Counterfactual learning supports context-dependent social behaviour

Sara Ershadmanesh[1], Stephen M. Fleming[2] & Dan Bang[2]

[1]School of Cognitive Sciences, Institute for Research in Fundamental Sciences, Tehran, Iran; [2]Wellcome Centre for Human Neuroimaging, University College London, London, United Kingdom

Introduction

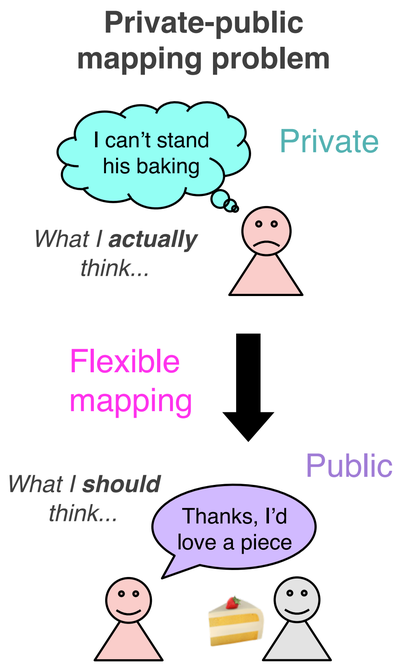
Actions are embedded within contexts and should be chosen accordingly

The importance of context sensitivity is perhaps most apparent when it comes to social behaviour

Social situations often require a dissociation between what we think *privately* and what we ought to do *publicly*

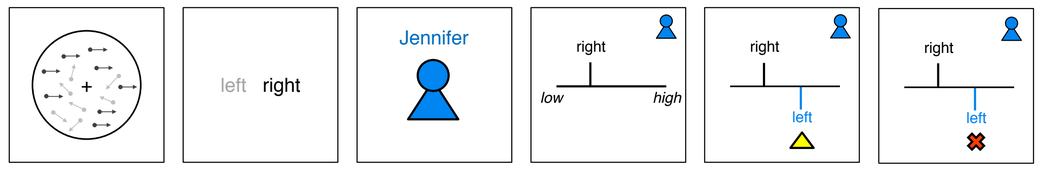
In our research we aim to address:

How do people learn which public actions are appropriate in a given social context?

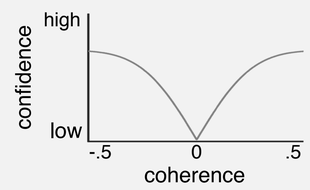


Experimental paradigm

We developed a **social interaction task** which required subjects to adapt their confidence reports according to the social context



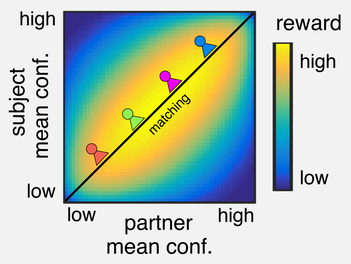
Private belief: higher coherence induces higher private confidence



Bang & Fleming, 2018, *PNAS*

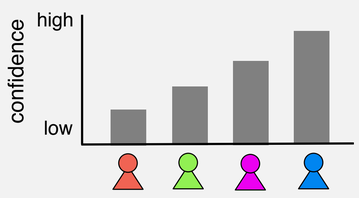
Individual decision made with ***higher confidence*** is selected [▽] and determines the outcome [✚ or ✖]

Public belief: in this task, the optimal strategy is to match each partner's mean confidence



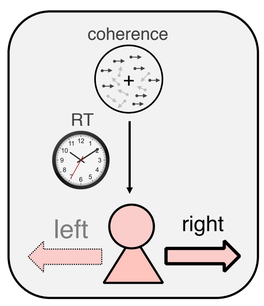
Bang et al., 2017, *Nature Hum Behav*

Social context: the partners reflect different norms for public confidence



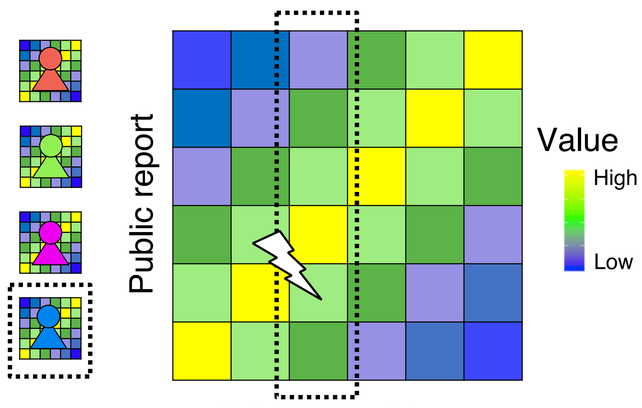
Computational modelling

Generation of private confidence



We used a logistic regression relating coherence and reaction time to choices to infer private confidence on the current trial

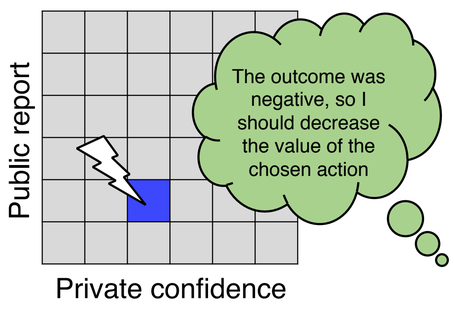
Context-dependent 'private-public' value functions for behavioural control



Actions are chosen probabilistically according to the distribution of values along the current state

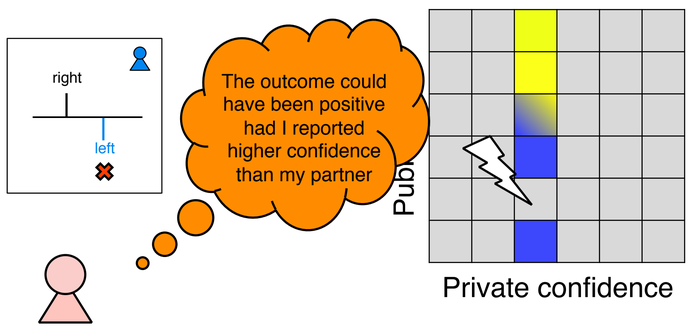
Update action values for current state using prediction errors

Factual learning for chosen action (basic model)



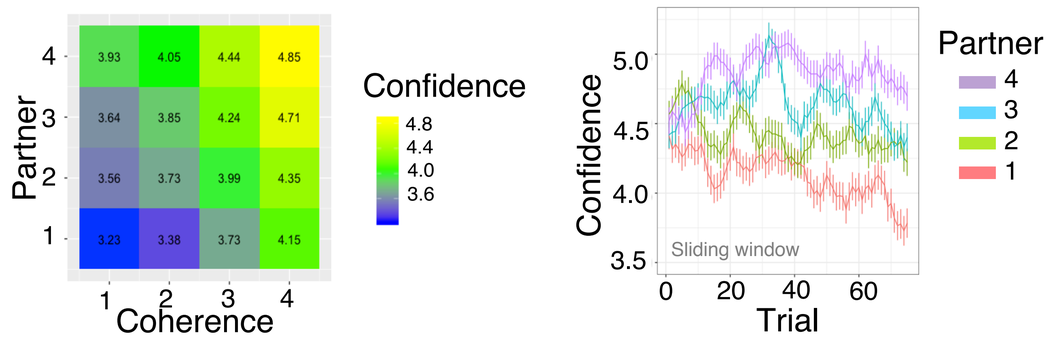
&

Counterfactual learning for unchosen actions (model 1)



Behavioural results

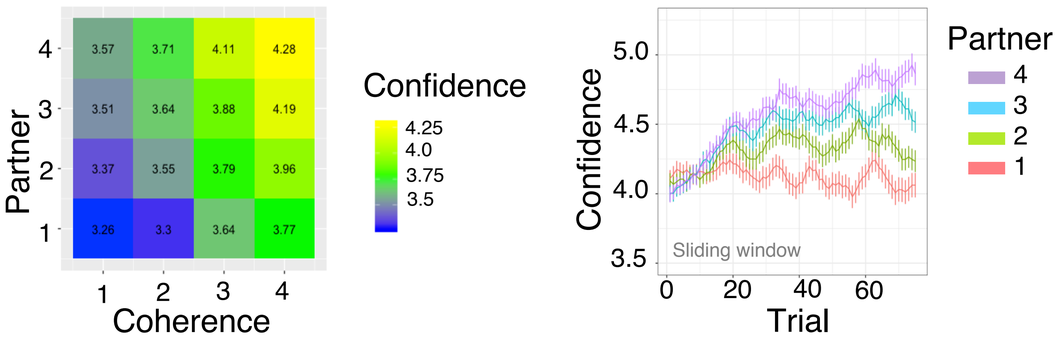
Empirical data



Stimulus strength and social context determined subjects' confidence reports

Subjects learnt context-dependent private-public mappings across time.

Model prediction

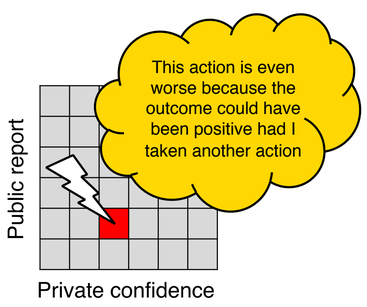


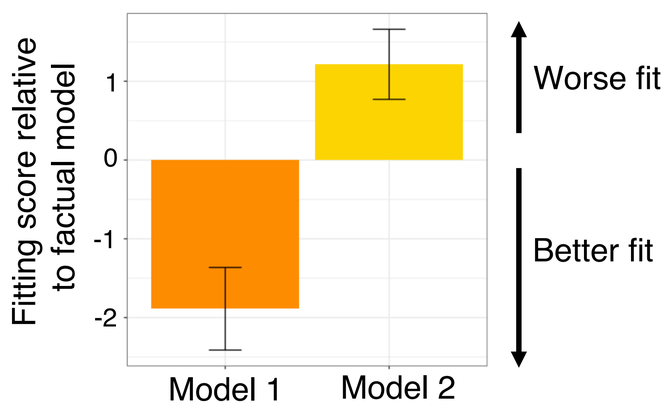
Model combining factual updating for chosen action and counterfactual updating for unchosen actions recapitulates the empirically observed data

Model comparison

Model combining factual updating for chosen action and counterfactual updating for unchosen actions provides best fit to the data

Counterfactual learning for chosen action (model 2)





We performed model fitting using STAN and compared models using a cross-validation procedure (WAIC as implemented in the 'loo' package).

Next steps

We have shown that people acquire context-appropriate private-public mappings through factual and counterfactual learning

We are now investigating how these processes are supported by the brain

Our hypotheses are:

- Private-public mappings are represented in prefrontal cortex
- Factual and counterfactual prediction errors are represented in striatum
- Striatal learning signals shape prefrontal representations

Cognitive-sciences & Technologies Council
Institute of Fundamental Sciences
wellcome centre human neuroimaging