The Cerebra Centre for Neurodevelopmental Disorders

UNIVERSITY OF BIRMINGHAM

Brain Activity and Attention Switching

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BRAIN ACTIVITY AND ATTENTION SWITCHING FEEDBACK REPORT

On DATE PARTICIPANT took part in a research study on brain activity and attention switching at the Cerebra Centre for Neurodevelopmental Disorders at the University of Birmingham.

In the study we aimed to look at how the brain works to allow people to switch their attention (changing from thinking about something in one way to thinking about the same thing in a different way) and how this might be different between people with Prader-Willi syndrome and people without the syndrome.

Why was it important for us to look at how the brain works during attention switching in people with Prader-Willi syndrome?

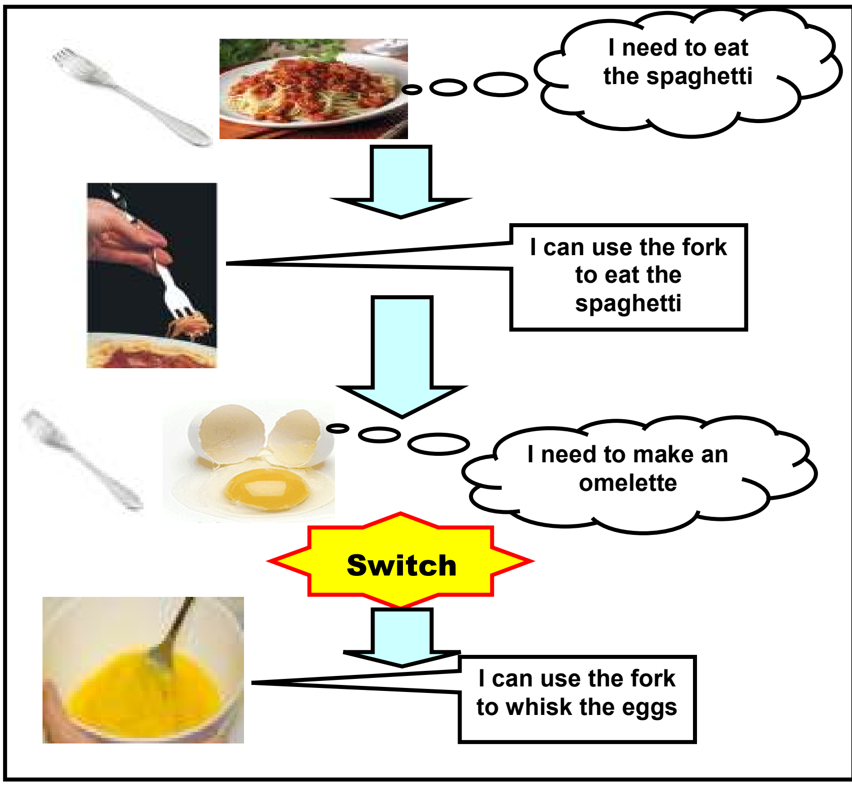
People with Prader-Willi syndrome can often be very resistant to changes to routines, expectations or plans. People can also show a lot of temper outbursts (sometimes called 'tantrums') that seem to be very difficult for the people with the syndrome to control. In our previous research we found that one of the times at which people with Prader-Willi syndrome can be very likely to show temper outbursts is when unexpected changes happen (e.g. changes to routines or to what the person was expecting).

In other research we have carried out we found that the resistance to changes to routines, expectations or plans that people with Prader-Willi syndrome often showed was linked to their ability to switch attention. So, people with Prader-Willi syndrome generally found it difficult to switch their attention, and the more difficult they found it, the more resistance to change they showed.

This means that attention switching seems to be closely linked with some very difficult behaviours in people with Prader-Willi syndrome. By looking at how the brains of people with Prader-Willi work when they have to switch their attention we might be able to understand why they find attention switching so difficult. This could help us to think of ways to make it easier for people to switch their attention.

What is attention switching?

Attention switching is changing from thinking about something in one way (that might lead to acting in a particular way) to thinking about the same thing in a different way (and then acting in a different way).

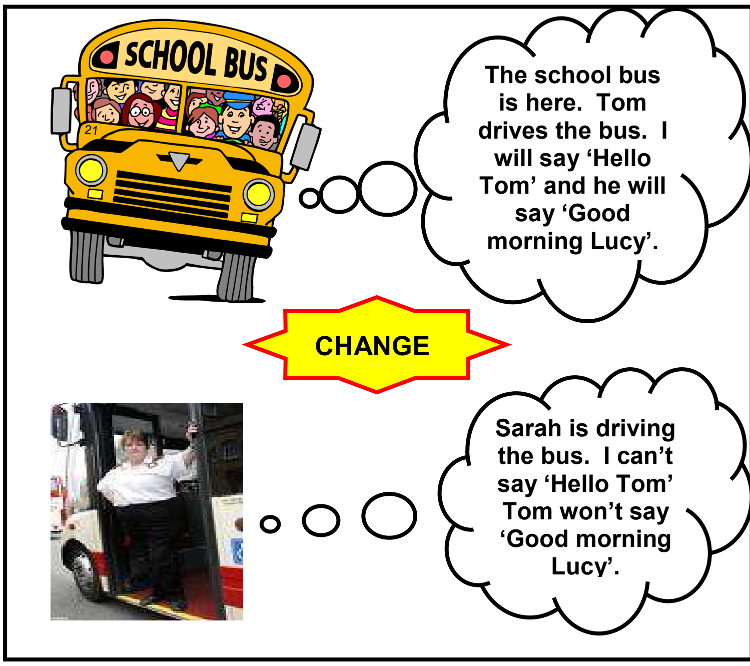


Here is an example of attention switching:

1) you see a fork next to a plate of food that you want to eat
2) you think about the fork as a tool for eating
3) you eat the food with the fork
4) you finish eating and wash the fork
5) you need to make an omelette
6) SWITCH
7) you think about the fork as a tool with prongs that can work like a whisk
8) you whisk the eggs with the omelette

How would difficulties with attention switching be linked to resistance to changes?

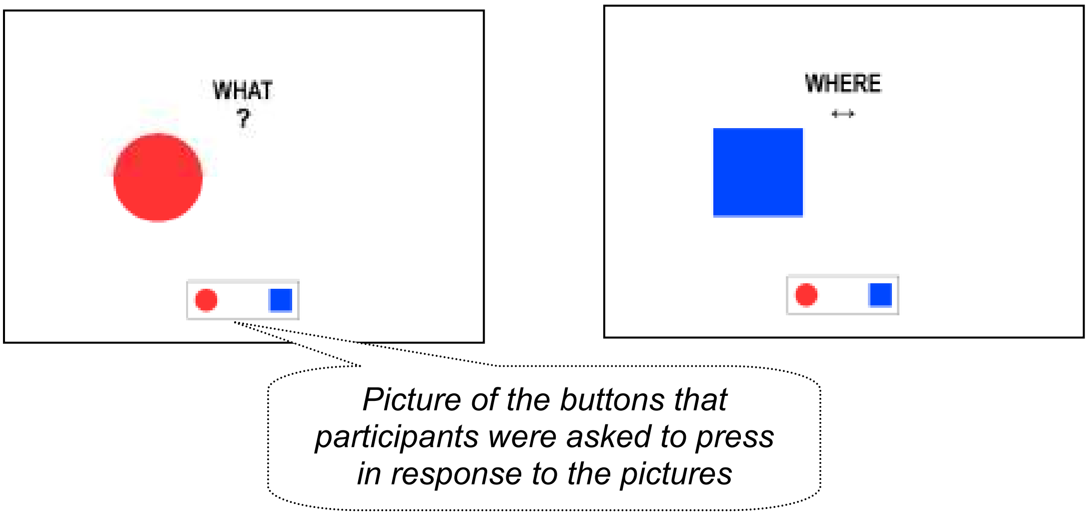
Changes to routines or to expectations can force people to switch their attention and so place a high demand on people's attention switching ability.



- You are used to catching the same bus everyday.
- The bus is yellow and has a driver called Tom who wears a hat.
- You know that when the bus comes you will say 'Hello Tom' and Tom will answer 'Good morning'.
- CHANGE
- A bus arrives, but Tom is not driving.
- You must change from thinking about the bus as the bus that Tom drives to thinking about the bus with a different driver.
- You must switch your attention to be able to act in the right way and greet Sarah.

How did we look at attention switching?
To look at how people switch their attention we asked participants to do a computer task that involved a lot of attention switching.

We showed participants a screen like one of these:



When peoplearticipants were shown a screen with the word ‘WHAT?’ above the picture, we asked them to press the button that showed the same picture as the one they could see. So in the above left side picture participants would have had to press the red circle (left side) button.

When participants were shown a screen with the word ‘WHERE←→’ above the picture, we asked them to press the button that was on the same side as the picture. So in the above right side picture participants would have had to press the left side (red circle) button.

This means that when the screen showed ‘WHAT?’ for one button press and then ‘WHERE←→’ for the next, participants had to switch their attention. They had to change from thinking about the picture as a red circle or a blue square, to thinking about the picture as a thing on one side of the screen or the other.

How did we look at how people’s brains work when they are switching their attention?
To look at how peoples’ brains work when they are switching their attention we used a technique called functional magnetic resonance imaging (fMRI) to take hundreds of photographs of peoples’ brains while they were doing the attention switching task.

Peoples’ brains contain millions of brain cells (neurons). Different areas of the brain contain different types of brain cells that are designed to do particular jobs. This means that when people are doing different things, the cells in some areas of the brain have to do a lot of work, while the cells in other areas of the brain have to do much less. When brain cells work they need more energy and this causes changes to the blood flow to those brain cells.

We used a magnetic resonance imaging machine to take photographs of the blood flow to all the different parts of the brain while participants were doing the attention switching task. This helped to show us how much work different areas of the brain were doing while the participants were having to switch their attention. We then compared these photographs to ones which we took while participants were not having to switch their attention (they were doing a similar task but the task didn't involve any attention switching). This showed us which parts of the brain were particularly involved in attention switching rather than in anything else that participants may have been doing at the same time (e.g. moving their eyes, reading 'WHAT? Or 'WHERE←→'etc.)

When we talk about the photographs that we took of people's brains we really mean images that the magnetic resonance imaging machine creates by measuring magnetic signals that the brain gives out when it is in the machine. Parts of the brain that are doing different amounts of work (and so have different blood flow) give out magnetic signals of different strengths just as different objects that you photograph with a camera are different colours because of the different amounts of light that they reflect.

What did we find out?

First we looked at the participants who do not have Prader-Willi syndrome. By comparing the images that we took while people were attention switching to those that we took while people were not switching, we created new images that showed us which brain areas were working particularly hard to allow people to carry out attention switching rather than anything else. We called these brain areas 'switching brain areas'.

Because everyone's brain is slightly different it was important for us to look at everyone's brain together. We created an average image of everyone's switching brain areas to show us which brain areas are really important for switching no matter which individual characteristics one person's brain might have.

The pictures on the next page show the switching brain areas averaged across the eight participants that visited us who did **not** have Prader-Willi syndrome.

We found three different 'switching brain areas' that were important:

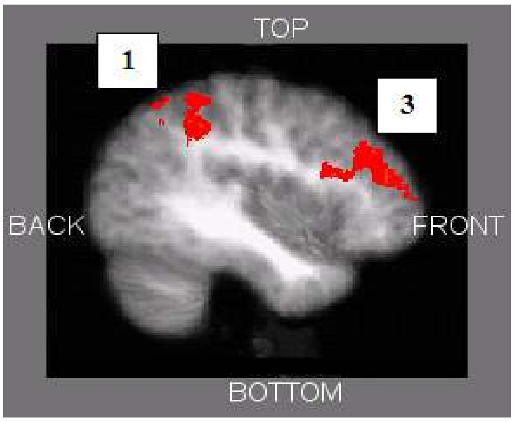
1) An area stretching from the left to the right side of the brain in a place we call the **parietal lobes.**

2) An area stretching from the left to the right side of the brain including a place we call the **anterior cingulate.**

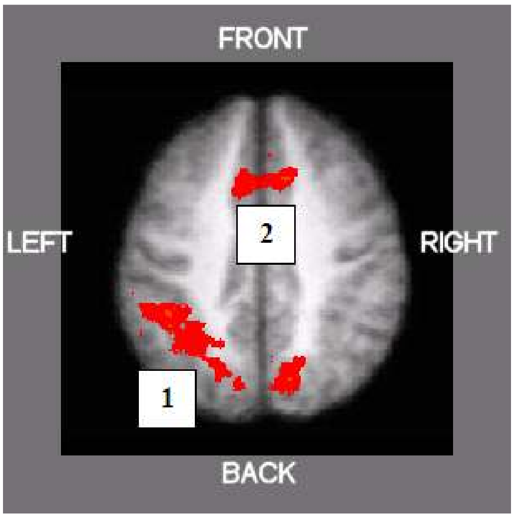
3) An area at the very front of the brain on the left hand side in a place we call the **frontopolar cortex.**

From research that other people have carried out before us we know that these brain areas match with the areas that are normally found to be important when people are switching their attention.

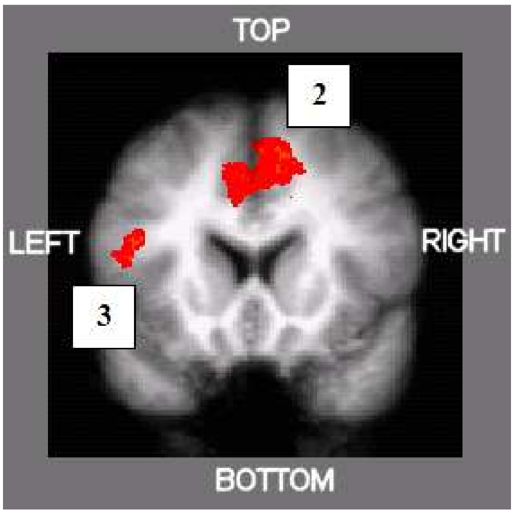
‘Switching brain areas’ averaged across the eight participants who did not have Prader-Willi syndrome



Looking at the brain from the right hand side of the person



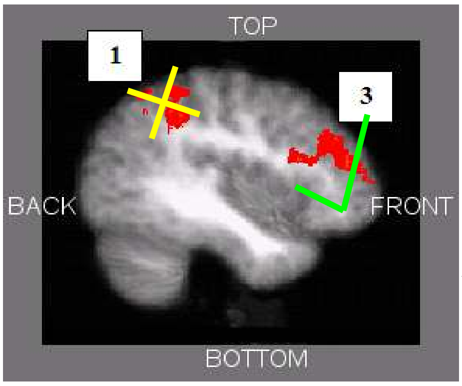
Looking at the brain from above the person’s head



Looking at the brain from behind the person, but as if the back part of the brain were transparent so we can see the inside of the brain as if it were sliced through the middle from ear to ear

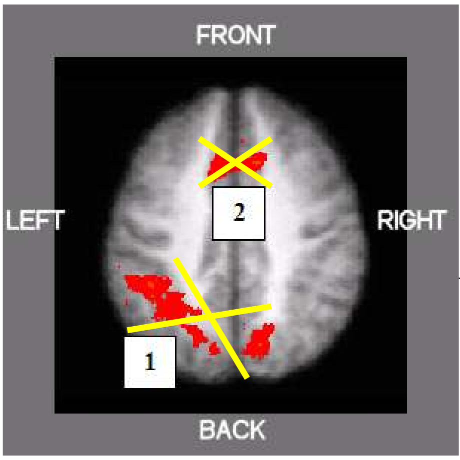
Next we looked at all of the people who had Prader-Willi syndrome. We looked at each of the 'switching brain areas' that were important in the people who did not have Prader-Willi syndrome. We wanted to see if the same areas were important for attention switching in people with the syndrome.

Which 'switching brain areas', important in people without Prader-Willi syndrome, are also important for attention switching in people with the syndrome?



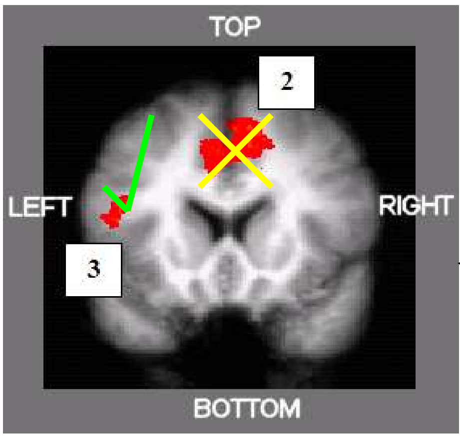
Looking at the brain from the right hand side of the person

Here we can see that the *parietal lobes* did not work hard during switching (x) in people with Prader-Willi syndrome, but the *frontopoloar* cortex did (√).



Looking at the brain from above the person's head

Here we can see that as well as the *parietal lobes* not working hard during switching in people with Prader-Willi syndrome (x), neither did the *anterior cingulate* (x).



Looking at the brain from behind the person

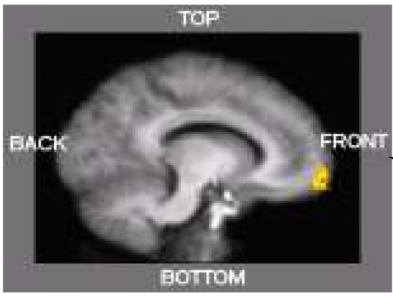
Here we can see again that the *anterior cingulate* did not work hard during switching in people with Prader-Willi syndrome (x), but the *frontopolar cortex* did (√).

So only one of the three typical ‘switching brain areas’ (brain areas that worked particularly hard during switching in people without Prader-Willi syndrome) worked hard during attention switching in people with Prader-Willi syndrome. This area was the area at the very front of the brain in the **frontopolar cortex**.

Finally, we wanted to see if there were any brain areas that worked harder during attention switching in people with Prader-Willi syndrome than in people without the syndrome. To do this we created images that showed us any areas where two things happened at the same time:

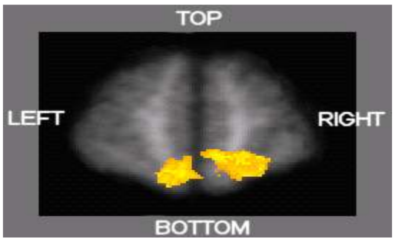
1) the area worked particularly hard when people were switching (it was a ‘switching brain area’)
2) the area worked harder in people with Prader-Willi syndrome than in people without the syndrome

Which brain areas work harder when people with Prader-Willi syndrome are attention switching than when people without the syndrome are switching?



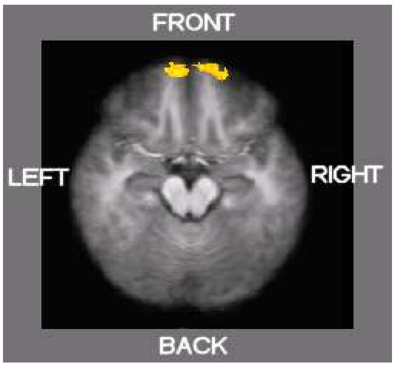
Looking at the brain from the right hand side of the person

We can see that an area right at the front of the brain in the *frontopolar cortex* worked harder during switching in people with Prader-Willi syndrome than in people without the syndrome.



Looking at the brain from above the person’s head

Here we can see the same area in the *frontalpolar cortex.*



Looking at the brain from behind the person, but as if the back part of the brain were transparent so we can see the inside of the brain as if it were sliced through the middle from ear to ear

Here we can see the same area in the *frontalpolar cortex.*

So an area at the very front of the brain (in the region known as the **frontopolar cortex**) worked harder during attention switching in people with Prader-Willi syndrome than in people without the syndrome.

What does this mean?
When people with Prader-Willi syndrome switch their attention they use different areas of their brain to people who do not have the syndrome.

Brain areas known as the **parietal lobes** and the **anterior cingulate** are usually important when people are switching their attention. But these areas are not used for switching by people with Prader-Willi syndrome. These brain areas are the ones that are normally responsible for changing the priority that the brain gives to paying attention to different aspects of objects and events, so these areas actually let an attention switch happen.

So, because of how the brain has developed in people with Prader-Willi syndrome, the brain does not seem to work in the right way to let attention switching happen as it normally should. This may be why people with the syndrome find it very difficult to switch their attention. So when people with Prader-Willi syndrome are forced to switch their attention because of changes to routines or expectations (e.g. if the bus driver changes from Tom to Sarah), their brain does not work in the right way to let them carry out the switch easily (e.g. they would find it very difficult to greet Sarah instead of Tom).

A brain area known as the **frontopolar cortex** actually works harder when people with Prader-Willi syndrome are switching their attention than when people without the syndrome are switching. This area of the brain may be responsible for letting people know that a switch has happened. So the brains of people with Prader-Willi syndrome seem able to tell them when a change has happened that would need them to switch their attention, but their brains are less able to deal with this change and actually carry out the switch.

Having said this, people with Prader-Willi syndrome *can* switch their attention even using completely different parts of the brain to those normally needed to carry out switching. It might be that people with Prader-Willi syndrome have been able to develop strategies to help them to switch their attention even when some parts of their brains that should be responsible for switching do not work properly (this might be why other parts of the brain e.g. the **frontopolar cortex** work harder). This is promising because it means that in future if we can find out which parts of the brains of people with Prader-Willi syndrome work particularly well then we might be able to work out how to teach these areas to compensate for the areas that do not work as well.

So, these results tell us that people with Prader-Willi syndrome seem to have a problem with the way particular parts of their brains work that is responsible for them not being able to switch their attention well. When changes to routines or expectations force people with the syndrome to switch their attention it is not through stubbornness or disobedience that people do not want the change to happen. There is a physical problem with the hardwiring of people's brains that causes switching, and so unexpected changes, to be extremely difficult.