The teenage brain

MYRIAD activities for young people.

Teenage Brain resources

Welcome

The Teenage Brain resources were created by researchers working on the MYRIAD (my resilience in adolescence) project. Originally an interactive, face-to-face workshop for young people, they aimed to shed light on this crucial period of life. Informed by the latest research into the mysterious working of the adolescent brain, the activities were designed to spark debate and discussion between young people, peers, teachers and families alike, and help people learn more about how the brain works.

We have adapted the workshop into activities to try in a school, a club, or at home, for audiences aged 9+.

How to use this pack

There are four main types of resources:

- Guides for teachers or leaders
- Worksheets to support the running of an activity
- Additional resources: further reading, wordsearch, crossword etc.
- Information sheets

For each activity from the original workshop, we have created a guide. This contains information about a psychological research tool and how it was used or adapted by MYRIAD researchers. We have included information about how you can try the tool, plan an investigation, what you can discuss and how to find out more.

There are accompanying worksheets for each resource guide. You can use them in any order or as stand-alone exercises. The activities can be adapted for different audiences and have already been used with Year 6 through to sixth form.

What teachers think

> "A really good set of resources to support PSHE teaching. Together they form a scheme of learning on the teenage brain that allows students to explore and understand the psychology and biology behind emotional and academic challenges of adolescence."

> "Great resources to engage students with both psychology and research methods. The activities are flexible enough to be scaled up or down, depending on how much time the teacher has - a great way of bringing practical research into the classroom."

> "An engaging set of activities to allow students to experience how their brains work and start to think about scientific research."

> "Great for using for taster sessions or open evenings."

What is in this pack?

The activities reflect research tools that psychologists use. We have also included a session on neuroscience, encouraging young people to find out more about their brains during adolescence.

In summary:

Title	Psychological tool	Activity description
The Teenage Brain	Neuroscience background	A collection of clips, worksheets, information and leaflets about neuroscience and the changes taking place during adolescence.
Are you a risk-taker?	Balloon Analogue Risk Task (BART)	A fun, practical, balloon-blowing test and a computer-based investigation.
How easily are you distracted?	Sustained Attention to Response Task (SART)	The SART adapted for a classroom or home setting with options for outdoor learning and role-play tasks.
Is it worth the wait?	Delay discounting	Delay discounting questionnaires used by psychologists. An easy investigation to replicate and can spark interesting discussions with teenagers around delay and reward.
How do you decide?	Stroop test	The well-known Stroop test, which can be used by all ages in a quick investigation. Or adapt the test to investigate emotional processing.

Contents

What is the MYRIAD Project?

The MYRIAD project considered the potential of mindfulness training in primary prevention of depression. The central hypothesis was:

> "Does mindfulness training in adolescence have the potential to shift the population away from psychological problems by addressing key processes of mental regulation that operate across the spectrum from risk to resilience?"

We know that adolescence is a vulnerable time for the onset of mental illness: 75% of mental disorders begin before the age of 24, and half by age 15 (Kessler et al., 2005). "By promoting good mental health and intervening early, particularly in the crucial childhood and teenage years, we can help to prevent mental illness from developing and mitigate its effects when it does" (Department of Health, 2011).

There were three themes within the project:

Theme 1: Examine the socio-cognitive-affective impact and mechanisms of mindfulness

This theme examined the impact on executive control in typically developing adolescents. Researchers observed how mindfulness affects the processing of thoughts and feelings and whether there are different effects at different stages of development. Researchers examined the effects among those with poor and good mental health. **It is this theme's work that forms the basis for this activity pack.**

Theme 2: Implementation of a Mindfulness curriculum

This theme aimed to discover the best way to train teachers to deliver a mindfulness curriculum and how to implement it in schools.

Theme 3: Mindfulness in schools: effectiveness, cost-effectiveness and mechanisms

A randomised control trial comparing existing, good quality social and emotional learning (known as 'teaching as usual') to a programme of study that utilises mindfulness techniques.

The project was led by Mark Williams and Willem Kuyken at the University of Oxford, with Sarah-Jayne Blakemore of University College London, and Tim Dalgleish of the MRC Cognition and Brain Sciences Unit at the University of Cambridge.

If you would like to know more about the project, please visit the MYRIAD project website at myriadproject.org

Why was this pack created?

We wanted to inspire an interest in science for the young people in the MYRIAD theme three trial schools. Taking inspiration directly from the work researchers were undertaking in theme one, the Teenage Brian interactive workshop was created with support from Wellcome.

The live workshop was run by MYRIAD researchers and toured schools and science festivals, giving over a thousand students a chance to try out some of the experiments undertaken in the project and learn more about the adolescent brain. This workshop included a basic explanation of the anatomy of the brain, activity stations with different psychological tools (SART, STROOP, BART, etc.), along with descriptions of what the tools measure. One (literally) massive part of this workshop was the giant inflatable brain, which allowed students to take a tour of the brain from the inside out!

The workshop covered how the various tools are used in real-life research including the MYRIAD project and what the findings might be able to tell us about the adolescent brain. During the workshop, the researchers worked with small groups of pupils to highlight the different parts of the brain that are activated in each psychological test. Students were supported to explore the following questions:

- What makes the teenage brain different?
- How does brain development affect behaviour?
- How do researchers find out how the brain works?

From this interactive workshop the MYRIAD team have created a lasting set of legacy resources that continue to reach young people, helping them begin to examine these questions with their peers, teacher, workshop leaders or parents.

Some of the resources in this pack have been adapted from the original workshop to make them accessible with minimal set up and technology. Follow up material for teachers and curious students are also available.

We hope to inspire young people to be curious about their brains, research and the psychological sciences!

What young people said

What young people wanted to know

> "Why do people get so easily distracted?"

> "Why do emotions control my decisions?"

> "How do they find out that teenagers think differently?"

> "Which is the most important part of the brain?"

> "Why do teenagers take more risks?"

DO

Find out about other MYRIAD resources for young people, including the young research challenge and MYPAD (MYRIAD young people's analysis of data), at myriadproject.org

The teenage brain

MYRIAD activities for young people.

Tool: The Teenage Brain

Explore: Be curious about neuroscience and changes that take place in the brain during adolescence

Time: 15-45 minutes

Key terms: neuroscience, MRI, pre-frontal cortex, limbic system, the fear response, amygdala, grey and white matter, neuroplasticity, neurotransmitter

The Teenage Brain

What you need to know

Different regions of the human brain develop at different rates. This becomes important when we look at what each part does since connections between them might be crucial for development. This is particularly the case during the teenage years, or more broadly during adolescence (anywhere between 10-24), as this is a major developmental period. Many of these changes impact on the social, emotional and behavioural development of young people during this time.

In this pack, you'll find a range of activities for young people to explore neuroscience and its impact on emotional and behavioural regulation.

What to do

1 **READ** this guide

2 **WATCH** Sarah-Jayne Blakemore's TED talk ted.com/talks/sarah_jayne_blakemore_the_mysterious_workings_of_the_adolescent_brain?language=en

3 **BUILD** your own brain hat to learn more about the parts of the brain and their roles ellenjmchenry.com/brain-hemisphere-hat/

4 **READ** about the brain using our two brain information sheets

5 **TRY** a crossword or wordsearch

6 **DISCUSS** What makes the teenage brain different? How does brain development affect behaviour? How do researchers find out how the brain works?

What you need

- ◯ Access to the internet (to access the TED talk and brain hats template)
- ◯ The Teenage Brain Information sheet
- ◯ The Brain Information sheet
- ◯ The brain crossword
- ◯ The brain wordsearch

How scientists use this tool

Until the late 1990s, we had very little idea about what is going on in the brain. That's because scientists had no way of looking inside the living human brain. Advances in technology, such as functional MRI or Magnetic Resonance Imaging, means that we can see which parts of the brain are activated during an activity. This has opened up many opportunities for research.

To investigate the link between neuroscience and development, scientists also use psychological tests. Participants answer questions or complete simple tasks designed to measure executive functions, such as memory, attention, response inhibition, etc.

'Hot' executive functions refer to the self-management skills we use in situations where emotions run high, and several brain regions are implicated in these mental processes. The MYRIAD team are investigating whether mindfulness teaching versus an active control can improve any of these processes (measured using a wide range of tasks), behaviourally and in terms of brain engagement.

What scientists already know

Scientists know quite a lot about the brain. Here are a few critical key facts, but for more information, see 'The Brain' and 'The Teenage Brain' Information sheets.

The brain continues to form new neural connections throughout a person's life and therefore, can adapt and change depending on its environment. This neuroplasticity is heightened during adolescence.

Neurobiologically speaking, the adolescent brain is poised for impulsivity and thrill-seeking. The frontal lobe is the area where planning, self-regulation, prioritising and other 'executive functions' are located, which are essential for assessing risk and consequences. This is the last area to develop in an individual. Meanwhile, the limbic region or 'reward' centre in the middle of the brain has developed earlier. It bombards adolescents with powerful signals in response to rewards and thrills, overpowering the contextualisation and risk assessment roles of the frontal lobe.

As a result of the internal and external changes taking place during adolescence, it is a period full of opportunities and vulnerabilities.

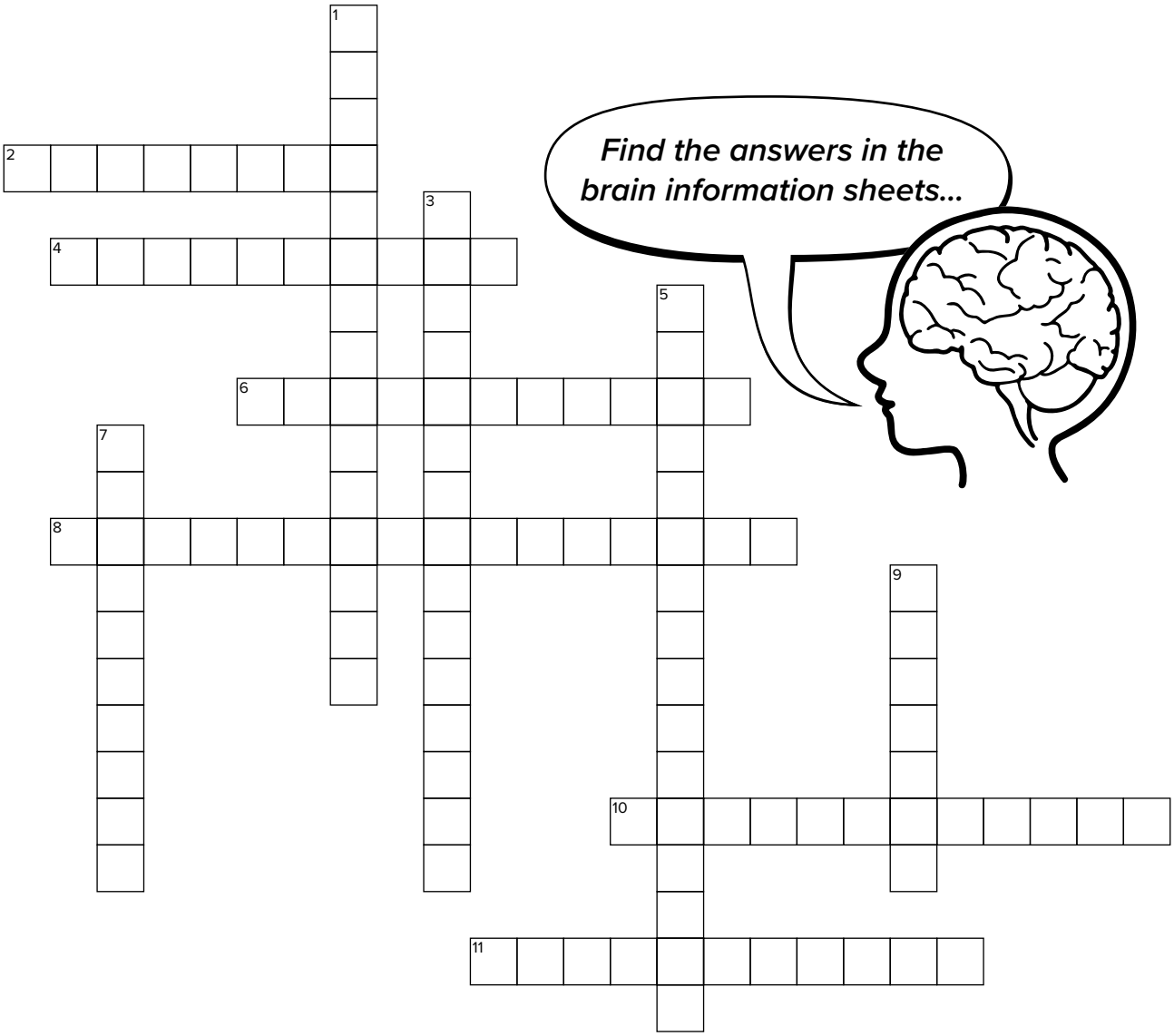
Want to know more?

Sarah-Jayne Blakemore, one of the principal researchers, has written two books on the subject:
The Learning Brain: Lessons for education

Inventing Ourselves: The secret life of the teenage brain
sites.google.com/site/blakemorelab/publications/blakemore-and-frith-book---the-learning-brain

Read about 'hot' and 'cold' executive functions in the brain here: **tinyurl.com/yao8dhm2**

The brain crossword: what is your brain and how does it work?



Across

2. An almond shaped tissue which plays an important role in the processing of "fight, flight or freeze" emotions **(8)**.

4. Tissue mostly made of cell bodies and unmyelinated axons; decreases in amount during the teenage years **(4,6)**.

6. Plays a role in long term memory and how knowledge is obtained **(11)**.

8. Last part of the brain to mature, responsible for thinking, analysing, planning and other executive functions **(3,7,6)**.

10. The brain's emotional centre, affected by increased hormonal release during puberty **(6,6)**.

11. Tissue made up of myelinated axons, which increases in amount during the teenage years **(5,6)**.

Down

1. The natural process that occurs in adolescence resulting in reduced synaptic connections **(8,7)**.

3. The brain's ability to change throughout an individual's life **(15)**.

5. The chemical messenger involved in the transfer of an impulse across a synapse **(16)**.

7. Regulates motor movements **(10)**.

9. The junction between two neurons **(7)**.

The brain crossword: answers

Across

2. An almond shaped tissue which plays an important role in the processing of "fight, flight or freeze" emotions **(8)**.

AMYGDALA

4. Tissue mostly made of cell bodies and unmyelinated axons; decreases in amount during the teenage years **(4,6)**.

GREY MATTER

6. Plays a role in long term memory and how knowledge is obtained **(11)**.

HIPPOCAMPUS

8. Last part of the brain to mature, responsible for thinking, analysing, planning and other executive functions **(3,7,6)**.

PRE FRONTAL CORTEX

10. The brain's emotional centre, affected by increased hormonal release during puberty **(6,6)**.

LIMBIC SYSTEM

11. Tissue made up of myelinated axons, which increases in amount during the teenage years **(5,6)**.

WHITE MATTER

Down

1. The natural process that occurs in adolescence resulting in reduced synaptic connections **(8,7)**.

SYNAPTIC PRUNING

3. The brain's ability to change throughout an individual's life **(15)**.

NEUROPLASTICITY

5. The chemical messenger involved in the transfer of an impulse across a synapse **(16)**.

NEUROTRANSMITTER

7. Regulates motor movements **(10)**.

CEREBELLUM

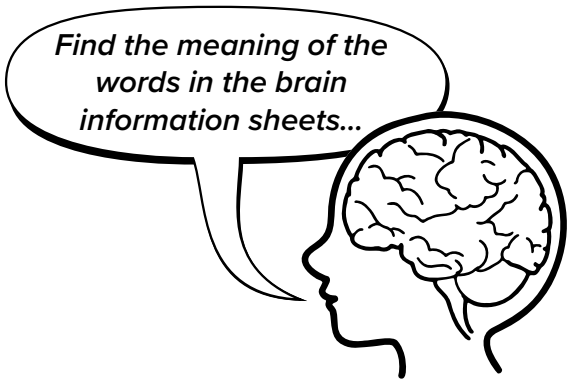
9. The junction between two neurons **(7)**.

SYNAPSE

The brain wordsearch

G A J U P S B J S N I M T E B R A I N J I H G N Y
C W S Q V U E W P R G A W S S E I B G R X G Z T B
Z S D J W V T N W K E B L P B V H R Y M Q A W A K
R A I J N Q I Y S I D I O A Q S J O V B X R L I V
P S Q S A N F Y D O M I N N D L F O A T E E O B S
R P W U T P G M T G R V U Y P G W F J Z O W N N J
C E H V M L B I B I N Y U S M V Y S U B U O O H C
R E T T A M Y E R G C M C N S X L M B J R I H F T
S A S J W V S A W A W I R O V C T M A U G K I C U
Q P A W Z A K T H I B K T I R Y G H E E E Q P F H
R T C Z O L I W X Q G X F S J T A N R G Q H P X Q
P G S L O F N K E C V J Y H A A E C P W D O O Y W
P O O C C I P I T A L L O B E L I X H Z Y W C I H
N U U J E K M Y R U W L C C T B P I O T O P A U D
I O B X T R D A O T T U K U M H T O J J Y X M L P
E P Q J W V C S C V E S H I E E A V R F T O P K B
U E A L M T I N L K R W L A M N R B G U Z E U D N
W T X V G Z I R A P I J J A F P K E H F E N S E R
F G A M D O B O T I A Y T H J I Y T Z X C N W A X
G G O K L U S W N P X T C X H S A B C U U F T V Z
W Y U O A F G P O X E Z Z Q J A S G I B H U H S X
I N P V C C S B R R S L D N H A V K D G V P I T Q
R X T U Y W U Z F R D U W V U B R R N Y U E P J S
Z R X C G D X C J Q A E B W V Y S L U E X J N I I
M G F V D L R P G T A C R H E K O D L U H U I Q G

AMYGDALA
BRAIN
FRONTAL CORTEX
GREY MATTER
HIPPOCAMPUS
LIMBIC REGIONS
MRI
NEURON
NEUROPLASTICITY
OCCIPITAL LOBE
SENSORY CORTEX
SYNAPSE
WHITE MATTER



The teenage brain

MYRIAD activities for young people.

Tool: The Balloon Analogue Risk Task (BART) test

Explore: The BART test, scientific validity and risk-taking behaviours in adolescence

Time: The live test (10 minutes); data gathering (30 minutes); analysis (30-60 minutes)

Key terms: risk-taking, risky behaviours, reward, impulsivity, peer pressure, scientific validity

Are you a risk-taker?

What you need to know

The BART (Balloon Analogue Risk Task) is a computerised decision-making task used to assess risk-taking. It simulates a real-world situation where taking a risk up until a certain point yields a reward. However, if risk behaviour continues, it results in poorer outcomes.

The participant is presented with a balloon and offered the chance to earn money by pumping the balloon up by clicking a button. Each click causes the balloon to inflate and money to be added to a counter, up until the balloon explodes. If the balloon explodes the money is lost. Each pump confers greater risk, but also greater potential reward.

This test is done on a computer. Alternatively, you could try out a group BART using real balloons. Think about how this affects the validity of results, for example, due to peer pressure!

Risk-taking on the BART peaks during adolescence. Participants could use the online BART to test this using scientific method.

How scientists use this tool

The BART test is a valid indicator of real-life risky behaviours such as substance use, gambling, carrying a weapon and fighting. It also correlates with scores on measures of sensation seeking, impulsivity, and deficiencies in behavioural constraint.

Several recent neuroimaging and physiological testing studies have successfully used the BART to identify brain regions involved in risky decision-making.

The BART task is a behavioural measure of impulsivity/risk-taking propensity. Research has shown mindfulness training can reduce impulsivity levels of adolescents with behavioural problems in the classroom (Fishbein et al., 2016; Franco et al., 2016; Oberle et al., 2011). More specifically, it has been found that participants high in trait mindfulness (general level of mindfulness across situations and time) tend to be less impulsive (less likely to blow up the balloon until it pops) on the BART task (Trapp, 2011) compared to those low in trait mindfulness.

What to do

1. **READ** this guide.
2. **HAVE A GO** at an online BART test.
3. **OR** Run your own **LIVE BART** using our worksheet to guide you.
4. **DISCUSS** the differences between the online and live BART tests in terms of their scientific validity.
5. **PLAN** your investigation using a BART test, e.g. How does risk-taking differ between teenagers and adults? Does gender influence risk-taking behaviour?
6. **RESEARCH** how scientists have used the BART.

What you need

- ◯ Access to the internet and online BART*: brainturk.com/bart
- ◯ 'Are you a risk taker' worksheet
- ◯ Balloons, balloon pump, measuring tape (or piece of string and a ruler), willing participants (don't tell them anything before the test!)
- ◯ Paper and pens/pencils
- ◯ 'Designing a research project' help sheet
- ◯ The BART information sheet

** Disclaimer: This is an independent website and MYRIAD are not responsible for the content on this site*

Want to know more ?

A description of the BART: impulsivity.org/measurement/BART

A paper describing an application of the BART in research: Lejuez et al. (2003): tinyurl.com/y7s4ayex

See our further reading list for more links and full references.

Worksheet 1

The teenage brain

MYRIAD activities for young people.

Are you a risk-taker?

Running a live Balloon Analogue Risk Task (BART)

The BART test is a decision-making task used to assess risk-taking. Participants are asked to blow up balloons as big as they can, BUT if they pop their balloon, their balloon size will not count. There is usually an incentive or reward offered for the biggest balloon.

What hypotheses could this test be used to investigate?

How does adding an incentive change the design?

Is it more valid to do the test individually or in groups? How does having others around affect the results?

What sort of risks do young people take?

Is being a 'risk-taker' a good thing?

What you will need:

- ◯ enough balloons for each participant
- ◯ tape measures or string and a ruler
- ◯ paper and pen
- ◯ optional – balloon pump

HINTS and TIPS

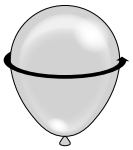
Warning: there might be loud bangs!
Do not share balloons.

What to do:

This exercise can be done one at a time, or simultaneously in groups.

If you want to, you can include a prize or incentive for the largest size, or the 'winner'.

1. Ask a participant to blow up a balloon as much as possible, without popping it.
2. When they are happy with the size, ask them to tie a knot, or hold it tight for measuring (you decide which method).
3. Use the tape measure or piece of string (which can then be measured using a ruler) to measure the circumference of the balloon at its widest point. Look at the diagram for help with this.



4. Record the reading in a results table.
5. Repeat this activity with other participants.

Compare the sizes of the balloons – whose was the largest? What does that tell you in terms of their willingness to take risks?

Discuss:

What results will you record? How will you record them?

Is it a well-designed experiment?

What hypotheses could this test be used to investigate?

EXPLORE

Does gender effect risk-taking behaviour?
Do teenagers take more risks than young children or adults?
Does taking part in competitive sport correlate with risk-taking behaviour?
Does having a sibling affect risk-taking behaviour?

How does adding an incentive change the design?

Is it more valid to do the test individually or in groups? How does having others around affect the results?

What sort of risks do young people take?

Is being a 'risk-taker' a good thing?

The teenage brain

MYRIAD activities for young people.

Tool: Sustained Attention to Response Task (SART)

Explore: The SART test, attention, concentration and distraction

Time: Practical task 1 (20 minutes not including organising); Paper task 2 (10 minutes per participant)

Key terms: sustained attention, response inhibition, reaction time, accuracy

How easily are you distracted?

What you need to know

How often do you find yourself distracted by background noise when you know you ought to be concentrating on something else? Whether or not you can keep your attention focused, and for how long, can be measured under different circumstances.

The Sustained Attention to Response Task (SART) has been used in a wide range of studies to determine the level of an individual's sustained attention (keeping your focus on a task) and response inhibition (the ability to avoid the attention drifting into automatic responses).

The tool measures both reaction time (how long it takes to press a button) and the accuracy of the responses (pressing the space bar when required and not touching the space bar when the number 3 pops up).

Usually, the SART would be carried out by participants on a computer. Participants would be asked to respond to the numbers (1-9) seen in random order by pressing the spacebar after every number EXCEPT when they see the number 3 (this is the target number). Failure to do this signifies a lapse in sustained attention. The speed and accuracy of the participant's responses are measured.

Our suggested activity is an alternative version of the SART that gets participants to work together to voice the numbers and observe responses. Unfortunately, the test is not currently publicly available.

How scientists use this tool

Researchers have used the SART to investigate attention. For example, the impact of practice on increasing sustained attention; the effect that having ADHD or autism has; the effect of sleep; and how the mind wanders when doing a task, etc.

MYRIAD researchers have adapted the SART to see what effect negative and neutral sounds have on adolescents' ability to sustain their attention during the task. They chose to add sounds as they thought two things might happen:

1. Participants would find the task more difficult in the adverse condition than the neutral condition (there is no positive condition in this task).
2. Those that had been through mindfulness training would be better at dealing with negative stimuli than those that had not been through mindfulness training.

What to do

1. **READ** this guide.
2. **TRY** the practical task on worksheet 1 **OR**
3. **TRY** the paper-based task on worksheet 2.
4. **EXTEND** your investigation by adding neutral and negative sounds with worksheet 3 (additional sounds worksheet).
5. **DESIGN** your own SART.
6. **WATCH** the video of the original computer-based SART to see what it looks like in research youtube.com/watch?v=OjvW4q0v5AI

What you need

- ◯ Access to the internet
- ◯ Clock, stopwatch or another way to record time
- ◯ Paper and pens/pencils
- ◯ 'How do you decide' worksheets 1 and 2
- ◯ Stroop test information sheet
- ◯ 'Designing a research project' help sheet

Want to know more?

A description of the SART measure:

scienceofbehaviorchange.org/measures/sustained-attention-to-response-task/

A paper describing an application of the SART in research: Robertson et al. (1997):

scienceofbehaviorchange.org/wp-content/uploads/2017/10/robertson_etal_1997-1.pdf

See our further reading list for more links and full references.

Worksheet 1

The teenage brain
MYRIAD activities for young people.

How easily are you distracted?

Running a live Sustained Attention to Response Task (SART)

The SART is a computer-based tool used to investigate how long participants can keep their attention on a task and the ability to avoid attention drifting into automatic responses (response inhibition). For instance, they might be asked to press a space bar every time they see a number from 1-9 on the screen, EXCEPT when they see the number 3 (this is the distractor number). The speed and accuracy of the participants' responses are measured. There is also a speed-accuracy trade-off – the faster participants respond, the more errors they tend to make.

MYRIAD researchers adapted the SART to look at the effect of different types of distracting information (emotional and non-emotional sounds) on teenagers' ability to sustain their attention during the SART.

DO

Watch this video to see what a traditional SART looks like **youtube.com/watch?v=OjvW4q0v5AI**

HINTs and TIPS

You could use a metronome to help with counting. You could find sounds online. Do not worry if anyone makes a mistake; just continue or start again at 1.

What you will need

- ◯ A largish room or outside space if possible (the activity may become noisy)
- ◯ Timer/stopwatch
- ◯ Digital sounds (see list below) if not using a person to create sounds
- ◯ Paper and pen to record results

What to do

This exercise can be done without the sounds (in pairs) or with sounds (threes)

1. Allocate roles:
   - **A** = participant
   - **B** = researcher
   - **C** = sound generator (live, or digital)
2. **A** stands or sits opposite **B** and away from **C**.
3. **A** counts from 1 to 10 at a steady pace. This is done on a repeated loop, starting again at 1 every time they reach 10. Continue for 2 minutes.
4. **A** now replaces the number 3, 5 and 8 with a neutral word/sound (e.g. blank) or a silent beat. For example, student **A** counts 1,2, blank, 4, blank, 6, 7, blank, 9, 10. This practice continues for two minutes.
5. Now it is time to start the task. **B** needs a results table to tally how many errors (hesitation, deviation, repetition, etc.) **A** performs in the 5 minutes.
6. *Optional extra*: introduce background sounds from a recording using headphones, or live via person **C**. See below for suggested negative and neutral tones you could use. Give clear guidance to person **C** on how to control the sound delivery to ensure fair testing.
7. Repeat the test with the other participant and compare scores.
8. Use the test in your own investigation as a measure of attention and response inhibition.

Discuss

Did anybody find the task boring? The MYRIAD test is usually 15 minutes long. Could you have done this for 15 minutes? What happens to your attention when you get bored?

Were there times when it was easier or harder to focus?

Did anybody find any of the sounds particularly distracting? Which noises do you remember?

What could you do to improve your concentration and attention on this, and other tasks?

Can you think of ways to adapt this experiment?

Sounds

For the SART that was used in the research, these sounds were played to participants through headphones. The sounds include negative and neutral sounds.

Can you have a go at replicating these sounds to see what effect they have on those trying to complete the counting activity?

After the task, discuss which sounds were the most off-putting...

Negative	Neutral
Vomiting	Clock
Coughing	Train
Wheezing	Chewing
Baby crying	Cows
Male or female crying	Sneezing
Car horn	Cat
Alarm clock	Dog
Sirens	Wind
Tyre skids	Pig

Worksheet 2

The teenage brain
MYRIAD activities for young people.

How easily are you distracted?

Running a live Sustained Attention to Response Task (SART)

The SART is a computer-based tool used to investigate how long participants can keep their attention on a task and the ability to avoid attention drifting into automatic responses (response inhibition). For instance, they might be asked to press a space bar every time they see a number from 1-9 on the screen, EXCEPT when they see the number 3 (this is the distractor number). The speed and accuracy of the participants' responses are measured. There is also a speed-accuracy trade-off – the faster participants respond, the more errors they tend to make.

MYRIAD researchers adapted the SART to look at the effect of different types of distracting information (emotional and non-emotional sounds) on teenagers' ability to sustain their attention during the SART.

DO

Watch this video to see what a traditional SART looks like. **youtube.com/watch?v=OjvW4q0v5AI**

What you will need

- ◯ Trail task per participant per test
- ◯ stopwatch
- ◯ pen
- ◯ (optional) sound recordings and headphones

What to do

1. Allocate roles: **A = participant. B = researcher**
2. **A** needs to complete the snail trail task. Using a pen, draw a line from a letter to a number. Do this in sequential order and without taking the pen off the paper. For example, starting from A à 1 à B à 2 à C à 3 and so on. It should generate a trail, without gaps. Speed and accuracy are both critical.
3. **B** will be keeping time, starting a timer when **A** starts the task, stopping the timer when the participant reaches number 26.
4. **B** needs to record the time taken and the number of errors.
5. Repeat the test with the same participant and see if it changed, or different participants and compare scores.
6. Use the test in your own investigation as a measure of attention and response inhibition.
7. *Optional extra*: introduce background sounds from a recording using headphones, or live via person **C**. See below for suggested negative and neutral tones you could use. If you have a person **C** be sure to give clear guidance on how to control the sound delivery to ensure fair testing.

Discuss

Did anybody find the task boring? The MYRIAD test is usually 15 minutes long. Could you have done this for 15 minutes? What happens to your attention when you get bored?

What could you do to improve your concentration and attention on this, and other tasks?

Can you think of ways to adapt this experiment?

Sounds

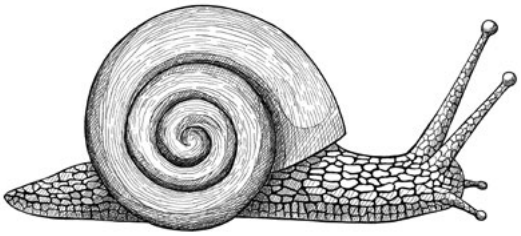
For the SART that was used in the research, these sounds were played to participants through headphones. The sounds are made up of negative and neutral sounds.

Can you have a go at replicating these sounds to see what effect they have on those trying to complete the counting activity?

After the task, discuss which sounds were the most off-putting...

Negative	Neutral
Vomiting	Clock
Coughing	Train
Wheezing	Chewing
Baby crying	Cows
Male or female crying	Sneezing
Car horn	Cat
Alarm clock	Dog
Sirens	Wind
Tyre skids	Pig

Trail Task



21 7 U H 20 A Z P 2 L Q B 10 J F 9 V O 12 E Y 26 1 3 G 23 16 N 19 17 W 14 18 D 15 8 I 13 4 22 X 6 R K M 25 T C 5 S 24 11

Image credit: ID 127148862 © Dmitry375 | Dreamstime.com

The teenage brain

MYRIAD activities for young people.

Tool: Delay discounting

Explore: Delay discounting and delayed gratification and how it relates to real-life decisions

Time: Worksheet 1 (20 minutes); Worksheet 2 (10 minutes); Own research project (40-60 minutes)

Key terms: delay discounting, gratification delay, reward, self-regulation and control, percentage, achievement, longitudinal analysis

Is it worth the wait?

What you need to know

Have you ever had to decide between an immediate small reward now or a bigger reward later on? Life is full of such choices. Whether they be financial, health, social or some other aspect of experience, we are always having to decide between benefits now or planning for the future.

Delay discounting is the tendency to prefer smaller and more immediate rewards to larger, perhaps more advantageous, rewards that are released later. It is a preference for 'quick wins'. Delayed gratification is the reverse, namely when a person resists a smaller but more immediate reward in order to receive a more substantial or more enduring reward later.

These activities explore the use of questionnaires to determine our natural tendencies and encourages young people to think of strategies for improving self-regulation. After all, we can learn self-control!

How scientists use this tool

In assessing how a delay affects the value of outcomes with humans, researchers most commonly ask people to make a series of choices between hypothetical options. Methods used to investigate delay discounting can differ and come with their strengths and drawbacks.

The ability to self-regulate and delay gratification has been found to vary, based on several factors including age, gender (a small difference), levels of impulsivity, behavioural factors, environmental and social factors. Choosing larger, future rewards over immediate smaller rewards can be associated with other positive aspects of life, including better academic performance, healthy social relationships, and reduced criminal behaviour.

The MYRIAD research team have been using the delay discounting questionnaire included in this pack to investigate delayed gratification. This task has been used widely as a measure of self-control. Research has shown that younger adolescents consistently demonstrate a weaker orientation to the future than do older adolescents/young adults and are more likely to choose immediate rewards (Steinberg et al., 2009). In MYRIAD, we are interested to know if mindfulness can improve an individual's capacity to resist immediate rewards for more beneficial long-term ones.

What to do

1. **CALCULATE** your delay discounting score using 'Is it worth the wait?' worksheet 1.
2. **COMPARE** your scores with somebody else and your views on the questionnaire.
3. **EXPLORE** some real-world examples with worksheet 2.
4. **WATCH** Sesame Street's Cookie Monster tackle his own delay discounting: youtube.com/watch?v=9PnbKL3wuH4
5. **WATCH** Sir Ian McKellan help Cookie Monster resist: youtube.com/watch?v=GxCpIsdCwxY
6. **DESIGN** your own delay discounting research questions.
7. Use the questionnaire to carry out your **OWN INVESTIGATION**.
8. **DISCUSS** How does delay discounting differ over a lifespan? Which rewards are more likely to help delay gratification?

What you need

- ◯ 'Is it worth the wait?' worksheets 1 and 2
- ◯ 'Designing a research project' help sheet
- ◯ Pen, paper and calculator
- ◯ Willing participants
- ◯ Delay discounting information sheet

Want to know more?

A description of delay discounting: apa.org/helpcenter/willpower

A paper describing an application of this test in research: 'Age Differences in Future Orientation and Delay Discounting'; Steinberg et al. (2009): psych.colorado.edu/~mbanich/p/AgeDiffFutureOrientation.pdf

See our further reading list for more links and full references.

Worksheet 1

The teenage brain

MYRIAD activities for young people.

Is it worth the wait?

Delay discounting

You have been asked to choose between receiving an amount of money now and a different amount in the future. Try to do this on your own, without talking and avoiding the influence of your peers.

You will have a choice between two amounts of money:

- smaller amount now
- a larger amount in the future.

Which would you prefer? You must imagine you are playing for real money - make sure you choose the amount of money that you would prefer to receive in real life.

So, what does this mean?

Delay discounting is the tendency to prefer smaller and more immediate rewards to more substantial, perhaps more advantageous, rewards later. A preference for 'quick wins' can indicate impatience, greater impulsivity of decision making and a preference for immediate gratification.

Delayed gratification is the reverse when a person resists a smaller but more immediate reward to receive a larger or more enduring reward later. Choosing larger, future rewards over smaller instant rewards can be associated with other positive aspects of life, including better academic performance, healthy social relationships, and reduced criminal behaviour.

The ability to self-regulate and delay gratification has been found to vary, based on age, gender (a small difference), levels of impulsivity, behavioural factors, environmental and social factors, and so on. The good news is that if you are not particularly good at self-regulation in terms of delaying gratification, then you can learn strategies to help you!

What to do

1. Tick the option you would like to choose (1 for each row).
2. Add up your total 'ticks' for each column.
3. What was your total score for the delayed '...or this?' column?
4. Calculate the percentage of delayed responses. There is a total of 30 options. To work out the percentage use: **Percentage (%) = your score / 30 x 100**
5. The higher your percentage, the better you are at delaying gratification!

This?		... or this?	
£27 today		£55 in 19 days	
£64 today		£80 in 93 days	
£12 today		£27 in 9 days	
£54 today		£55 in 117 days	
£55 today		£75 in 61 days	
£19 today		£25 in 53 days	
£31 today		£85 in 7 days	
£14 today		£25 in 19 days	
£47 today		£50 in 160 days	
£15 today		£35 in 13 days	
£25 today		£60 in 14 days	
£78 today		£80 in 162 days	
£40 today		£55 in 62 days	
£11 today		£30 in 7 days	
£67 today		£75 in 119 days	
£34 today		£35 in 186 days	
£27 today		£50 in 21 days	
£69 today		£85 in 91 days	
£49 today		£60 in 89 days	
£80 today		£85 in 157 days	
£24 today		£35 in 29 days	
£33 today		£80 in 14 days	
£28 today		£30 in 179 days	
£34 today		£50 in 30 days	
£25 today		£30 in 80 days	
£41 today		£75 in 20 days	
£54 today		£60 in 111 days	
£54 today		£80 in 30 days	
£22 today		£25 in 136 days	
£20 today		£55 in 7 days	

EXPLORE

Can you think of examples in life where you choose smaller immediate rewards over the longer term, perhaps more advantageous rewards? Now use the questionnaire to design your own research project.

Delay discounting participant questionnaire

Name: _____ Age: _____

Date: _____ / _____ / _____

Instructions: For each row, circle the option you would like to choose.

£27 today	£55 in 19 days
£64 today	£80 in 93 days
£12 today	£27 in 9 days
£54 today	£55 in 117 days
£55 today	£75 in 61 days
£19 today	£25 in 53 days
£31 today	£85 in 7 days
£14 today	£25 in 19 days
£47 today	£50 in 160 days
£15 today	£35 in 13 days
£25 today	£60 in 14 days
£78 today	£80 in 162 days
£40 today	£55 in 62 days
£11 today	£30 in 7 days
£67 today	£75 in 119 days
£34 today	£35 in 186 days
£27 today	£50 in 21 days
£69 today	£85 in 91 days
£49 today	£60 in 89 days
£80 today	£85 in 157 days
£24 today	£35 in 29 days
£33 today	£80 in 14 days
£28 today	£30 in 179 days
£34 today	£50 in 30 days
£25 today	£30 in 80 days
£41 today	£75 in 20 days
£54 today	£60 in 111 days
£54 today	£80 in 30 days
£22 today	£25 in 136 days
£20 today	£55 in 7 days

Delay discounting participant questionnaire

Name: _____ Age: _____

Date: _____ / _____ / _____

Instructions: For each row, circle the option you would like to choose.

£27 today	£55 in 19 days
£64 today	£80 in 93 days
£12 today	£27 in 9 days
£54 today	£55 in 117 days
£55 today	£75 in 61 days
£19 today	£25 in 53 days
£31 today	£85 in 7 days
£14 today	£25 in 19 days
£47 today	£50 in 160 days
£15 today	£35 in 13 days
£25 today	£60 in 14 days
£78 today	£80 in 162 days
£40 today	£55 in 62 days
£11 today	£30 in 7 days
£67 today	£75 in 119 days
£34 today	£35 in 186 days
£27 today	£50 in 21 days
£69 today	£85 in 91 days
£49 today	£60 in 89 days
£80 today	£85 in 157 days
£24 today	£35 in 29 days
£33 today	£80 in 14 days
£28 today	£30 in 179 days
£34 today	£50 in 30 days
£25 today	£30 in 80 days
£41 today	£75 in 20 days
£54 today	£60 in 111 days
£54 today	£80 in 30 days
£22 today	£25 in 136 days
£20 today	£55 in 7 days

Is it worth the wait: Real-world choices!

Worksheet 2

Rewards – short-term or long-term?

Time to think about real world choices. Cut out the real-world examples provided. For each of the examples decide by placing along the line how often you would choose the short-term reward or long-term reward.

MYRIAD

I would choose the short-term reward ⟷ I would choose the long-term reward

EXPLORE

What affected your decision in placing the cards on the line. For example, did the size of the rewards make a difference to your choice?
What could you do to help you to choose the long-term reward more often? E.g. break big tasks down and give yourself small rewards when revising.

HINTS and TIPS

This activity can be done individually, in pairs, groups or part of a large group discussion.

The teenage brain
MYRIAD activities for young people.

Is it worth the wait: Real-world choices!

You are given £2 a week

Do you choose to spend the money each week on something small?

OR

Do you choose to save up the money to buy something bigger?

You have homework due the next day

Do you choose to complete the homework on time?

OR

Do you choose to hang out with friends instead?

You have a big exam at school in a week's time

Do you choose to spend time revising for the exam?

OR

Do you choose to do something more fun instead?

You can choose to eat healthy food or junk food

Do you choose junk food often, but you might be less physically fit later as a result?

OR

Do you choose healthy food, so you are more physically fit later?

You have an early start at school

Do you choose to stay up late playing games/ watching TV/chatting with friends?

OR

Do you choose to go to sleep early?

You can choose to get the bus or walk for 1 hour to school

Do you choose to walk and save money and get exercise?

OR

Do you choose to get the bus?

You have a small exam at school in a week's time

Do you choose to spend time revising for the exam?

OR

Do you choose to do something more fun instead?

You can choose to get the bus or walk for 1 hour to school

Do you choose to walk and save money and get exercise?

OR

Do you choose to get the bus?

Can you think of your own real-world example where you either have a reward now or a bigger reward later?

Write it here:

Can you think of your own real-world example where you either have a reward now or a bigger reward later?

Write it here:

The teenage brain

MYRIAD activities for young people.

Tool: The STROOP test

Explore: The Stroop effect and cognitive interference

Time: The Stroop test (20 minutes); investigation or designing an emotional Stroop (60 minutes)

Key terms: Stroop effect, attention, cognitive processing speed, reaction time

How do you decide?

What you need to know

When faced with conflicting information like the word 'RED' written in blue ink, the brain takes longer to process the data. It needs extra time to decide whether to use information from the colour of the ink or the written text. This slowing down in reaction time is called the **Stroop effect**. The more interference the brain experiences, the slower it is to respond and the harder it is to make the correct response.

Participants can have a go at the original Stroop test in pairs; develop an emotional Stroop test like the one used by the MYRIAD team; or design a new test of their own. Encourage them to plan their own investigation using the scientific method.

How scientists use this tool

Psychologists use the Stroop test to measure selective attention and processing speed ability. It has been adapted in all sorts of ways to tell us more about how different people's brains prioritise information. Stroop tests are used to study fear, e.g. arachnophobia. With fear, your brain will be 'on the alert' for certain types of information and may find it harder to ignore this information and prioritise the ink colour.

As we get older, our brains become better at dealing with interference. Research shows children have more difficulty with the Stroop test than adults.

The MYRIAD team have developed an emotional Stroop test. Participants have to state whether a written emotion is 'happy' or 'sad', against a background of different photographed emotions. It helps us to see if mindfulness improves our selective attention and processing speed for emotional information.

What to do

1. **WATCH** the David Eagleton pbs.org/video/brain-david-eagleman-episode-4-clip-2/ or Mythbusters youtube.com/watch?v=xrowWGi20bM clip about the Stroop test.
2. Work as a pair to **HAVE A GO** for yourself using the 'How do you decide' worksheet.
3. **PLAN** your own investigation using this test such as: Is there a difference in test results with age? Does the presence of peers affect the brain's processing time?
4. **DESIGN** your own emotional Stroop test with the help of MYRIAD's emotional Stroop worksheet 2 (suitable for older students).
5. **DEVELOP** a new Stroop test – how could scientists of the future use this effect?
6. **DISCUSS** How do we make decisions when we have multiple pieces of input information? Are our brains slower when we are upset?

What you need

- ◯ Access to the internet
- ◯ Clock, stopwatch or another way to record time
- ◯ Paper and pens/pencils
- ◯ 'How do you decide' worksheets 1, 2 and 3
- ◯ Stroop test information sheet
- ◯ 'Designing a research project' help sheet

Want to know more?

A description of the Stroop test: en.wikipedia.org/wiki/Stroop_effect

Try out an online Stroop test: faculty.washington.edu/chudler/java/ready.html

The original paper describing the Stroop test in research: psychclassics.yorku.ca/Stroop/

See our further reading list for more links and full references.

Worksheet 1

The teenage brain

MYRIAD activities for young people.

How do you decide?

The Stroop Test

Try this out in pairs. You will need paper and pen to write down the times.

You could:

- make your own results table
- repeat the test and calculate mean times

Person A – you will complete the task. For each list, say out loud the **colour of the ink** (not the colour that the word describes).

Person B – your role is to time person A using a stop clock. If you want, you can also count how many mistakes they make.

Now swap and have a go at the other role.

Test 1: Congruent (the same)	**Test 2:** Neutral	**Test 3:** Incongruent (conflicting)
red	xxx	red
blue	xxxx	blue
green	xxxxx	green
orange	xxxxxx	orange
purple	xxx	red
red	xxxx	blue
orange	xxxx	black
blue	xxx	orange
red	xxxxxx	red
black	xxxx	orange
purple	xxxxx	purple
blue	xxxx	blue
orange	xxxxx	purple
red	xxxx	orange
purple	xxxx	black
red	xxxxx	blue
green	xxxx	purple
black	xxx	green
black	xxx	red
orange	xxxxxx	orange

EXPLORE

What did you notice? What was it like taking the test?

How do you decide?

The Stroop Test results sheet

Person A

Test type:	Time taken (s)
Congruent	
Neutral	
Incongruent	

Person B

Test type:	Time taken (s)
Congruent	
Neutral	
Incongruent	

What did you notice?

The Stroop Test results sheet
Person A

Test type:	Time taken (s)			Mean time (s)
	1	2	3	
Congruent				
Neutral				
Incongruent				

Person B

Test type:	Time taken (s)			Mean time (s)
	1	2	3	
Congruent				
Neutral				
Incongruent				

What did you notice?

How do you decide?

The Stroop Test results sheet

This is what the person should be saying. Use it to help track any mistakes they make.

Design your own results table.

Test 1: Congruent (the same)	✗/✓	**Test 2:** Neutral	✗/✓	**Test 3:** Incongruent (Conflicting)	✗/✓
red		green		green	
blue		red		orange	
green		orange		red	
orange		green		blue	
purple		blue		black	
red		red		orange	
orange		purple		red	
blue		black		black	
red		green		blue	
black		blue		red	
purple		purple		green	
blue		black		blue	
orange		orange		green	
red		green		purple	
purple		blue		orange	
red		black		purple	
green		purple		black	
black		red		red	
black		orange		purple	
orange		blue		blue	

What did you notice?

NOW USE THIS STROOP TEST TO DESIGN YOUR OWN INVESTIGATION

Worksheet 2

The teenage brain
MYRIAD activities for young people.

How do you decide?

Design your own emotional Stroop test

HINTS and TIPS

This activity is suitable for an older (KS5) or a more able audience

Background

Researchers often adapt the Stroop test for use in a new context. MYRIAD researchers developed a version to test attention and response time in relation to emotional stimuli.

The team used pictures of faces with either sad, happy or neutral expressions. They then superimposed a happy or sad word over the face. The participant had to state whether it was a happy or sad word and ignore the facial expression. The test included a congruent (word and expression matched), incongruent (mismatch between the word and facial expression) and neutral condition (pixelated face).

Preliminary tests informed the design of the tool, such as finding out which facial expressions young people considered to be happy or sad. The final testing utilised a computer programme to record the time taken to respond and any errors for each face. You won't have that luxury!

You have been given some examples from the MYRIAD emotional Stroop test.

Can you use the pictures to help you design your own emotional Stroop test?

Think about

- How many photos will you use?
- Which order should they appear?
- How will you present them? e.g. will you cut them out on card and show one at a time; paste into PowerPoint and rotate the slides, or have them all printed in a row on a sheet?
- How will your participant indicate if they think it is a happy or sad word? Will they call out, hold up an H or S card, or tap right or left hand as an indicator?
- How will you record the results?
- What will you record? Time taken? Errors made? Or both?
- What hypothesis could you test with your emotional Stroop?

EXPLORE

Does performance on this task change as adolescents get older?
Is the task easier for some adolescents than others, depending on their mood?
Can adolescents get better at this task if they train their attention in different ways?

HINTS and TIPS

This task will require quite a lot of thinking and trial and error. When psychologists design tools, it can take some time to work out whether they are measuring what they think they are!

The teenage brain

MYRIAD activities for young people.

Designing a research project

Using scientific method

When thinking about designing your research project, consider the **scientific method**:

1. Make an observation
2. Form a question and hypothesis
3. Experiment/collect evidence
4. Explore your findings

Observation

Observation is using your senses, or scientific tools and instruments, to collect information from the outside world. Any data collected during an experiment can be called an observation.

Question and hypothesis

When you are thinking up a question, choose something interesting to you. Could it be something that challenges your personal opinion? You need to be specific.

What is the difference between a research question and your hypothesis?

Research question: the question your research sets out to answer

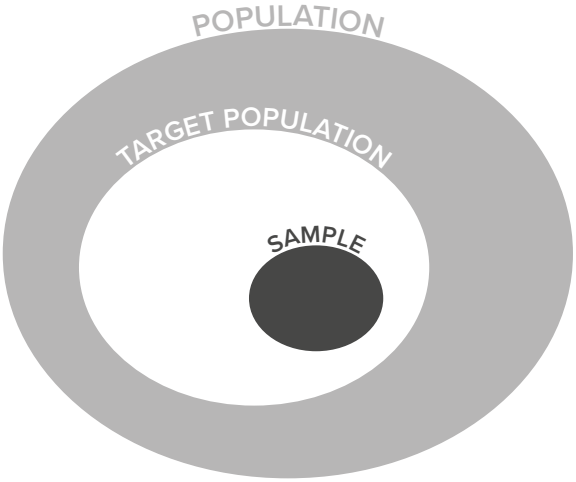
Hypothesis: a statement about what you expect to find

HINTS and TIPS

There are other things you need to consider when conducting your research project:
Ethical considerations: Research must consider the ethics of the study to ensure the protection of the participants. More often than not, psychological research uses human subjects, and you must consider their privacy, dignity, confidentiality, amongst other things.
Consent: participants must be given adequate information to consent freely before participating in any form of research.
Peer review: this is the process of having your work evaluated by others who are experts in the field – research cannot be published without being peer-reviewed!

Collecting evidence

You need people to take part in your research. The people taking part, or participants, are called your "sample". Sampling means getting data from a few people, selected from your target population. This sample needs to be representative of the whole group.



Here are some examples of common methods used in research:

- Interview
- Questionnaires e.g. delay discounting
- Observations
- Tasks or experiments e.g. the BART, STROOP, or SART.

Exploring your findings

What do your results tell you? Did you answer your research question? Was your hypothesis correct? If not, why do you think that is? Could you have done anything differently?

You may not have a conclusive answer to your questions but that is ok. You can now share your findings by writing a conclusion, report or even an article for a blog or website.

EXPLORE

What are some of the strengths and weaknesses of these methods?

The teenage brain

MYRIAD activities for young people.

Further reading list and references

MYRIAD

The MYRIAD project is led by Oxford University in partnership with other universities and organisations:
myriadproject.org/myriad-project/

Research papers

Kessler RC, Berglund P, Demler O, Jin R, Walters EE. Lifetime prevalence and age-of-onset distributions' of DSM-IV disorders in the national comorbidity survey replication. Archives of General Psychiatry 2005; 62(6): 593-602.
Department of Health. No health without mental health. London: Department of Health, 2011.

The Teenage Brain

Sarah-Jayne Blakemore, one of the principle researchers on the MYRIAD Project, has written two books on the subject:

- The learning brain: lessons for education
- Inventing ourselves: The secret life of the teenage brain

sites.google.com/site/blakemorelab/publications/blakemore-and-frith-book---the-learning-brain

TED talk 'The mysterious workings of the adolescent brain':
ted.com/talks/sarah_jayne_blakemore_the_mysterious_workings_of_the_adolescent_brain?language=en

The Blakemore Lab:
sites.google.com/site/blakemorelab

Find out more about the research on the teenage brain from the Blakemore Lab:
sites.google.com/site/blakemorelab/media/ri_interviews?authuser=0

Read about 'hot' and 'cold' executive functions in the brain here:
understood.org/en/community-events/blogs/expert-corner/2016/10/05/executive-functions-they-can-be-hot-or-cool

Sustained Attention to Response Task (SART)

YouTube clip of an original SART:
youtube.com/watch?v=OjvW4q0v5AI

A description of the SART measure (please note this link does not work on all browsers):
scienceofbehaviorchange.org/measures/sustained-attention-to-response-task/

Research papers

Oops!: Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects; Robertson et al. (1997):
scienceofbehaviorchange.org/wp-content/uploads/2017/10/robertson_etal_1997-1.pdf

The Stroop test

YouTube clip. The Brian with David Eagleman. Episode 4, the STROOP test (you need to scroll down and click on the Stroop Test):
pbs.org/the-brain-with-david-eagleman/episodes/how-do-i-decide/

YouTube clip. Take the Stroop test: MythBusters:
youtube.com/watch?v=xrowWGi20bM

Read some background on the STOOP test:
en.wikipedia.org/wiki/Stroop_effect

Try out an online Stroop test:
faculty.washington.edu/chudler/java/ready.html

Research papers

I know how you feel: Task-irrelevant facial expressions are spontaneously processed at a semantic level; Preston and Stansfield, 2008:
link.springer.com/content/pdf/10.3758/CABN.8.1.54.pdf

Studies of interference in serial verbal reactions; Stroop (1935):
psychclassics.yorku.ca/Stroop/

Balloon Analogue Risk Task (BART)

The BART as a measure of risk taking:
impulsivity.org/measurement/BART

conductscience.com/portfolio/balloon-analog-risk-task/

Research papers

Test-Retest Characteristics of the Balloon Analogue Risk Task (BART). *White, Lejuez and de Wit (2014)*:
ncbi.nlm.nih.gov/pmc/articles/PMC4244869/

Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART) *Lejuez CW, Read JP, Kahler CW, Richards JB, Ramsey SE, Stuart GL, Strong DR, Brown RA (2002*) Journal of Experimental Psychology: Applied, 8, 75-84. PubMed ID 12075692
pubmed.ncbi.nlm.nih.gov/12075692/

Effects of Age and Initial Risk Perception on Balloon Analog Risk Task: The Mediating Role of Processing Speed and Need for Cognitive Closure. *Koscielniak M, Rydzewska K, Sedek G. 2016*. Frontiers in Psychology. VOLUME 7. P 659

frontiersin.org/article/10.3389/fpsyg.2016.00659

Franco, C., Amutio, A., López-González, L., Oriol, X., & Martínez-Taboada, C. (2016). Effect of a mindfulness training program on the impulsivity and aggression levels of adolescents with behavioral problems in the classroom. *Frontiers in Psychology*, *7,* 1385.

Fishbein, D., Miller, S., Herman-Stahl, M., Williams, J., Lavery, B., Markovitz, L., ... & Johnson, M. (2016). Behavioral and psychophysiological effects of a yoga intervention on high-risk adolescents: A randomized control trial. *Journal of Child and Family Studies, 25*(2), 518-529.

Oberle, E., Schonert-Reichl, K. A., Lawlor, M. S., & Thomson, K. C. (2012). Mindfulness and inhibitory control in early adolescence. *The Journal of Early Adolescence, 32*(4), 565-588.

Trapp, M. E. (2011). The effects of a brief mindfulness intervention on impulsivity in college students

Delay discounting

YouTube clip: Cookie monster resource for younger children:
youtube.com/watch?v=9PnbKL3wuH4

Watch The Brian with David Eagleman: Adolescents' performance on delay and probability discounting tasks: Contributions of age, intelligence, executive functioning, and self-reported externalizing behaviour:
pbs.org/the-brain-with-david-eagleman/episodes/how-do-i-decide/

American Psychological Association (APA) explaining delay gratification with further reading materials:
apa.org/helpcenter/willpower

Research papers

Review of delay discounting methods. Odum (2011):
ncbi.nlm.nih.gov/pmc/articles/PMC3213005/

Age Differences in Future Orientation and Delay Discounting; Steinberg et al. (2009):
psych.colorado.edu/~mbanich/p/AgeDiffFutureOrientation.pdf

Discounting of delayed rewards: (A)theoretical interpretation of the Kirby questionnaire. Myerson et al (2014):
sciencedirect.com/science/article/abs/pii/S0376635714001697?via%3Dihub

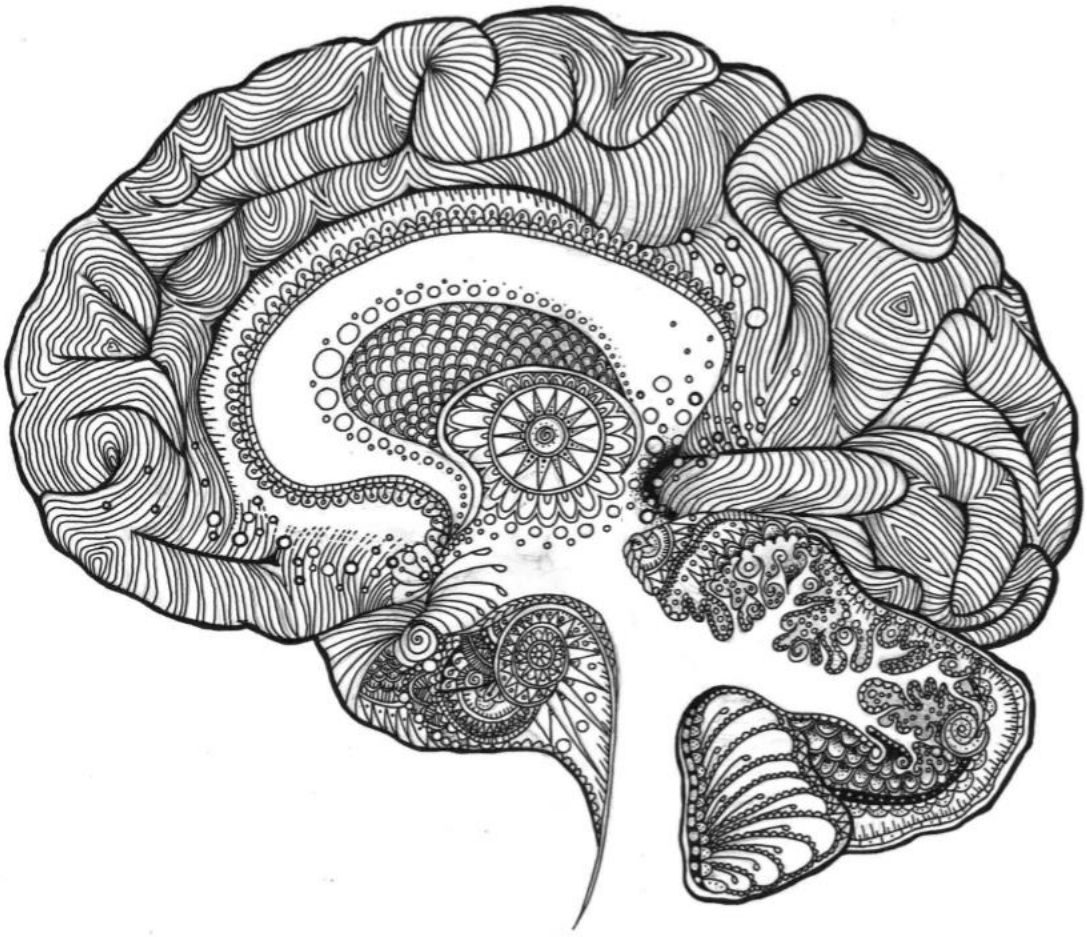
Behavioral and neural correlates of delay of gratification 40 years later. Casey et al. (2011):
pnas.org/content/108/36/14998#sec-12

Colour me:

The teenage brain's reward centre develops before the area responsible for self-control… which is one reason why teenagers are more likely to take risks than adults!

The brain processes 400 billion bits of information every second. The synapses in your brain can fire at a rate of 200 times per second. How does our brain process and select between all this information without our head exploding???? ☺

It is a myth that humans only use 10 percent of their brain. You actually use all of it. You're even using more than 10 percent when we sleep!



Mandala brain, by Kirsty Griffiths.

The brain can generate approximately 23 watts of power when awake.

During adolescence, the brain undergoes many changes including synaptic pruning and increased myelination.