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The enduring importance of the "fine cuts" approach to psychology: EPS Mid-Career Award Lecture 2024

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Abstract

In this article, I take a selective review of work undertaken by my colleagues and me in an attempt to show the enduring importance of the "fine cuts" approach to psychology. This approach highlights the importance of causal, specific, and falsifiable psychological models, and the rigorous experimental designs needed to test them. I hope the review shows that it is still necessary to consider cognition, despite the exciting advances in Big Data, Artificial Intelligence, and computational modelling characterising our field.

Keywords

fine cuts; mid-career award

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This is going to be a personal paper (my first sole-authored paper ever!), and it will be largely focussed on a selective review of work conducted by my colleagues and me. Although I have been blessed with a group of astonishingly brilliant collaborators, I should emphasise that this is my perspective on our work and I haven't checked it with them. Mistakes should be assumed to be mine, whereas most of the credit for the work goes to them.

Everyone says it is a surprise and an honour to win an award—maybe it is not true for some people, but it certainly was for me. I am incredibly grateful to everyone who worked on my behalf as part of the process, but I am also so utterly thankful for all those who have taught and mentored me along the way, along with all the students and collaborators who made literally everything about the

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work better. To be honest when deciding what to give my talk about this concerned me, I wanted to somehow mention everyone's work and leave nobody out. I quickly realised this was impossible, as I have been fortunate to have worked with very many people on a number of different problems using a variety of techniques from psychology and neuroscience. So, I went back to my first academic mentors, Cecilia Heyes, Uta and Chris Frith, and Francesca (Franky) Happé, and tried to work out what values I tried to take from them and instil in my students. Luckily, Uta & Franky (Frith & Happé (1994) alongside others including John Morton and Alan Leslie) had already outlined some of the core values they worked by in an article describing their "fine cuts" approach. Central features of this approach were psychological models that were specific and falsifiable, providing causal explanations of patterns of thought or behaviour. They recommended mechanistic models—models which specified the psychological components involved, how those components interact, what information is necessary and how it is encoded, to produce the phenomenon to be explained.

Luckily, I have been well-trained in such an approach by Cecila Heyes who formally supervised my PhD, but who informally taught me how to think. We were working on models of our ability to imitate the actions of others, and Celia had developed a model which specified exactly the types of psychological representations necessary for imitation, the type of experience necessary to develop this ability, and the formal rules governing that development (Cook et al., 2014). This theory had exactly those virtues promoted by Uta and Franky, and it was causal, specific, and falsifiable—a mechanistic theory in an incredibly rich sense. Celia was also able to train me in the careful experimental methods to test the predictions of the theories we were working with, methods which are on the same pedestal as the fine cuts approach in my mind, and which I later saw deployed with such expertise by people such as Jon Driver and Tania Singer.

An example of such an experiment was based on a very clever idea by Jason Mattingley and colleagues (Chong et al., 2008), which was to use functional magnetic resonance imaging (fMRI) adaptation to index the response of mirror neurons. fMRI adaptation is the term used when a stimulus is repeated during an fMRI experiment and you see a reduced neural response on the second presentation, thought to provide good evidence that your stimulus caused activity in the same population of neurons twice. Mirror neurons were originally discovered in monkeys and (at least as typically described, see Cook & Bird (2013) for nuance) fire both when the monkey performs an action and when they see the same action being performed by another. fMRI adaptation is useful to demonstrate the existence of mirror neurons in humans as you can ask people to alternate between observing and performing actions, and compare the neural signal when actions are performed when preceded by observation of the same action or a different action. The logic of this procedure is that if humans do have mirror neurons, then they should be activated by observation of an action and performance of the same action, but not by observation of one action and performance of another. Thus, if fMRI adaptation is observed, we can be confident it is caused by mirror neurons.

This clever technique was used by a group of us in Celia Heyes' laboratory to test her associative sequence learning model of mirror neuron development (Press et al., 2012). Celia's theory suggests mirror neurons are formed by correlated experience of seeing and doing actions and crucially suggest there is little (if any) biological tuning to this process—that any visual stimulus should be able to be associated with performance of a specific action. Thus, mirror neurons should be able to be activated by a nonbiological, nonaction, visual stimulus. Accordingly, we asked participants to perform specific actions in response to abstract geometric cues (e.g., "when you see the yellow star splay your fingers"), before conducting an fMRI adaptation experiment where participants alternated between observing those abstract cues and performing actions. Sure enough, we saw fMRI adaptation with the abstract cues, suggesting that the same neurons were firing to observation of the abstract cues and performance of the actions. However, this result merely shows that there are a population of neurons that respond both when actions are performed and when visual cues are presented which have been associated with performance of those actions. The smart thing about the design used in this article was that participants were trained to perform actions in response to the abstract cues without being allowed to observe their own actions. Despite this being the case, when tested, fMRI adaptation was also seen when participants alternated between seeing actions and the abstract cues paired with performance of those actions. The only way we could have seen fMRI adaptation in this condition was if the training to perform actions in response to observation of the abstract cue-induced mirror neurons to respond to those abstract cues—when tested those neurons fired for sight of the actions paired with the abstract stimuli and for the abstract stimuli themselves.

My postdoctoral work was carried out with Uta and Chris Frith and attempted to uncover the differences between the cognition of autistic and nonautistic individuals, using a combination of behavioural techniques and fMRI. I will forever be grateful to Sarah-Jayne Blakemore for encouraging me to apply for the job with Uta and Chris, even though I knew nothing about either autism or fMRI! Together with Caroline Catmur (who became a 20—and counting—year collaborator), Giorgia Silani, and Tania Singer, we were trying to test different cognitive models of autism, and also to determine which cognitive differences are attributable to autism and which to alexithymia. Alexithymia is a condition which commonly co-occurs with autism (and with maybe every single other condition you could be diagnosed with) which is defined by an inability to identify and describe one's own emotions. Our research suggests that a lot of the so-called "emotional symptoms of autism" (such as impaired emotion recognition and an absence of empathy) are not; instead, they are a product of co-occurring alexithymia which is independent of autism (Brewer et al., 2015; Cuve et al., 2022). Investigating this issue led to some fun experimental design challenges for us. I liked the study led by Richard Cook that demonstrated that alexithymic individuals (whether they were autistic or not) had problems recognising emotional expressions (i.e., naming the emotion being expressed) but were perfectly capable of recognising whether two expressions were the same or not (Cook et al., 2013). This finding allowed us to design an informative upgrade to studies of early neural responses to emotional facial expressions using electroencephalogram (EEG) with fast periodic visual stimulation (FPVS) designs. EEG is a technique to measure the electrical fields evoked by the brain, and FPVS is a specific technique designed to measure very fast early brain responses to stimuli.

The standard FPVS technique to investigate neural responses to emotional facial expressions involves presenting two types of stimuli ("base" and "oddball") at incredibly fast rates. Base stimuli—presented 5 times at a rate of approximately 5 Hz—are followed by one presentation of an oddball stimulus at approximately 1 Hz—and this pattern of base and oddball stimuli are repeated numerous times. Base stimuli consist of an image of a person with a neutral facial expression repeated over and over again, while the oddball stimulus is an image of the same person with an emotional expression (e.g., disgust). Instead of analysing the EEG data recorded during the experiment as activity evoked by each stimulus independently, the data are analysed according to frequency. The logic of this approach is simple—if the neural signals evoked by such brief presentations of the face stimuli differentiate between the neutral and the disgusted face, then there will be signal at the base and oddball frequencies. If the neural signals do not differentiate between neutral and disgusted faces but are evoked by any face stimulus, then the neural signal will be at the sum of the base and oddball frequencies (approximately 6 Hz).

We appreciated the FPVS technique very much, but had a problem with standard designs. The standard design described above demonstrates that the neural signals differentiate the base stimuli (an individual with a neutral expression) from the oddball stimuli (the same individual with a disgusted expression) but they do not show what cognitive process the signal evoked by the oddball stimulus reflects. What we know is that the oddball stimulus evokes neural activity when it is presented, but we don't know whether the activity reflects: (1) detection of a change in stimulus, (2) that the expression is no longer neutral, (3) that the expression is now emotional, (4) recognition of a particular class of facial expression, and (5) recognition that the individual is disgusted.

To identify what the oddball signals reflect we changed the standard FPVS design. In our version, base stimuli changed on every presentation—each stimulus was a random emotional expression displayed on a new person. The oddball stimulus was one emotion (e.g., disgust), which each time was displayed on a new person (note the oddball emotion did not appear in the base stimulus stream). Thus, the oddball signal can no longer reflect a change signal (as there is a change on every trial); it cannot signal that the expression is no longer neutral, or that it is emotional (as all expressions are emotional); it must reflect recognition of the particular category of disgusted expression (without recognising it as disgust) or full recognition of the emotion disgust. Luckily, our previous work had shown that alexithymics could categorise emotional facial expressions but could not recognise them, meaning that if alexithymics showed a reduced oddball signal it would suggest the signal related to recognition of disgust—which was indeed what we found (Coll et al., 2019).

One implication of the "fine cuts" approach is that it is useful to examine the constituent cognitive processes required for any higher-order process. For example, we have argued that researching individual differences in "empathy" (assuming we can agree what that is) is less useful than researching individual differences in the cognitive processes required for empathy (Bird & Viding, 2014; Coll et al., 2017). One task we designed to achieve this is known as the CARER task (Santiesteban et al., 2021) and allows independent measurement of both a participant's ability to determine the emotional state of another ("emotion identification") and the degree to which the participant is affected by the other's state ("affective resonance"). Common measures of empathy investigate the degree to which the participant's state matches that of another person, but this measure conflates emotion identification and affective resonance—if a participant feels nothing in response to another's distress, we don't know if this is because they haven't realised the other is distressed (impaired emotion identification) or because they have recognised their distress but feel nothing in response (a lack of affective resonance).

A second example comes from studies into face recognition. Face recognition (as it is usually tested) refers to the ability to recognise a photograph of an individual as a photograph of that specific individual. However, a failure to recognise a photograph of an individual could arise from a failure of one or more constituent processes. We have performed work in this area too—trying to separate out the contributions of face perception (the ability to build a three-dimensional model of the face from an impoverished two-dimensional stimulus), face matching (the ability to determine whether two faces are the same or different), and face memory (the ability to store and recall accurate face representations). We have found some interesting patterns of results, for example, while autistic individuals and individual with developmental prosopagnosia are both thought to have poor face recognition (in the case of prosopagnosia this is the defining feature of the condition), when assessed in the more granular fashion described above we found that prosopagnosic individuals demonstrated poor face perception, matching and memory, whereas individuals with autism had intact face matching in the presence of impaired face perception and memory (Stantić, Brewer, et al., 2022, 2023). I like this work as it also required us to develop a novel test of face matching (Stantic et al., 2022) which made use of artificial intelligence to develop a test that was not—unlike all others to our knowledge—biased towards neurotypical individuals and, therefore, robust against falsely identifying deficits in neurodivergent groups.

The final example in this area, and the focus of a lot of current work, is Theory of Mind (ToM)—somewhat confusingly typically described as the ability to represent mental states but tested as the ability to make accurate mental state inferences. We have worked on the nature of ToM (and its role in autism) at both the theoretical level (Conway & Bird, 2018; Conway et al., 2019, 2020; Long et al., 2025) and the empirical level, questioning whether tests have really demonstrated the existence of an "implicit" form of mental state representation (and concluding that they have not; Conway et al., 2017; Santiesteban et al., 2014, 2015). The majority of our recent work, however, has been on developing a mechanistic model of how mental state inferences are made (which we call Mind-space) and developing new ways to test this model.

The mind-space model was developed to try and explain how we infer the mental states of others in the manner specified by the "fine cuts" framework. We wanted to produce a mechanistic model—causal, specific, and falsifiable—and to test it in suitable manner. What we wanted to do was go beyond the simple computational models of the sort that worked when programmed in software agents capable of one or two behaviours in a simplified virtual world (which implement logic like "When I grasp something it's because I desire to have it, if you grasp something I infer you desire it"), to explain the rich inferences real humans make in our complicated, messy, situation-specific social environments. While this is a sizable challenge, the first and most obvious change we wanted to make is to put the mind back into ToM . . .

One of the chief determinants of what someone is thinking (i.e., their mental states) is the type of mind they have—an extrovert will have different thoughts at a party to an introvert, a suspicious person different thoughts to a trusting person in a negotiation, and a forgetful person different thoughts to someone with a good memory when recounting a shared experience. In other situations, the influence of the mind giving rise to the mental state is less diagnostic, in times of extreme emergency for example. At its most basic, the Mind-space model simply says that we infer the likelihood of specific mental states based on the combination of both the situation the agent is in and what we know of the qualities of their mind (for full details, see Conway et al., 2019; Long et al., 2025). Our latest work suggests that this model can be applied not only to inference of an agent's mental states (what they think or know) but also to inference of their emotional state (Sevi et al., under review).

We wanted to test the model but were unhappy with some of the features of current tests of ToM. The first issue was that if you want to assess the accuracy of a participant's ToM you need to know what the correct answer is. This seemingly simple requirement is not met by most tests of ToM, as they use stories, scripted videos, or consensus scoring. Consider one of the better tests of ToM, the Movie for the Assessment of Social Cognition (Dziobek et al., 2006). In this test, the participant watches a scripted movie where they watch four characters interact. At certain points, the movie pauses and participants are asked questions about the characters' mental states. The problem is that the characters aren't real, and they don't have mental states. The correct answer becomes one determined by any of dramatic convention, what was originally scripted, what the experimenter thought the character would think, or what the majority of people think the character would think if they were real. Other general issues with tests of ToM include a lack of sensitivity (most typical adults make very few errors) and debate about whether the tasks really measure mental states (Heyes, 2014; Oakley et al., 2016).

We, therefore, developed the interview task (Long et al., 2022) in which participants watch videos of real social interactions (practice job interviews) where the interactants were asked—while the interviews were being recorded—to report their mental states. These reported mental states serve as a ground truth against which accuracy of mental state inferences can be assessed. Using this task, and others, we have shown that the accuracy with which a participant can determine what an agent's mind is like predicts the participant's ability to infer accurately the agent's mental states (Conway et al., 2020; Long et al., 2022), consistent with the predictions from Mind-space.

I hope these examples show the importance of the "fine cuts" approach, and in doing so that they emphasise the importance of cognitive models for psychology. It is easy to forget cognition in this new world of Big Data, Artificial Intelligence, and computational modelling, but I think it would be a mistake to do so. I hope these examples also demonstrate the importance of good experimental design. I will always be eternally grateful for having been taught this and believe it is the most valuable thing I can pass on. On this topic, as can be seen above, I have been incredibly fortunate to have worked with brilliant people and to have had such fantastic teachers and mentors. There are too many to acknowledge everyone, but I hope Caroline Catmur and I have managed to pass on the lessons we learned to our students at least half as well as the lessons were passed onto us. That is, after all, the nature of the game, and one I have felt very honoured to have been involved in.

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