0ej4tW7hLkE

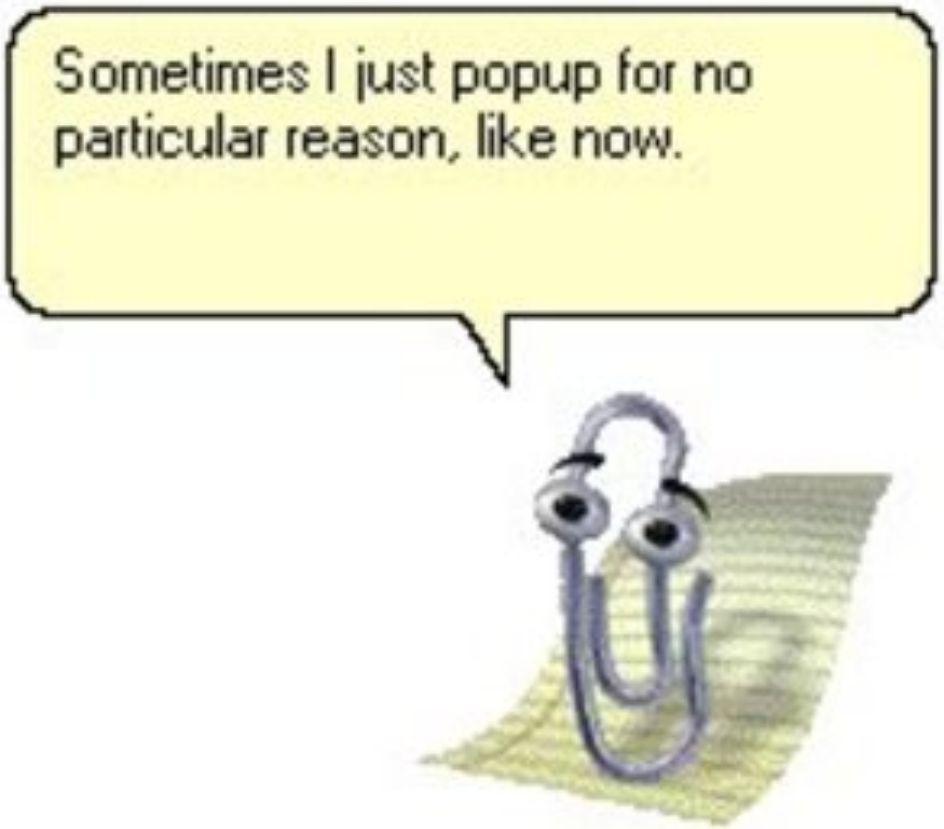




Unobtrusive direct manipulation strategy: semantic pointing

Unobtrusive direct manipulation strategy: gesture keyboard




Sometimes I just popup for no particular reason, like now.

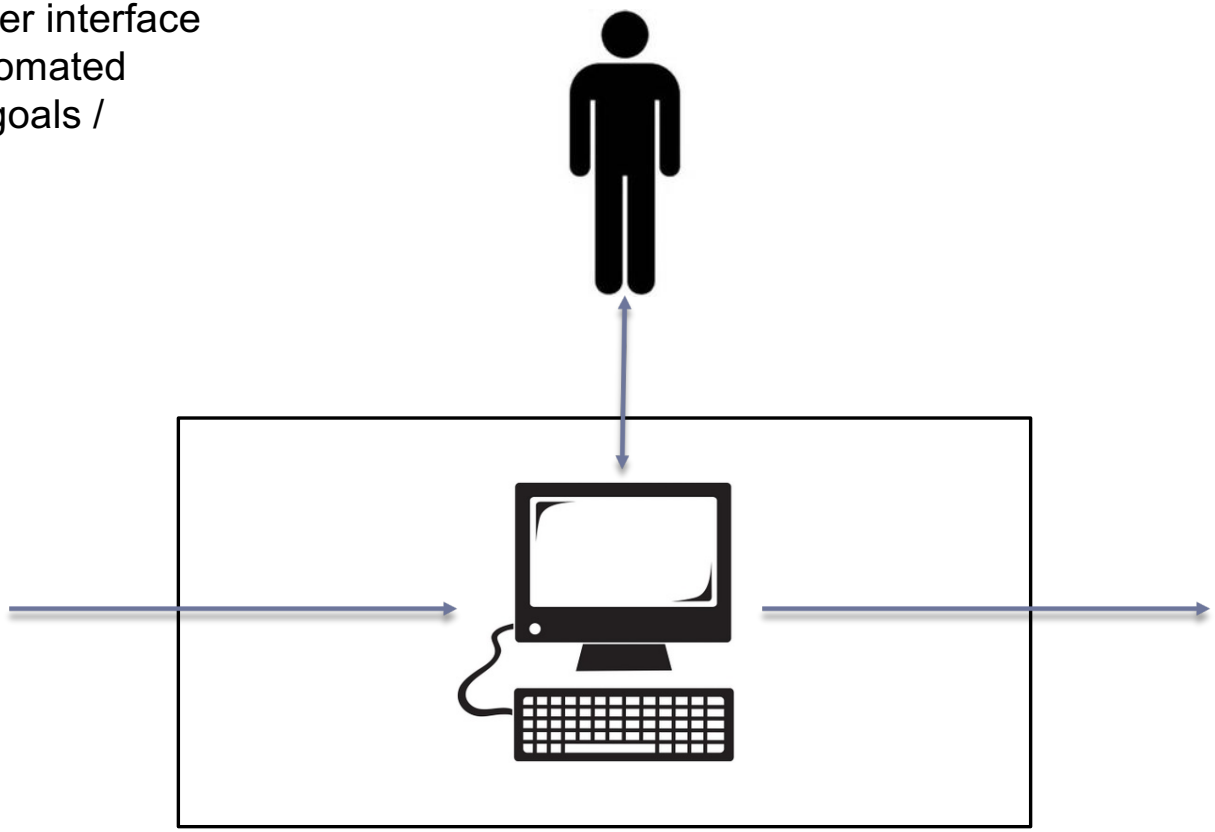
Information flow and mixed initiative

System boundaries – autonomous vehicle case

- See Shneiderman (2020) for broad background (linked to course materials page)
- Where does information enter the system?
  - User defines setpoint ("cruise control")
  - Supplier offers features ("active braking")
  - Regulator defines policy ("following distance")
  - Government provides infrastructure ("lane markings")
- Notes:
  - Even if the system includes "autonomous" closed loop control algorithms, information is acquired through more or less costly interactive processes outside the system boundary.
  - All closed loop control systems do machine learning (reacting to error signal, tuning gain and stability etc), but as interaction with such systems becomes routine, these *cybernetic* components are no longer considered intelligent.

Human in the Loop? Conventional system design

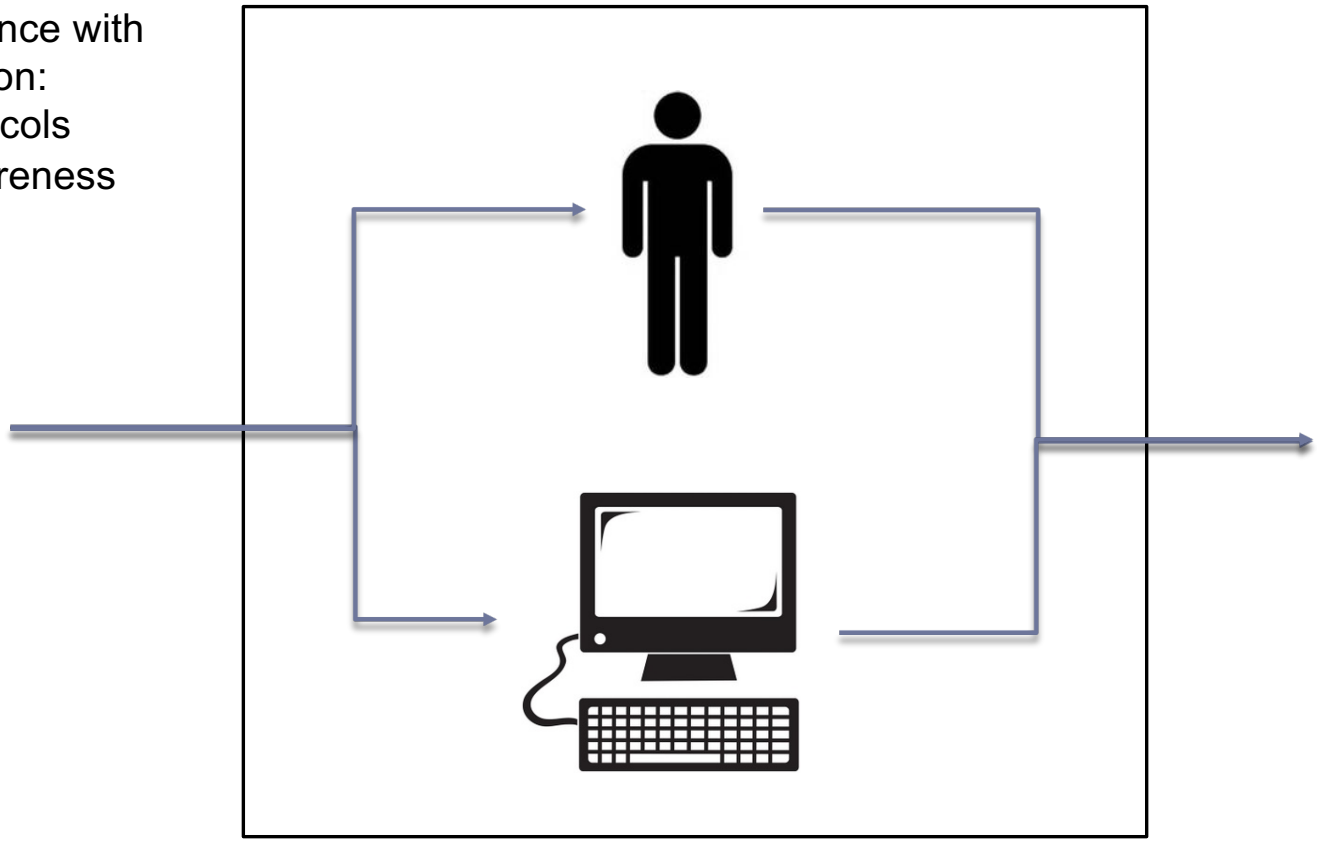
The purpose of the user interface is to configure the automated behavior (e.g. define goals / setpoints)



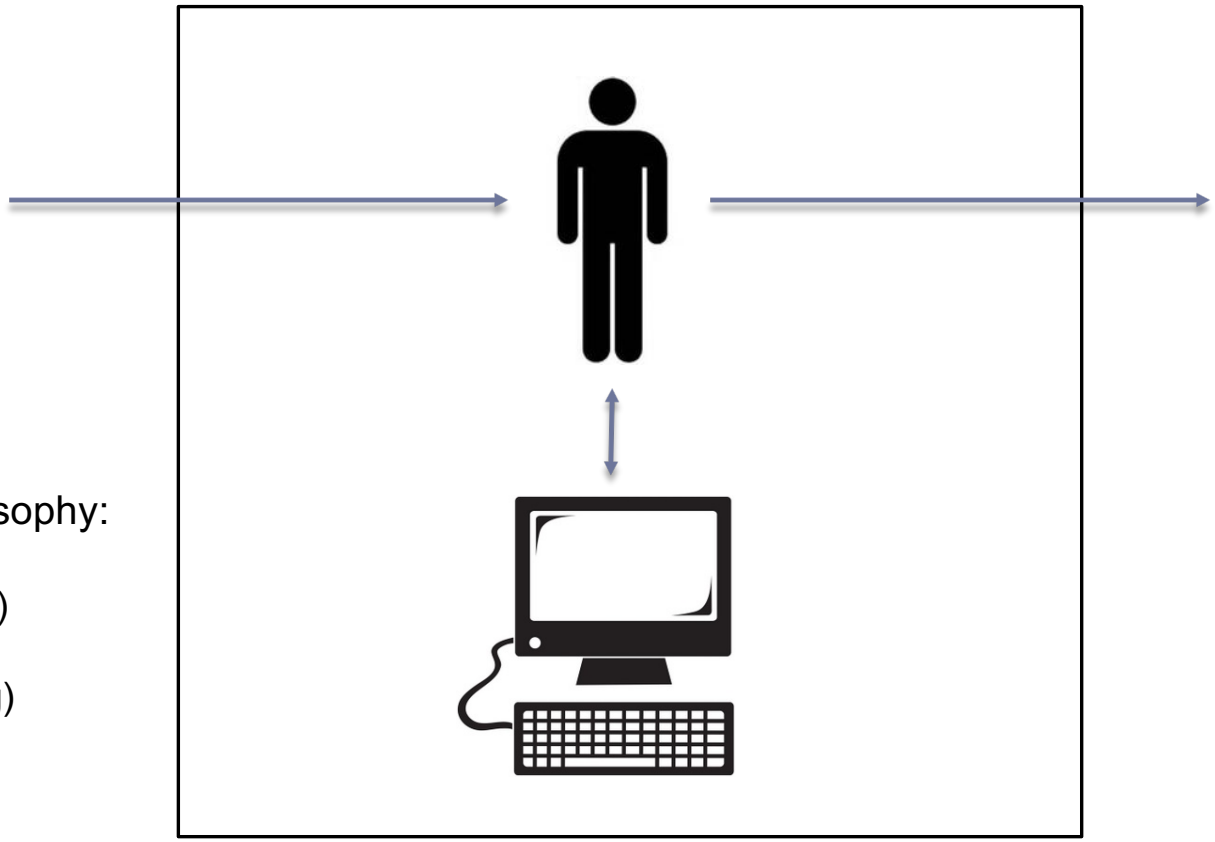
Human in the Loop? Hybrid system design

From long experience with autopilots in aviation:

- Handover protocols
- Situational awareness



Human in the Loop? Human-centric system design



The intelligent tool philosophy:

- Context-specificity
  (e.g. parking assistance)
- Error avoidance
  (e.g. out of lane warning)

Studying Agency and Control

- Work with David Coyle, Per Ola Kristensson and clinical collaborators

The ***experience of agency*** is defined as:

- *The experience of controlling one's own actions and, through this control, affecting the external world.*
- It is the experience of ourselves as agents that allows us to instinctively say:

"I did that"

Haggard, P. & Tsakiris, M., *The Experience of Agency: Feelings, Judgments, and Responsibility.* Current Directions in Psychological Science, 2009.

Fact vs. the experience of agency

- Passivity phenomena in schizophrenia
  - People feel that their actions - and sometimes their thoughts and emotions - are not under their own control. Rather they are under the control of some external force or agent.
- Mellor reports on a patient with schizophrenia saying:

> *"It is my hand and arm that move, and my fingers pick up the pen, but I don't control them."*

Mellor, C.S., First rank symptoms of schizophrenia. Br J Psychiatry, 1970.

Golden rules of HCI

Rule no. 7: **"Support an internal locus of control"**

This rule is based on the observation that:

> "*Users strongly desire the sense that they are in charge of the system and that the system responds to their actions.*"

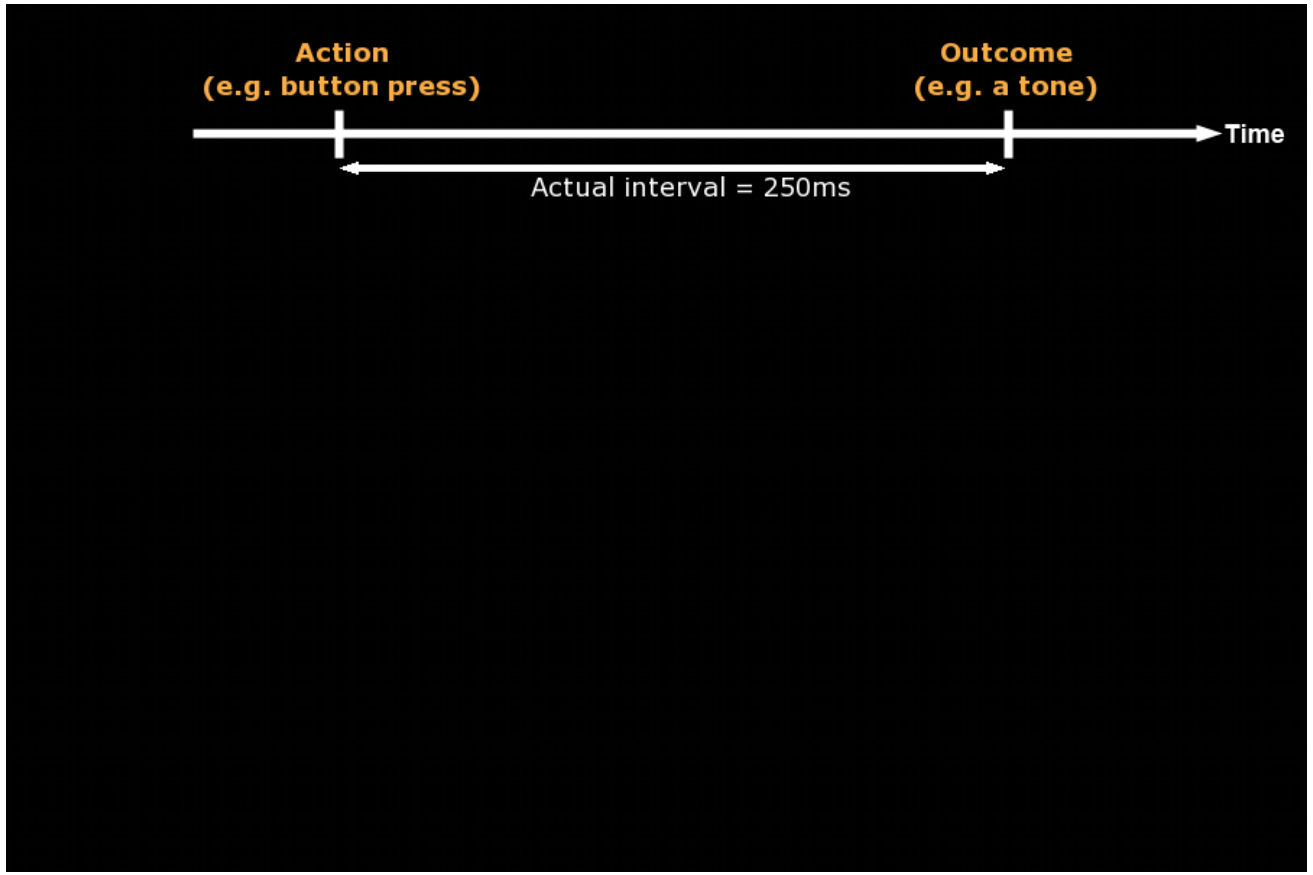
Shneiderman, B. & Plaisant, C. 2009
Designing the User Interface: Strategies for Effective Human-Computer Interaction.

Developing a research agenda

- An implicit metric to measure peoples' experience of agency.

- Two experiments that apply this metric in HCI contexts.

Intentional binding



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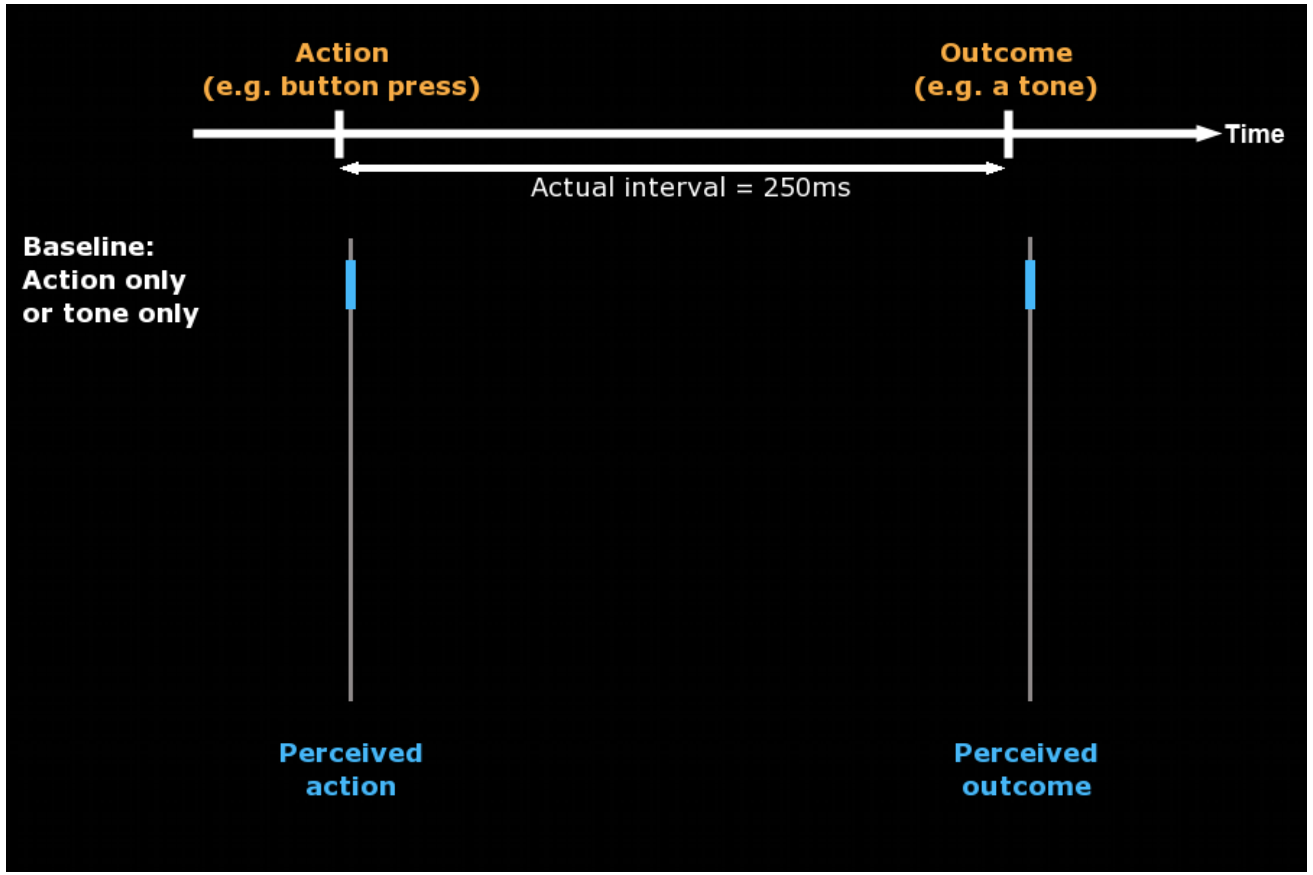
Intentional binding



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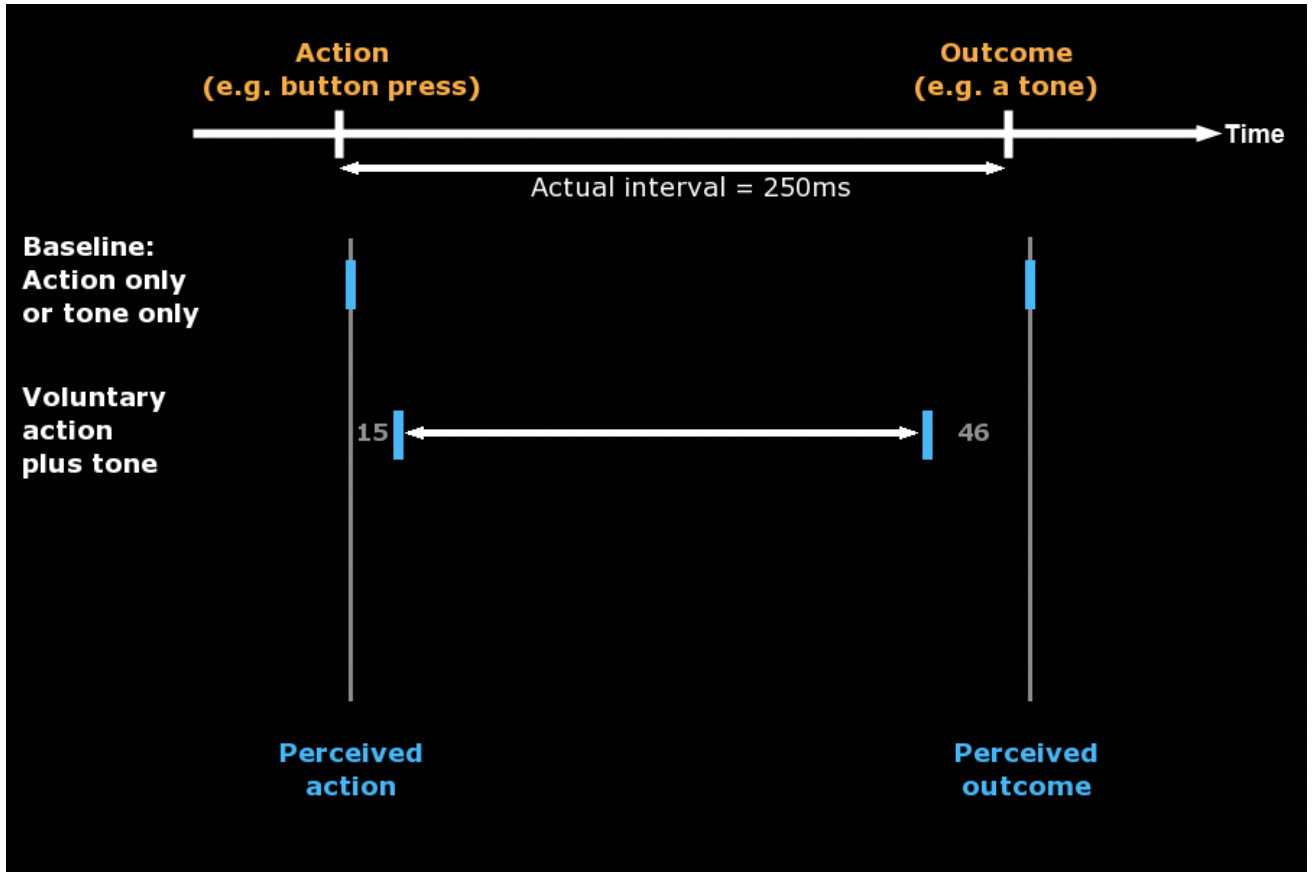

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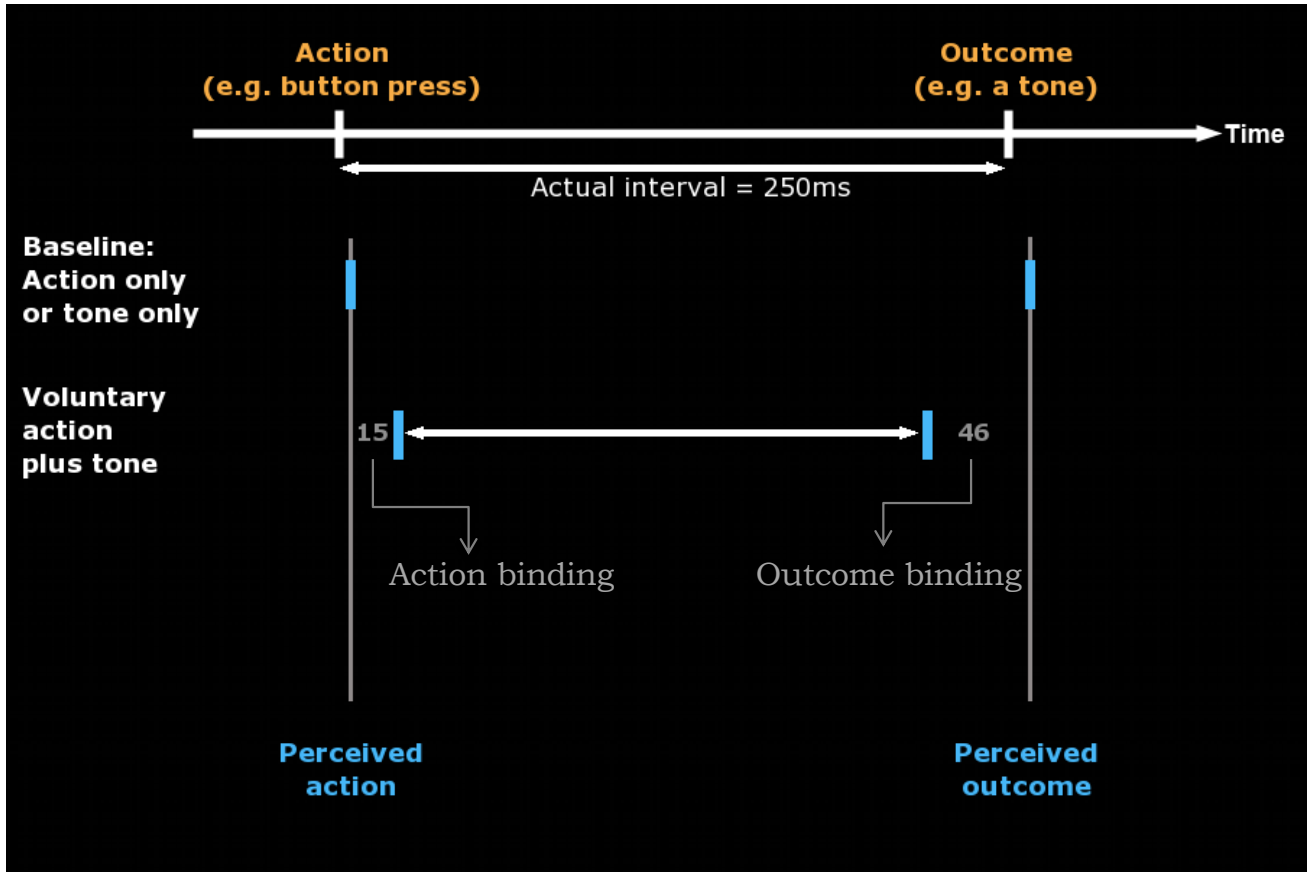

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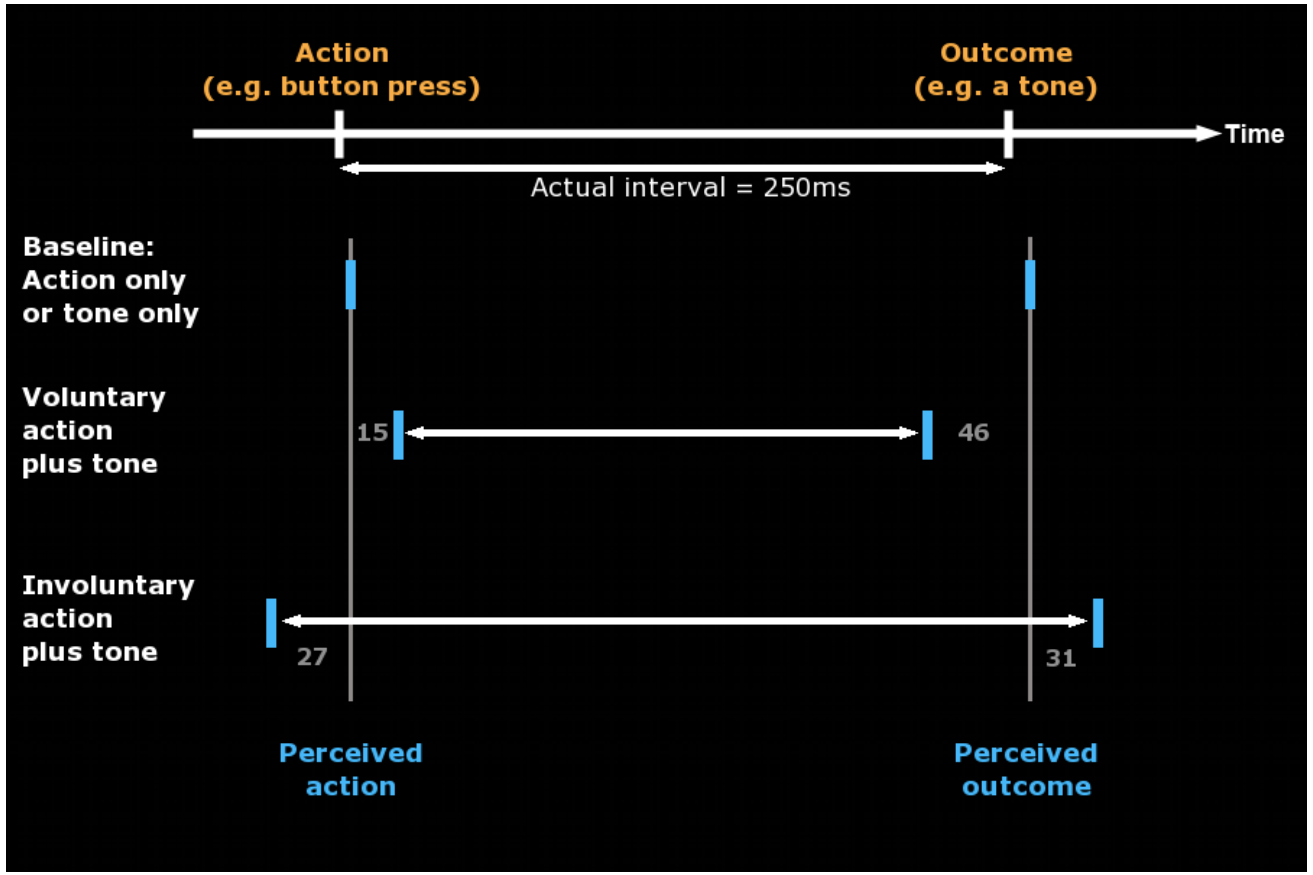

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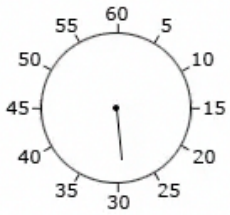
The Libet clock method



- Approx. 100px in diameter.
- Shown at the centre of screen.
- Arm rotates once every 2560ms.

Strengths:

- Provides robust measures.
- Detailed breakdown of where binding occurs.

Weaknesses:

- Not suitable for visual tasks.
- Time consuming: 4 blocks of trials per condition.

Interval estimation

Participants estimate the time between their action and an outcome.

Strengths:

- Suitable for visual tasks.
- Less time consuming:
  1 block of trials per condition.

Weaknesses:

- Less robust measure.
- No breakdown of where binding occurs.

An experimental manipulation

- Skinput: appropriating the body as an input surface.
  - Harrison, Tan, & Morris. CHI 2010.

Images: © Chris Harrison

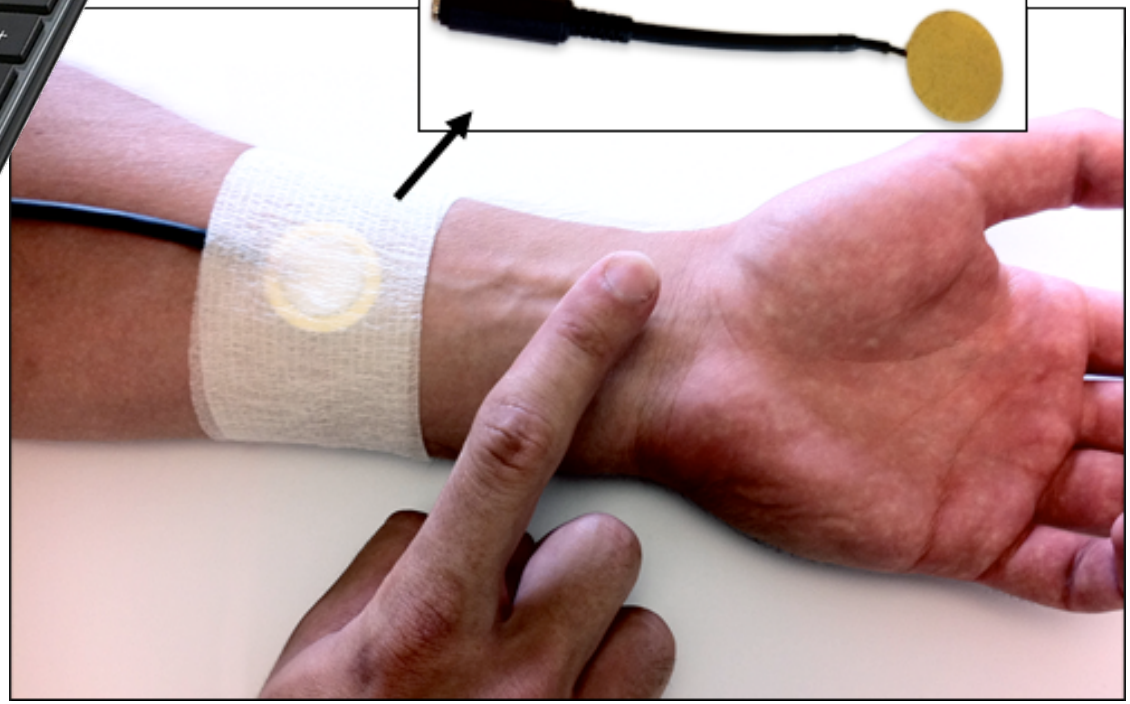
Experiment 1

What's it like to be a button?

Do changes in the input modality of an action have an impact on the sense of agency?

Two input conditions: button and skin-based input.

Piezo electric contact microphone.



Procedure

They press a footswitch to start a trial. Libet clock begins to rotate.

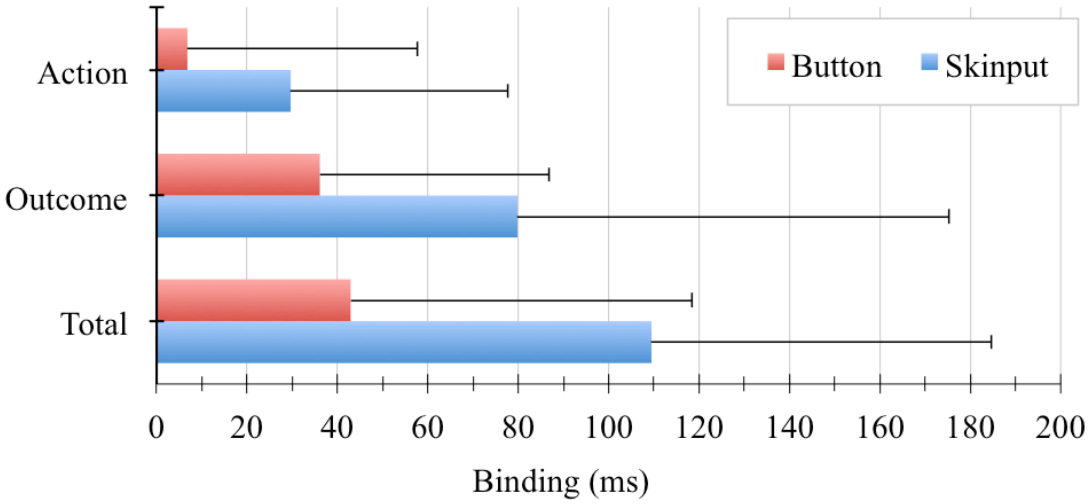
Participant takes an action, either a button press or an arm tap.

After a fixed interval of 250ms a buzzer sounds.

The participant is prompted to record either the time of their action or the buzz.

Results

	Action binding	Outcome binding	Total binding
Button	6.81ms (45.6ms)	36.11ms (45.46ms)	42.92ms (67.43ms)
Skin-based	29.66ms (42.84ms)	79.82ms (91.23ms)	109.47ms (74.54ms)



t(18) = 4.05, p<0.01

Observations

- Yes, changes in the input modality can have an impact on the experience of agency.
  - Intention binding is a useful metric for design research:
  - It can be used it to compare and refine input techniques.
  - Compare experiences for a given input technique when other conditions of the interactions change.
- For future research
  - What kind of intelligent interfaces might use the skin as an input surface?
  - Body-area networking is already a focus of commercial research
  - 'Transhuman' character Bethany in Russell T Davies' BBC series *Years and Years*

Experiment 2

Intelligent interfaces:

What happens when a computer helps out?

Procedure

1. Participant presses a footswitch to begin a trial. A red start area appears.

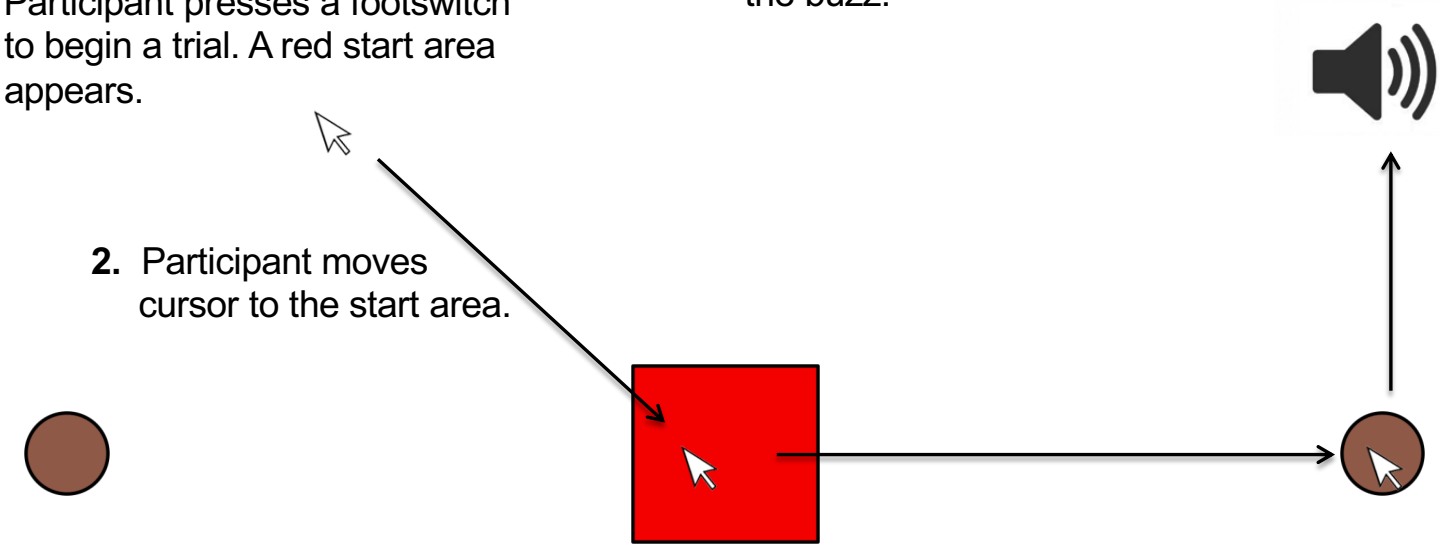
2. Participant moves cursor to the start area.

3. Having waited in start area for 1500ms two green targets appear.

4. Participant chooses a target and moves cursor to hit it as quickly and as accurately as possible.

5. Hitting target causes a buzz – with a random time interval.

The participant is prompted to estimate the interval between hitting the target and the buzz.



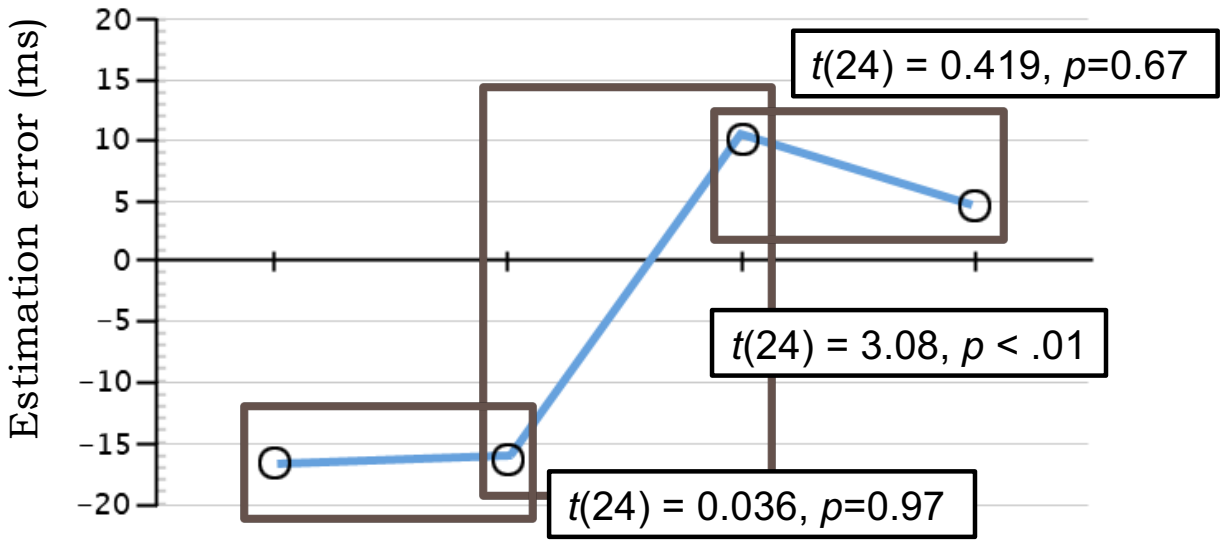
Experiment design

- Treatment: the assistance algorithm has the effect of adding "gravity" to targets.
  - Four levels of assistance: none, mild, medium, high.
- Within subject design, with:
  - 1 block if trials for each assistance level
  - 36 trials per block.
  - 24 participants.
- The order of the assistance level blocks was counter-balanced across participants.

Results

	No assistance	Mild assistance	Medium assistance	High assistance
Estimation error	-16.78ms (70.70ms)	-16.32ms (82.03ms)	9.93ms (85.92ms)	4.53ms (79.12ms)

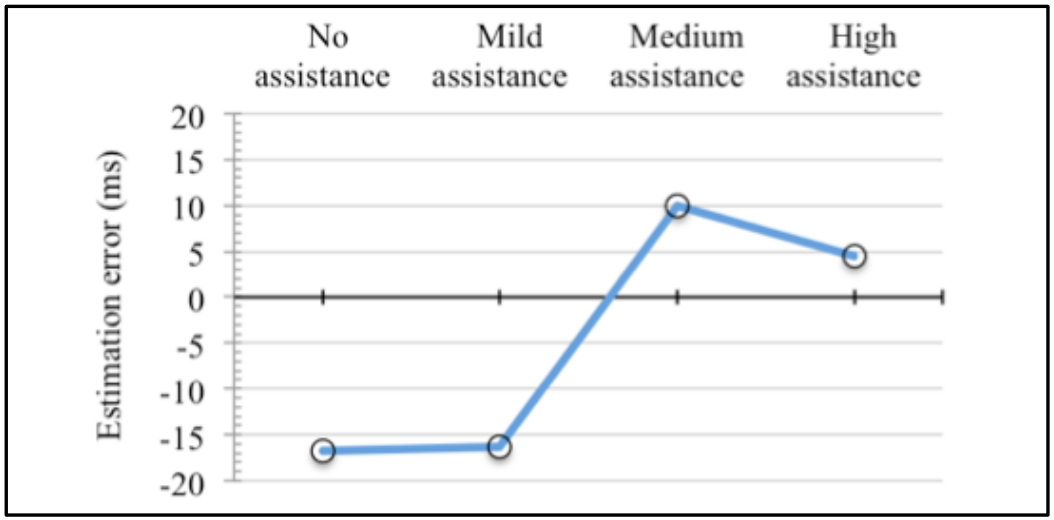
Greater intentional binding, greater sense of agency



Repeat measure ANOVA: $F(3,69) = 2.74$, $p=0.05$

Observations

- Up to a point, the computer gave assistance, but people retain a sense of agency.
- Beyond a certain point people experience a loss in sense of agency.
- This technique could provide an experimental means of mapping the personal agency characteristics of intelligent input techniques.



Enhancing agency through timing in "conversational interfaces"

- Christine Yu Guo (2021)
  - Perception of Rhythmic Agency for Conversational Labeling (HCI Journal)
- Series of mixed-initiative experiments, comparing 4 treatments:
  - Computer-Arrhythmic (CA)
    - the Computer takes the initiative using aperiodic time intervals.
  - Computer-sets-Rhythm (CR)
    - the Computer takes the initiative using rhythmic timing.
  - User-followed-by-Computer (UC)
    - the User takes the initiative, and the Computer follows
    - the idea is to imitate *conversational entrainment* between humans.
  - User-sets-Rhythm (UR)
    - the User takes the initiative, setting their own rhythm – today's industry standard

Results

- *Predictable rhythms produce intentional binding:*
  - CA < CR < UC < UR
- *Predictable rhythms give sense of control:*
  - CA < CR < UC < UR
- *Predictable rhythms reduce task stress (NASA TLX scales)*
  - CA > CR > UC > UR
- *Predictable rhythms increase confidence of task success (NASA TLX scales)*
  - CA < CR < UC < UR

Overall conclusions

- Changes in the input modality and in levels of assistance can have a significant impact on users' experience of personal agency.
- Intentional binding can provide an implicit metric for probing and mapping experiences of agency.
- This metric can be applied in a wide range of design contexts. E.g.:
  - Comparison and refinement of different interfaces and assistance techniques.
  - Investigating the impact of uncertainty or different types of feedback.
  - Comparisons of user groups, e.g. different age groups, people experiencing mental health difficulties.
  - Enhancing mutuality in "conversational" mixed initiative

Design for control

Case Study: Coda

- Mixed initiative interface developed for Africa's Voices Foundation
  - http://explain.avf.world/
  - http://www.africasvoices.org/ideas/newsblog/introducing-our-latest-analysis-tool-coda/

- Guo explored effects of conversational rhythm when using this style of interface

AFRICA'S VOICES

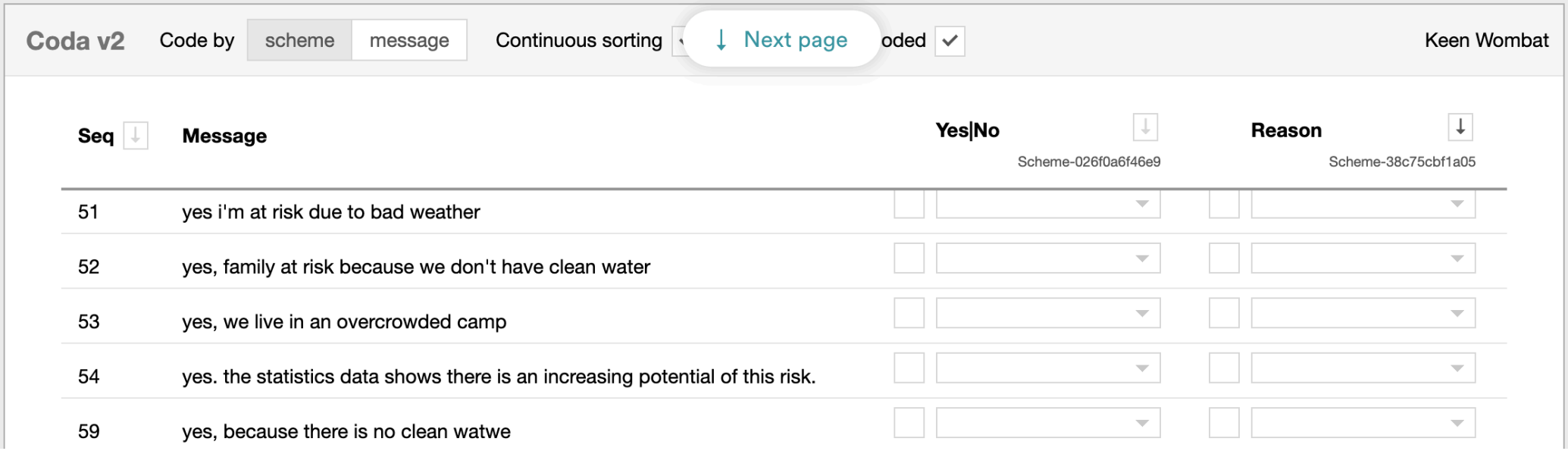
ABOUT WHAT WE DO PROJECTS CONTACT IDEAS

Data receipt and coding

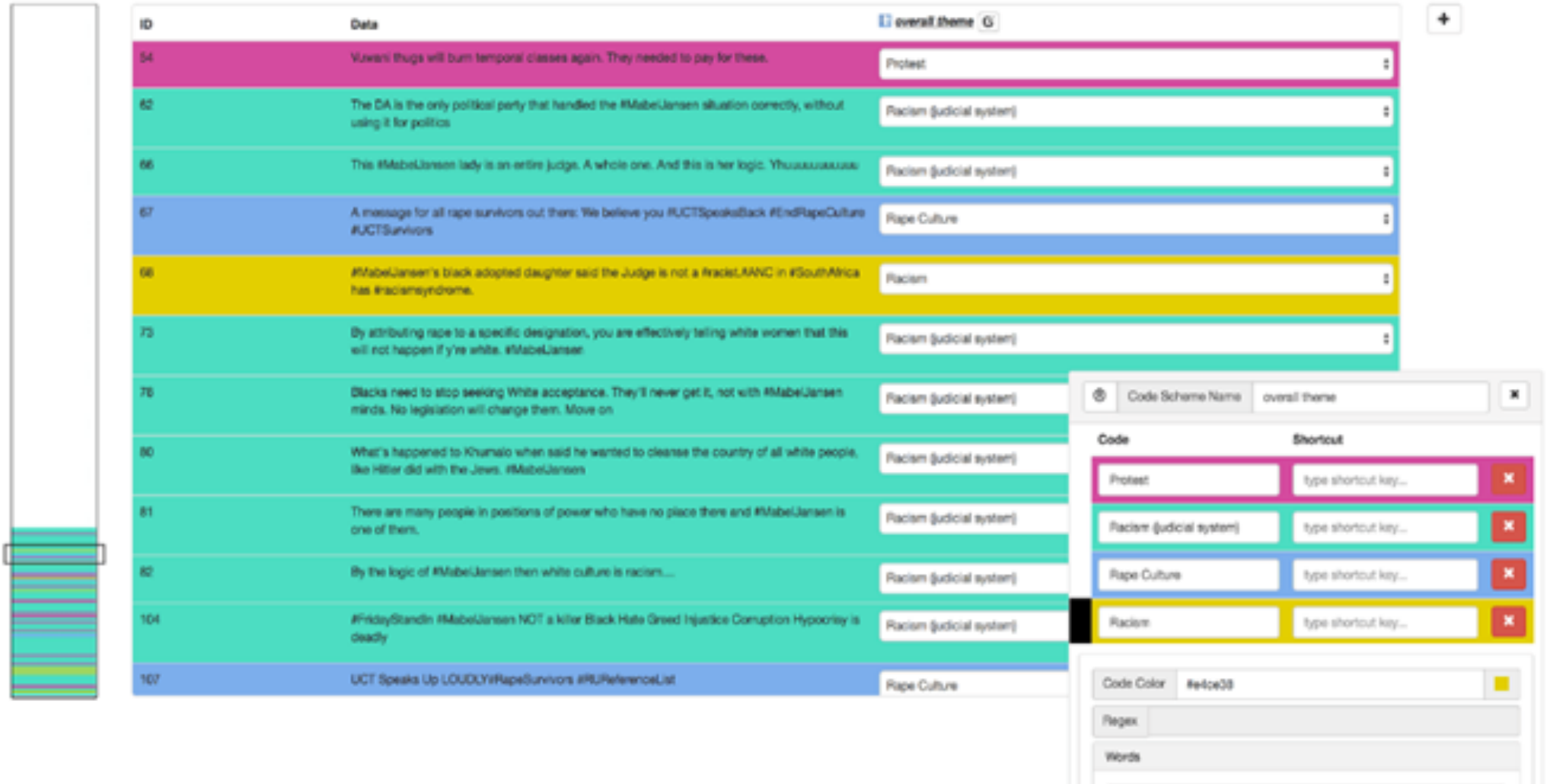
Now imagine you are a researcher at Africa's Voices Foundation and you have received text message responses from radio show listeners in Somalia. Your task is to label these data based on some of the emerging themes.

You label these data using a programme called CODA that uses artificial intelligence not to automate data analysis but to augment human ability to make sense of large sets of data.

Have a go at labelling some of the messages.



Mixed-initiative Coda concept



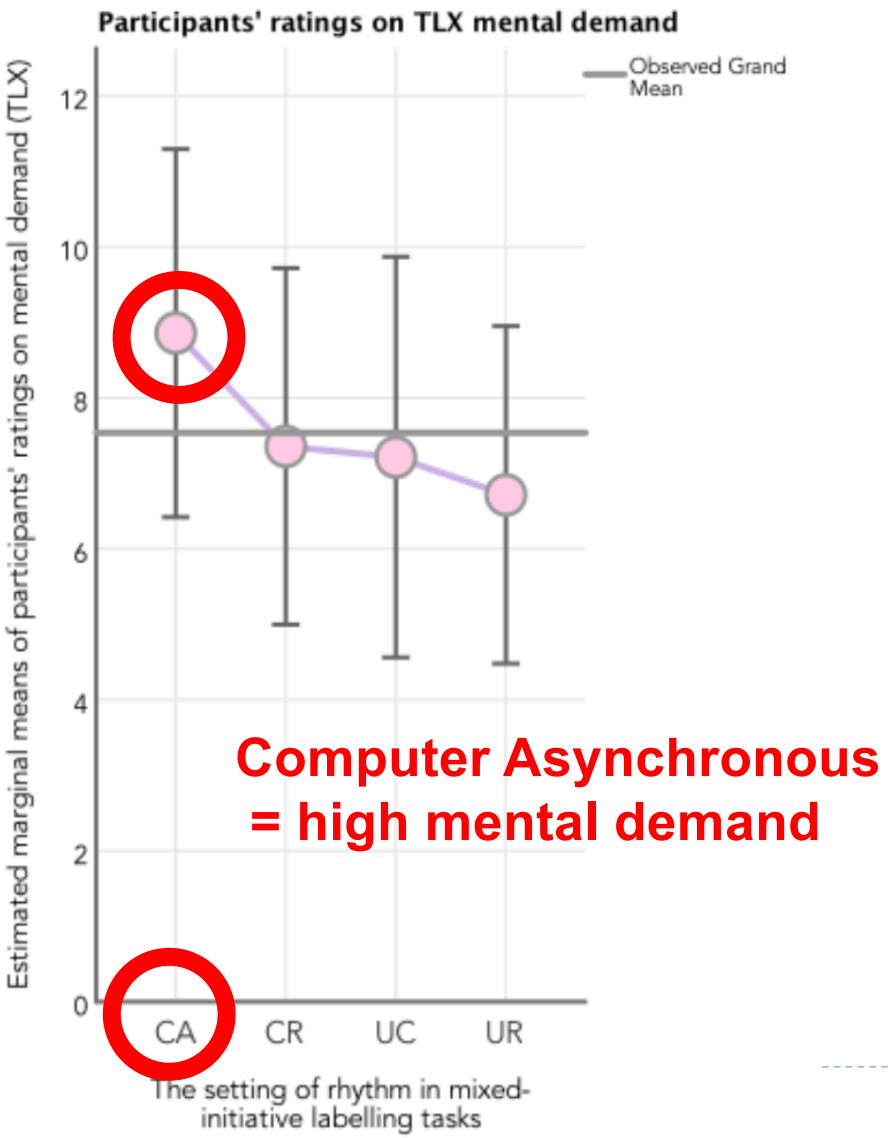
Simplified version for controlled experimental study

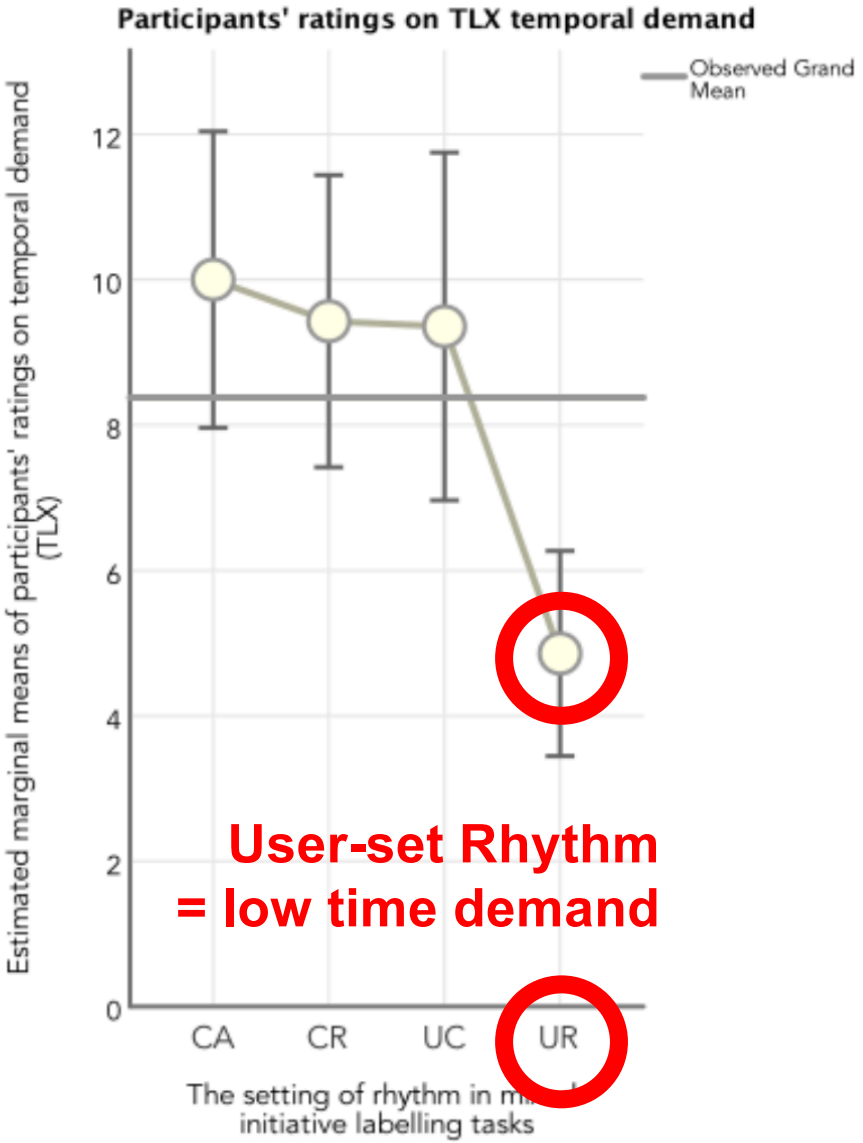
No.	Time	Content	Computer's Judgement	correct?	wrong?
41	1/2/2017 6:02:18 PM	Can I ask if you have the Game of Scones baking tray?	It is about delivery.	Correct	Wrong
42	1/3/2017 5:50:11 PM	When could you deliver the Kallax shelves to my office?	It is about delivery.	Correct	Wrong
43	1/4/2017 5:02:12 AM	Just checking if this saucepan works on an induction oven?	It is NOT about delivery.	Correct	Wrong

Each participant makes 30 decisions with each of the 4 different interfaces (CA/CR/UC/UR)

Confusion matrix of experimental stimuli – user should correct these

		Label presented by the system		
		Delivery	Not Delivery	Totals
Actual content of the text	Delivery	5	5	10
	Not Delivery	10	10	20
	Totals	15	15	30


Participants' ratings on TLX mental demand
Observed Grand Mean
Estimated marginal means of participants' ratings on mental demand (TLX)
12
10
8
6
4
2
0
CA
CR
UC
UR
The setting of rhythm in mixed-initiative labelling tasks
Computer Asynchronous
= high mental demand


Participants' ratings on TLX temporal demand
Observed Grand Mean
Estimated marginal means of participants' ratings on temporal demand (TLX)
12
10
8
6
4
2
0
CA
CR
UC
UR
The setting of rhythm in mi
initiative labelling tasks
User-set Rhythm
= low time demand

Confusion matrix of user labelling performance

		User judgement of the label	
		Wrong	Correct
Accuracy of system label	Wrong	211 / 215 / 216 / 215	14 / 10 / 9 / 10
	Correct	3 / 8 / 3 / 10	222 / 217 / 222 / 215
	Totals	214 / 223 / 219 / 225	236 / 227 / 231 / 225

Table 3 - confusion matrix with breakdown by condition CA / CR / UC / UR

User-set Rhythm results in less 'mutual respect' for system judgments, more errors from false positive rejections