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# The effect of Incentivisation on Emotional Control

### Using computational psychiatry in the study of Emotions

* Computational psychiatry aims to apply mathematical and computational techniques to help improve psychiatric care (to understand and improve mental health). It is mainly motivated by the necessity to bring novel statistical and machine-leaning techniques to bear on the rapidly expanding complexity of novel datasets relevant to mental health.
* Emotions play a crucial role in forging and maintain social relationships, which is a major adaptation of our specially. Emotions are central to mental health, and emotional disorders contribute substantially to the burden of mental illnesses. Thus, **as emotions play an important role across many psychiatric disorders, such computational methods must encompass emotions**. However, the **traditional dichotomisation of emotion and reason might question the feasibility of applying computational techniques to the cores issues of emotion**.
* Some have argued to it is imperative for computation psychiatry to address core emotional phenomena which requires the introduction of model-based valuation and meta-reasoning (meta-reasoning considers optimal valuation in the face of resource constraints). Furthermore, there is no single underlying substrate for particular emotions. Rather, each emotional category depends on a distributed network of limbic but also cortical components that reflect the particular neurocognitive processes involved.

### Definition of Emotions

* Key features of human emotions are 1) correlated physiological psychological and behavioural processes shaped by evolutionarily predefined neural circuitry; 2) interpretations or appraisals; and 3) conscious verbal self-report about emotions.
* Basic emotion theories suggest that there are a limited, relatively fixed, number of universal, evolutionarily shaped, culture-independent, and neurobiologically hard-corded emotional categories including happiness, surprise, sadness, disgust, anger and fear. They represent a set of innately interlinked physiological, behavioural, and psychological processes that are triggered in an inflexible manner by salient stimuli.
* Human emotional responses to stimuli are characterised by substantial within- and between-subject variability. Appraisal theory locates one explanation for this variability in the interpretation (be it conscious or unconscious) of a particular situation or stimulus as being relevant to the individual’s goals (thus the interpretation depends on the goa and the individual’s beliefs).
* The evidence for discrete emotions is controversial. Autonomic responses, electroencephalographic features, and facial expressions do not permit simple categorisation and show little evidence of the predicted correlations, though newer machine learning approaches have shown that categorical information can be extracted from physiological and neural data (Wager et al., 2015).
  + By using hierarchical Bayesian modelling of 2200 participants, Wager et al. found that the each of the five basic emotions is associated with unique, prototypical patterns of activity across multiple brain systems including the cortex, thalamus, amygdala, and other structures. Furthermore, the model provides a precise summary of the prototypical patterns for each emotion category and demonstrated that a sufficient characterisation of emotion categories relies on 1) differential patterns of involvement in neocortical systems, and 2) distinctive patterns of cortical-subcortical interactions. They are consistent with componential and constructionist views, which propose that emotions are differentiated by a combination of perceptual, mnemonic, prospective, and motivational elements.
  + An alternative view is that the discreteness of emotions arises from the categorical labelling of internal events for the purpose of intra- and intersubject communication. The ventrolateral prefrontal cortex is involved in categorical labelling of emotional states (REF) evolving along the two major axes of valence (from good to bad) and arousal (from high to low). Factor analyses of a variety of measures of emotions including similarity ratings among words, facial expression, and autonomic measures reliably identify these two separate dimensions (Russell, 2003). Neuroimaging has also been used to argue that while the amygdala tracks arousal, the orbitofrontal cortex tracks valence across emotions (Wilson-Mendenhall et al., 2013).

### Model-based and Model-Free accounts of emotional expression

* Computationally, inferring adaptive choices involves integrating not only immediate rewards, but also longer-term rewards, and for that reason requires consideration of the future course of events. Specifically, valuation involves summing over an exponentially expanding decision tree of future possibilities. Optimal valuation would search the entire tree, which is rarely feasible. Reinforcement learning is a thriving subfield of machine learning concerned with algorithmic solutions to this problem.
* A substantial body of work has related an algorithmic solution to optimal valuation problem (valuation involves summing over an exponentially expanding decision tree of future possibilities. Optimal valuation would search the entire tree, which is rarely feasible) to how emotional expressions change over time (Bach and Dayan, 2017).
  + In a so-called model-free reinforcement learning, the stability of the world is exploited to replace integration over the future with actual past experience. They used Bayesian decision theory to conceptualise emotions in terms of their relationship to survival-relevant behavioural choices. Decision theory indicates which behaviours are optimal in a given situation. They thus conjecture that the brain uses a range of pre-programmed algorithms that provide approximate solutions. These solutions seem to produce specific behavioural manifestations of emotions and can also be associated with core affective dimensions.

### Meta-reasoning

* Model-based inference is mostly impossible due to the sheer size of most relevant model-based valuation problems. Optimal decision in realistic situations are computationally extremely demanding. The limited resources lead to the meta-reasoning problem, which concerns the optimal deployment of the available computational power. The estimated value of performing a computation is the difference in expected utility between taking a choice without the additional computation, and taking a new alternative choice after having invested in the computation. Stimulations do not actually incur the costs of the real problem, and while taking real poor actions should be avoided to avoid incurring their loos, internally simulating poor actions can be useful.

### Emotions implement approximate meta-reasoning strategies.

* Model-based reasoning is hence faced with two profound challenges, 1) the size of the problem and the even harder task of apportioning limited resources in an adaptive manner. Emotions have been proposed to be able to implement approximate solutions to these challenges. In particular, emotional states 1) come with a strong focus on particular behaviours and 2) induce a strong perceptual and processing focus such that evaluation is concentrated on a narrow set of states. Emotions thereby effectively function as approximate meta-reasoning strategies that prescribe how computational resources are allocated.
* Action tendencies.
  + One of the features of emotions is that they prioritise certain actions. Constraining the action space can substantially simplify the valuation problem because the computational cost is exponential in the size of the action space.
  + Emotions also induce physiological and vegetative changes. A preparatory increase in heart rate to compensate for the anticipated drop in peripheral resistance upon supplying blood to large muscle groups is required when running. As such, these can be seen as a preparation toward a class of behaviours that share physiological requirements
* State observation
  + The complexity of model-based evaluation is also exponential in the range of states considered. There is ample evidence for emotion- or mood- congruent processing biases. By restricting attention to particular states and disregarding others, the problem could again be reduced in size, for instance by pruning searches along branches of the decision tree that result in states outside the attentional focus.
  + By asserting the state, the complexity results from the computational task of valuation because policies for the various possible states can be reduced. Introspection about the state of the body likely plays a particularly important role.

### Controlling Meta-reasoning Strategies

* If there are multiple approximate metareasoning strategies, then there must be some control over which is deployed when.
  + The first source of control is likely evolutionary. Species-specific responses provide a bias toward evaluating particular actions.
  + The second source of control could be model-free. Etkin et al. have recently argued for a model-free component in serial adaptations in the emotional conflict task (Etkin et al., 2015). Model-free learning has been argued to account for learning in strategy selection: with repeated experience, individuals can slowly increase their frequency of using adaptive strategies for solving problems.
  + The third evaluative process for emotions allows for knowledge to be incorporated in the form of heuristics. Individuals can access approximate measures of how adaptive a particular cognitive strategy is, and use this to guide their choice. In the affective domain, misguided beliefs or schemas about the adaptiveness of strategies relate to a number of pathological emotion regulation phenomena. People who dislike emotion regulation are more likely to respond with anger to provocation (Etkin et al., 2015). Depressed persons are not impaired at emotion regulation strategies such as positive imagery to iprove their mood, but they have a reduced tendency to employ them (Ehring et al., 2010).
  + The fourth evaluative process could be model-based, where the precise consequences of particular emotions are examined and evaluated. Psychotherapy allows patients to learn to consciously and explicitly assess whether a particular emotion is appropriate and helpful in a given situation, and to adapt it by using reappraisal and other emotion regulation strategies if necessary.
    - * Emotions may have a potentially important role in facilitating model-based decisions by functioning as internal strategies to allocate computational resources. But also, different processes can lead to adaptive or maladaptive deployment of emotion strategies.
      * This computational framework of emotions contrasts with the view of basic emotions as relatively fixed behavioural and physiological action packages by reflecting the lack of identifiably discrete physiological or behavioural patterns of single neurobiological cause. Rather, it emphasizes the importance of emotional processes in more complex decision-making settings.
      * The complexity of the model-based valuation required for the ability to account for appraisal and contextual effects, led to the notion of approximate metareasoning strategies. These approximate strategies are necessarily often suboptimal and may capture the prototypical adverse influences of emotion on cognition. The focus on valuation is compatible with models emphasizing predictions must be about long-term utility, and that emotions play a key role in facilitating such predictions, albeit approximately.
      * Situations with a higher estimated value of computation should recruit neural resources more extensively, and hence be more likely to involve the brain-wide states postulated as representing the global workspace. It had also been suggested that the component processes in verbal self-report involve an introspective component followed by a classification process.