Module:
Psychological Foundations of Mental Health

Week 2
Cognitive processes and representations

Topic in Action
Control processes – Part 2 of 2

Dr Charlotte Russell
Senior Lecturer, Department of Psychology, King's College London

Lecture transcript

Slide 2
Planning is certainly a complex cognitive skill. It involves thinking ahead to your end goal, working out how to achieve that goal, while accomplishing all the necessary stages to get there and also understanding when it's necessary to break down your plan into smaller sub-goals. Evidence suggest that patients with damage to their prefrontal cortices are impaired in these processes.

One way that this has been measured is with a simplified version of the Tower of Hanoi puzzle. If you want to try the Tower of Hanoi, have a look at the link included in the topic. The simplified version is known as the Tower of London task and was developed in London by Ros McCarthy and Tim Shallice. In this task, patients must plan how they'll solve the puzzle before they start making any moves.

They're given a goal state and a start state. And they must follow the rules to reach the goal state in the correct number of moves. Prefrontal patients are impaired on the Tower of London. But note that they're not impaired on tests of IQ, on memory, or in visual spatial construction. It's only the planning aspect of this task, that is, planning how to reach their goal state, that is affected.

Slide 3
Tim Shallice and Paul Burgess also tested their patients on a further test of planning, but this time, one, tapping into more everyday skills. They devised a paradigm that's still used today, called the multiple errands task, in which patients were required to complete goals in a shopping street, for example, to buy, write, and post a postcard, to buy a lettuce, to find out some pieces of information that had been cued by the experimenter.

Compared to non-frontal control patients, the prefrontal patients made many errors in sequencing or in not following standard rules, for example, not waiting to pay for their items or in leaving without collecting their change. Linked to this paradigm and the deficit shown by the patients is the concept of scripts in cognitive psychology.

Slide 4
Schank and Abelson were the first to coin the term "script" for the inherent plan that some events possess. That is, for certain events which regularly occur in our life, we implicitly learn a script. This implicit script-- that's nonconscious, if you think back to the previous topic-- means that the actions and the order they're performed in become somewhat automated.

For example, going to a restaurant, you would enter, ask for a table, sit down, get a menu, read the

Transcripts by 3Playmedia

menu, choose what you want, order what you want, receive your food, eat it, and then ask for the bill.

The purpose of our brains' compartmentalising events into scripts is that it reduces the cognitive effort required to perform that function. We need to activate our cognitive control and re-plan only if the event doesn't follow our expected script, for example, if we walk into a restaurant and find out we don't get given a menu.

Angela Sirigu was interested in how prefrontal patients would perform in a task that tested the use of routine events, for which they might have preserved scripts, and other less routine events.

Slide 5
Sirigu and her colleagues tested prefrontal patients, patients with posterior cortical damage, and neurologically healthy control participants.

They gave them all various scenarios, for which they first tested the accuracy for sequencing events that should occur in each scenario. There were three conditions of possible scenarios. First, routine events, such as getting ready to go to work. Second, non-routine events, for example, going on holiday. Or third, novel events that they were not expected to have ever done before, like opening a beauty salon.

You can see on the slide here the errors made by the prefrontal patients in sequencing the different types of scenario. They are making significantly fewer errors for the routine events, rather than the other two conditions. This reflects the fact that the routine events are likely to require less planning ability, as they might be able to rely on established scripts. It's worth noting, though, that this is not perfect performance. Only the frontal patients made any errors at all. Both control groups were at ceiling.

Slide 6
Have a look now at the same paper, but a different task. Here, they asked the groups to rate the importance of each event within the given scenario. On the slide here, you can see the events in a routine script for going to work. Although very few sequencing errors were made for this established script, if you think back to the previous slide, you can actually see that the patients really are quite inaccurate at selecting the correct importance of each event.

Performance of the posterior patients and healthy people match each other very well. But the frontal patients are significantly different at each point, rating having a shower as the most important, compared to getting up or leaving home, which is the most important for the posterior patients and the healthy people. This reveals failures in many executive control functions, the poor planning abilities compounded by an inability to structure in a meaningful way an event. This inability reflects poor task monitoring and poor attention, as well as planning itself.

Slide 7
Here are the results for the same task, but in a non-routine condition. This is for going on holiday. Remember that the prefrontal patients made more sequencing errors here too. But you can also see, again, the very matched performance of the two control groups and the complete disparity with the frontal patients. They're rating buying presents as the most important aspect of planning a holiday. This is very nice of them, but it's not as useful as packing a suitcase.

Slide 8
For the final section this week, I'm going to return to something I mentioned in passing earlier. That is the many years it takes for the frontal lobes to reach maturity. It's known that children are more impulsive than adults and are poor on the incompatible type of trials I talked about earlier, when I covered the Stroop task.

Classic studies of developmental cognition by Adele Diamond have revealed poor executive control in young participants. For example, in her version of Piaget's A not B task, babies continue to search in an incorrect location for a toy, despite having seen it moved right in front of their face. This is a perseverative manner, analogous to the perseveration in frontal patients that I talked about earlier. These are all related to the lack of maturation of relevant executive control regions.

Slide 9

Two papers were published in 1999, which both provided excellent data on the development of prefrontal cortices. You can see some of the data here from the longitudinal study by Giedd and colleagues. The graph on the left is grey matter volume in frontal cortex. Purple and red lines represent males and females, respectively.

You can see that volume grows up to about the ages of 10 and 12. And then, what takes place is known as neuronal pruning. Learning and experience is shaping and cultivating the frontal lobes throughout development. And this is completed by around 22. The graph on the right indicates white matter communication tracts between frontal cortex and the rest of the brain.

Here, you see continual development and growth. As I mentioned earlier, frontal cortex is extremely well-connected, and these white matter tracts indicate the growth and expansion of these connections. So throughout infancy, childhood, and then adolescence, the frontal cortices develop in response to learning and experiences of the individual.

But what happens if these cortices cannot grow or if the child cannot develop these executive control processes?

Slide 10

If you think for a moment about Phineas Gage's personality changes and the inappropriate behaviour listed as a core symptom of dysexecutive syndrome, these are failures of learned control processes. Our executive control enables us to understand other people and situations, prevent us from using our automatic responses, and they stop us from putting our own needs first.

So we're learning social and moral codes of behaviour throughout childhood and adolescence. And these complex tasks actually load heavily on executive control functions. This learning is incorporated into our prefrontal cortices by the neuronal pruning and increased white matter connections that we looked at on the previous slide.

Anderson and his colleagues were interested in what potential effects there might be from very early damage to frontal cortices, for example, whether these people might suffer from different symptoms than those who suffer from the prefrontal damage much later in life, after they've already acquired moral and social learning.

Here on the slide, you can see structural brain scans from the two patients they assessed. Subject A was a female aged 20 years at time of testing, and she'd suffered the damage you see to her prefrontal cortices at only 15 months of age.

The reports from her family and teachers indicated that she was disruptive throughout her life. She lied. She stole from her parents. She was constantly verbally and physically abusive. As she got older, she made no plans for her future, and she had no ability to hold down jobs that her parents had found for her.

Subject B was a male, who was age 23 when he was tested. He had suffered from his prefrontal damage at only three months of age. He was a very unmotivated person. He had a flat emotional affect, with bursts of anger. He did nothing all day apart from watch TV and eat. He even ate frozen food that hadn't been cooked. He became obese, and he had poor hygiene. And he was unable to hold down jobs as well.

Transcripts by 3Playmedia

Slide 11
Formal testing revealed these two subjects to be poor at the Wisconsin Card Sorting Task and the Tower of Hanoi, in the way that you would expect from dysexecutive patients or adult onset patience, as described in the table you can see on the slide. However, remember that their IQs, their memory, language are all in the normal range. If you look at the table here, the social and moral reasoning was extremely impaired in the young patients.

The authors tested them in a series of reasoning tasks, which loaded on the ability, for example, to think of others or to mentally put yourself in other people's shoes. The early onset patients were only level one of social and moral reasoning. This is characteristic of most children who are under the age of nine. This involves an egocentric perspective, making your decisions based on avoiding punishment or reasoning, for example, that to serve your own needs, you have to recognise other rights a little.

This is very different from the adult onset patients. You can see that five out of six of them were at the conventional level, which is characteristic of most adults and adolescents. And one of them was even in the level three, post-conventional level, achieved by only a minority of adults. If you're interested in this work, please follow up on the readings I provided.

Slide 12
In this final topic, we've learned about executive control processes. These are a diverse set of operations, including executive attention to task, task monitoring, task switching, inhibition, and planning. And you've seen how these are controlled by the prefrontal cortices and how damage to that region impairs cognitive control.

We have looked at paradigms that are used to assess inhibition in planning. And in the final section, we learned that these processes are central to the complex learning we must do to understand social and moral reasoning and fit ourselves well within human society. We finished with a fascinating study on the effects of very early prefrontal damage.