Module:
Psychological Foundations of Mental Health

Week 2
Cognitive processes and representations

Topic in Action
Control processes – Part 1 of 2

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

Lecture transcript

Slide 2
Imagine that you are home, making dinner. You're waiting for the water to boil, so that you can start cooking your pasta, and you're listening to a debate on the radio that you're really interested in. While this is going on, your phone rings. It's an old friend, who you haven't heard from in a long time.

So though you're very hungry and want to have dinner as soon as possible, and although you're very interested in what the people on the radio are saying, you answer the phone. Your friend's ringing, as they're coming to town tomorrow and would really love to meet up with you.

You know that your day tomorrow is packed full of things to do and finish, but you would very much like to meet them. So while you wait for the water to boil, talk to your friend, try to ignore the conversation on the radio, you're thinking now about tomorrow and trying to work out if you can rearrange things, so that you can see your friend.

This pretty simple everyday scenario actually involves you juggling many complex cognitive tasks, and it's a great way to understand the main processes involved in what are known as executive functions or sometimes cognitive control processes. And here, we're going to call them executive control processes.

Slide 3
So thinking about this scenario, you want to avoid any delays to your dinner. You don't want to be rude to your friend. And you'd like to plan a way in which to meet them tomorrow. To do all this successfully, you need to juggle many cognitive tasks efficiently. This juggling is another word for controlling the relevant mental processes.

Let's have a think about what these mental processes are. First, you need to get the pasta on as quickly as possible and understand what your friend is saying. So you need to pay attention to both the water, monitoring its progress, and the conversation on the telephone.

Secondly, we know that we don't actually efficiently divide attention between two tasks simultaneously. What we do is switch the bulk of our attentional resources at the relevant time to the other task. This means that we can give a large amount of resources to complete the given tasks sequentially, as we can't do this as efficiently simultaneously. So part of our task here is to switch attention to the water or the conversation at the right time.

Transcripts by 3Playmedia

Importantly, remember that we were also interested in that debate on the radio. If we now want to efficiently make dinner and arrange how to see our friend, we need to ignore this debate. Otherwise, it would compete for attention and interfere with our other tasks. Finally, we want to think about whether there's a way to rearrange our day tomorrow.

Slide 4
Here on this slide, you can see the main cognitive tasks that define these executive control processes. First, attention and task monitoring. Attention clearly links us back to the topic earlier in the week. And so through what you've learned so far, I hope it's clear why we need to be paying attention to a task in order to complete it effectively.

This links to the concept of task monitoring. Here, we're monitoring the water. And to do this, we're paying attention to it. But you might see the term "monitoring" as listed separately, so I wanted to put it in the context for you here.

Secondly, task switching. Moving your cognitive resources around efficiently, so that you attend to the relevant part at the right time is known as task switching. Third, inhibition. This is a crucial task for us when we're trying to effectively complete complex cognitive tasks in a complicated environment containing many distractions.

We must inhibit external events that will distract us. But we also must inhibit internal information that would prevent us from operating successfully. And I'll talk about this in more detail soon.

Finally, planning. A critical executive control process is in organising events into a coherent structure to enable us to act effectively within our world. To do this, we need to access long-term memories and manipulate them within working memory, which we were learning about in the previous topic. And we'll return to this in more detail soon too.

Slide 5
I just want to say a few words about why these cognitive functions are often parcelled together into executive functions or executive control processes. Think for a moment about the executive board of a company. What do they do? They might be deciding what the important goals for their business are. They will be deciding which of these goals will be prioritised. And then, they'll be allocating resources to the chosen tasks to complete these goals.

Meanwhile, they'll be keeping tabs and monitoring what's going on in the business. So they're not the same as the workers who are doing the tasks. They're administrating them. And this is analogous to the roles of executive control processes.

And I hope also that the term "executive" reminds you, too, Baddeley and Hitch's model of working memory from the previous topic. And indeed, the roles of the central executive in their model relate directly to executive control functions here.

Slide 6
We talked in the last topic about where in the brain might be potential sites for the short term stores of verbal and visual-spatial information in working memory and I left out at that point where in the brain might be involved in the executive control also needed in the model.

My introduction and your previous learning has hopefully made you familiar with the fact that the frontal lobes and particularly the most anterior part of these lobes are necessary for the complex cognitive control demanded by these executive tasks. There are some important points to be aware of regarding this region. First, the prefrontal cortex, which is the name for the most anterior part of the frontal lobes, in each hemisphere is very large in humans, much larger than the analogous regions in even our near primate relatives. Secondly, they are very well connected, receiving neuronal communication from most perceptual and motor cortical areas and from subcortical structures.

They also feedback information through numerous backwards projections to posterior regions. It's worth noting that the prefrontal regions are the last to reach maturity in the human brain, with reasonable estimates suggesting that they are not mature until at least 20 years of age and I'll talk about the implications of this later on.

Slide 7

I talked in the introduction about a carefully documented case, which illustrated the crippling effects of acquired prefrontal damage in Dr. P. But the most famous, even if less carefully documented case, is that of Phineas Gage. In 1848, Gage was employed helping to make the railway lines across America.

As part of this job, large holes were required. And the railway men had to make these by making small holes and packing them with explosives. The explosives used were packed down by being prodded with iron tamping bars. Unfortunately for Phineas Gage, one day at work, an explosive went off as he tamped it down, forcing the iron bar up through his cheek and out through the top of his skull. You can see in the images on the slide a quite recent reconstruction of what evidence suggests was the route of this iron bar.

Parts of the prefrontal cortex in both hemispheres seemed to be affected. Gage actually survived the accident, but as a very different man. Whereas he had previously been hard working and reliable, he became impulsive, occasionally violent, and unable to hold down even menial jobs. He ended up drifting around the country and often getting in trouble with the law.

His doctor, John Harlow suggested at the time that this behaviour change was a direct consequence of the type of damage his brain had suffered, although he didn't go further at that point to outline what the functions of these prefrontal regions might be. If you think of all the complex tasks the anterior frontal cortex has to manage, the change in Phineas Gage might begin to make sense.

His violence and unpleasant behaviour reveals impaired inhibition. And his failure to gain in employment and eventual descent clearly shows that without these control processes, the other cognitions and not properly functioning. Nowadays, the consequences of frontal damage are well known and formally outlined.

Slide 8

Norman and Shallice coined the term "dysexecutive syndrome" to describe the bundle of symptoms that follow damage to the prefrontal regions.

Some of the cardinal features of this syndrome are outlined on the slide. Inappropriate behaviour is often the most salient sign of frontal damage. This might include swearing, being rude, making inappropriate comments, and generally failing to respect certain norms of social behaviour. This was very clear in Gage, and the root cause of this behaviour is likely to be a failure in inhibition control processes.

Secondly, that behaviour is often perseverative. That is, once they've started doing one thing, they can't stop. They keep on with how they previously carried out a task. This describes them as having no cognitive flexibility. The famous Wisconsin Card Sorting Task is a good test of this symptom.

In this task, patients must sort cards by a rule, simply by being guided by the experimenter saying whether they're correct or not. These cards can be sorted by colour, number, or shape. Once they've learned one rule of sorting, for example, sorting according to colour, the examiner shifts the rule. And healthy performers learn from the fact that previous thoughts are now incorrect and so switch the sorting rule, for example, now sorting by shape.

However, those with prefrontal damage do not shift the rule effectively and perseverate with their previously successful method. Perseveration reflects a failure in many executive control processes, for example, task switching, but also attention in task monitoring and inhibition of previous response.

Distractibility is also a key feature of dysexecutive syndrome. These patients are frequently unable to complete tasks, as they become distracted by external or, indeed, internal stimuli that they're unable to ignore effectively. This symptom relates to many features, again, of the bundle of control processes, for example, task monitoring failures and inhibition failures.

The final deficit, that of planning abilities, has been shown in many experimental studies. These patients are unable to correctly organise events in their life or plan how to complete even quite simple tasks, like buying a list of products from shops, for example. I'll return to some concrete example shortly.

Slide 9
Let's now turn to inhibition, in order to learn more about this essential feature of executive control processes. We'll run through a couple of common paradigms, in order for you to learn how this ability's measured in cognitive psychology. First the go/no-go task.

Slide 10
In this task, the participant is asked to go, that is, press a button for all the digits shown, with exception of the digit four. Therefore, four is the no-go stimulus.

Slide 11
After several trials in which go stimuli are presented, the no-go stimulus is introduced.

Therefore, the participant is required to inhibit the frequent response, pressing a button when a digit appears, in favour of the less frequently occurring one, not pressing a button and for the number four. The number of go trials prior to a no-go stimulus varies between trials, making the task less predictable.

The number of errors on a go/no-go task is inversely proportionate to a participant's inhibition ability. That is, the higher number of errors, the lower the person's inhibition rating.

Slide 12
I hope those trials gave you an insight into the processes involved in a go/no-go task. The more go trials you're presented with sequentially, the more that response becomes automatic, and the harder it is to not go when a no-go trial comes. It's harder, as you require more cognitive control to withhold that automatic response.

On this slide here, you can see an adaptation from a recent paper of a simple go/no-go paradigm to include now neutral and emotional faces. The authors here were interested in whether certain personality types responded differently to the threatening fearful faces and the rewarding happy faces, for example, whether there was more control needed to withhold responses when the stimuli were one of these identities.

And you can find this paper in your reading test. You'll learn more about this type of emotional adaptation of cognitive psychology paradigms next week.

Slide 13
Let's look now at another paradigm assessing executive control processes, particularly inhibition. This is called the stop signal paradigm. On the slide, you can see a sketch of the different types of trial. For normal go trials, participants see a fixation cross and then a signal to go.

So in this paradigm, go means to move their eyes, make a saccade to the small right dot. Their response is then recorded, for example, how accurate the eye movement is and what was the saccadic latency, that is, the speed of the response. In the critical stop trials, they see a fixation cross and then a go signal and the saccade target dot.

But at varying times, which is known as the stop signal delay, a signal comes on that indicates that they must stop and not move their eyes. If they successfully withhold the original response, they are correct, and their eyes stay in the centre on the fixation task. If they hadn't managed to stop and move their eyes, they're incorrect.

To stop a prepared saccade like this is very hard. And how hard it is depends on the stop signal delay as well. That is, if the stop signal's presented immediately after the go signal, it's much easier to withhold the response, compared to when it's presented later. It requires a large amount of executive control to inhibit these prepared responses. And so this paradigm is an excellent way to measure how well someone's executive control processes are working.

Slide 14
On the slide now, you can see the famous Stoop task. Here, you must read out what the word says as quickly and as accurately as possible. The two conditions for comparison are here, one in which the response you make is compatible with the stimuli, i.e., the colour red written in the colour red, and one in which the required response is incompatible, for example, the colour red written in green.

All paradigms like this, in which there is a comparison between errors and reaction times for compatible versus incompatible trials, are tests of executive function. You must use executive control for incompatible trials in order to avoid mistakes based on automatic or prepotent responses.

Slide 15
Before we have a look at planning, let's have a think about the paradigms I've covered, that is, the go/no-go trials, the stop signal paradigm, and the Stroop task. I place them here all under the banner of inhibition. But is this the whole story? Are they really assessing purely the ability of an individual to inhibit an automatic or, we would say, a prepotent response?

If you have a look at the elements of executive control processes I outlined at the start, hopefully you'll agree with me that these paradigms are not only loading on inhibition skills. You need excellent attention towards relevant task characteristics. You need correct task monitoring. And you're also often switching the type of task you perform within the different conditions. So I'd suggest that they're all measuring quite broadly across all the different executive control processes.

Transcripts by 3Playmedia