

ACTIVITY BRIEF

Investigating the Wisconsin card sorting test

The science at work

The Wisconsin card sorting test, or WCST, has shown itself to be very valuable for the diagnosis of problems associated with the frontal lobe of the brain. It is easy to administer. The original version required only a deck of cards, but the scoring system was quite elaborate. Modern versions, using computers, automatically calculate and record the scores.

The test measures the ability to carry out certain types of abstract reasoning, particularly the ability to change problem-solving strategies as needed.

Although the test requires certain cognitive functions to be intact (for example, attention, working memory and visual processing) it is still known as a “frontal lobe test”. This is because any sort of frontal lobe malfunction usually gives rise to a poor result for the test.

Participants try out different rules, to find a correct method for sorting the cards. With severe frontal and prefrontal cortex damage, patients tend to get stuck in the card sorting task. They keep on applying the same rule for sorting, no matter how often they are told that they are sorting incorrectly. This persistence with an incorrect strategy is called *perseveration*.

Using perseveration and other measures derived from the test, clinical psychologists and others can assess a variety of aspects of what they call *executive dysfunction*.

Your brief

You need to carry out a trial implementation of the WCST on a partner to train yourself in its use. You will:

- learn how to carry out and score the test
- learn how to analyse the results and form conclusions
- understand how the test works

Start by reading *Fact sheet: The Wisconsin card sorting test*.

If you have access to a computerised version of the test use: *Practical sheet: Using computerised versions of the WCST*.

If you are going to use a card version of the test use: *Practical sheet: Using card versions of the WCST*.

Further investigations

This work will prepare you to be able to use the WCST in an investigation of your own (see *Activity brief: Wisconsin card sort testing correlational studies*).

FACT SHEET

The Wisconsin card sorting test (WCST)

About the test

The Wisconsin card sorting test has proved to be a valuable clinical tool for assessing dysfunction of the prefrontal cortex and basal ganglia. It is widely used by psychiatrists and clinical psychologists to test patients with brain injuries, neurodegenerative diseases and mental illnesses such as schizophrenia.

Using cards

The original test¹ used cards which had to be sorted into piles in front of four stimulus cards. The matching was done according to a rule which the participant had to work out. The cards could be matched by number, colour or shape of the symbols. This can be seen in the illustration above:

1, 2, 3 or 4 / circles, stars, squares or crosses /

red, green, blue or yellow. Hence the two red crosses can be matched by 'two' or 'red' or 'cross'. The participant will be told "correct" or "incorrect" depending on whether they guess the rule correctly or not. The rule is applied for a run of trials and then changed without warning.

The computerised version

Nowadays the test is computerised and Windows-compatible².

See publisher's website at:

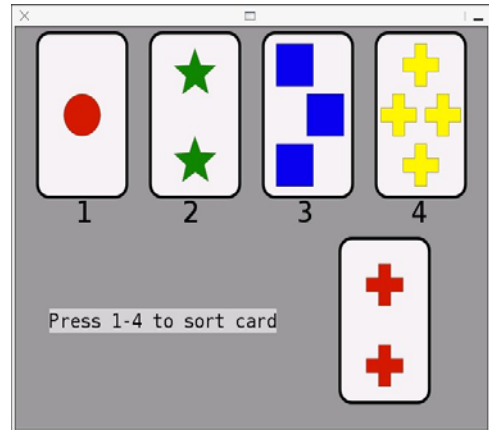
<http://www3.parinc.com/products/product.aspx?Productid=WCSTCV4>.

Frontal lobe test

The test is often called a *frontal lobe test*, as any type of frontal lobe damage leads to poor performance. Cognitive functions such as working memory, attention and visual processing are involved. Set-shifting behaviour, i.e. the ability to change responses to match changes in reinforcement patterns, is particularly affected. So patients tend to make a significantly higher number of what are called *perseverative errors*, sticking to a rule for some time, even though a new one is in force.

In modern psychology, the brain processes related to making decisions in goal-oriented behaviour are called *executive control* and malfunction is referred to as *executive dysfunction*.

Research continues, using neuroimaging techniques such as PET and MRI to show how activity in parts of the card sorting task is related to brain function. Parts of the prefrontal cortex show increased activity when the participants receive either negative or positive reinforcement, specifically at the point where current information is related to earlier events



Screenshot of the public-domain computerised version of the WCST, available as part of the [PEBL Psychological Test Battery](#).

¹ Berg, E A (1948) *A simple objective technique for measuring flexibility in thinking* Journal of General psychology **39** pp 15-22

² Heaton, R K (2003) *Wisconsin Card Sorting Test Computer Version 4 Research Edition (WCST:CV4™)* Psychological Assessment Resources

stored in the working memory. The basal ganglia show increased activity during negative feedback, when set-shifting is needed.

The article by Monchi *et al* at <http://www.jneurosci.org/cgi/reprint/21/19/7733.pdf> contains fMRI of brain activity, see page 7737.

Scoring the WCST

Score	Description
Number of trials	The total number of cards matched minus the number of the last trial
Number correct	On score sheets, the responses which have not been marked X for "wrong" (most easily found by subtracting the number of Xs from the total number of trials)
% Correct	Number correct divided by number of trials then multiplied by 100
Perseverative responses	The number of incorrect responses that would have been correct for the preceding category / rule
Perseverative errors	The number of errors where the participant has used the same rule for their choice as the previous choice
% Perseverative errors	Total perseverative errors divided by number of trials then multiplied by 100
Non-perseverative errors	All the remaining incorrect responses other than the perseverative errors above
Total errors	Total of all the incorrect responses (recorded as X), should be the same as the sum of perseverative and non-perseverative errors
% Errors	Total errors divided by number of trials then multiplied by 100
Trials to complete first category	The total number of trials needed to achieve the first 10 consecutive correct responses
Categories achieved	The number of runs of 10 correct responses
% Conceptual level responses	The number of correct responses that occur in runs of three or more divided by the number of trials then multiplied by 100
Failures to maintain set	The number of times five or more consecutive correct responses occur without completing the category (do not reach 10 consecutive correct)

Notes on terminology

- 1 *Perseveration* may be due either to the inability to give up an old category in favour of a new one or the inability to see a new possibility.
- 2 For a 128 card trial, the typical *number of perseverative errors* for "well educated young adults" is 11. With reasonable executive control, scoring tends to improve as the test progresses. So for a 64 card trial, an equivalent score would be about 6 or 7.
- 3 Executive control declines after age 60. Over 70 year olds typically score about 21 for perseverative errors.

- 4 *Categories completed* can range from 0, for someone who has no idea what to do, to a maximum of 6 (when the test is stopped).
- 5 The following are not recommended for clinical use because they are less reliable than the base scores:
 - *percentage perseverative errors*
 - *percentage perseverative responses*
 - *percentage non-perseverative errors*
- 6 *Percentage conceptual level responses* is thought to give a measure of insight into sorting principles.
- 7 *Failure to maintain set* shows the inability to continue with a strategy that has been successful.

PRACTICAL SHEET

Using computerised versions of the WCST

Obtain access to one of the computerised versions of the original test which appear on the internet (for example: <http://java.mdlogix.com/wcst/index.jsp> provided by Stanford Cog Psych) or one which your teacher may have for you to use.

You will also need a partner to act as a participant and quiet area with no distractions.

Health and safety

You should always carry out a risk assessment before you start any practical work. When using human participants, you should take into account any *ethical* considerations. In this case, you should fully advise any participant of what you expect them to do and the purpose of your investigation.

Procedure

Administering the test

- Brief the participant
 - Thank the participant for their help. Explain:
 - I am trying out this test to see how it works.
 - Some clinical psychologists use it to test people for brain damage after accidents, so I am *not* assessing you and your results will be kept confidential.
- Follow the instructions which should appear on the screen.
- Print out the results.

Scoring

- 1 Computerised versions can give a long list of different scores. The most important scores used as measures of executive control are:
 - *categories achieved* - the number of runs of 10 correct
 - *perseverative errors* - the number of errors where the participant has used the same rule for their choice as the previous choice.
- 2 Have a look at the other scores to see which are available and note any that you think may be interesting. If you design your own investigation, you may decide to use other scores.

You can find a description of the scoring system section *Scoring the WCST* of *The Wisconsin card sorting test (WCST)*. This also gives some typical scores

Write-up / Conclusions

- Using information from *Scoring the WCST* (from *Fact sheet: The Wisconsin card sorting test (WCST)*) to help you, write a short description and some brief conclusions. Discuss the WCST with the participant and comment on the test and the results.
- Describe how the test is carried out and how the results are interpreted.
- Record the results.
- When writing your conclusion, think about these questions
 - What did the results show?
 - How easy was the test to administer?
 - Why is this test in common use?
 - How did the participant feel about the testing procedure?

PRACTICAL SHEET

Using card versions of the WCST

Carry out a 64 card test. Although the WCST is normally used in two successive trials to give 128 results, researchers have used 64 card trials successfully. The instructions look complicated, but don't worry. The test is popular because the procedure is easy to carry out. Follow the instructions below to find out how the test works. Note: The *Results sheet* contains spaces for 128 trials, so you have the option to use the full version in later investigations.

Requirements

You will need test materials for the WCST:

- 64 item card set
- *Results sheet*
- four stimulus cards
- *Fact sheet: The Wisconsin card sorting test (WCST)*

You will also need a partner to act as a participant and quiet area where they will not be distracted.

Health and safety

You should always carry out a risk assessment before you start any practical work. When using human participants, you should take into account any *ethical* considerations. In this case, fully advise any participant of what you expect them to do and the purpose of your investigation.

Procedure

Read the instructions all the way through before starting.

Starting the Results sheet

- 1 Keep the *Results sheet* out of sight of the participant.
- 2 Enter their name (with permission) or a code for the participant in the space provided.
- 3 Obtain the sequence for applying the rules or categories. Use:
 - either the table on the next page (randomly select a column number from 1 to 24)
 - or the *Excel WCST category sequence* file if it is provided by your teacher (selects a new sequence randomly each time it is downloaded).
- 4 On the *Results sheet*, enter:
 - the category sequence to be used in the box at the top left hand side
 - the first rule or category to be applied for the first trial in the second column.

For example, if you use set 16 above, the category sequence is CNSNSC. The first rule is "C": match by colour. The next rule will be "N": match by number of symbols, etc.

Table: Sequence for applying the rules or categories

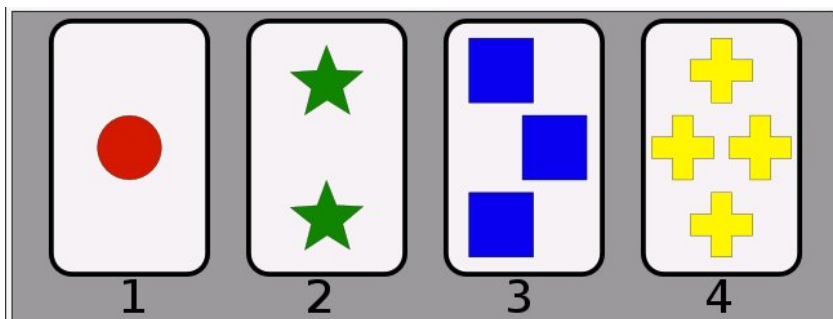
Key: C = match by colour; S = match by shape; N = match by number of symbols

1	2	3	4	5	6	7	8	9	10	11	12
C	C	C	C	S	S	S	S	N	N	N	N
S	S	S	S	N	N	N	N	C	C	C	C
N	N	N	N	C	C	C	C	S	S	S	S
C	C	S	S	S	S	N	N	C	C	N	N
S	N	C	N	C	N	C	S	S	N	C	S
N	S	N	C	N	C	S	C	N	S	S	C

13	14	15	16	17	18	19	20	21	22	23	24
C	C	C	C	S	S	S	S	N	N	N	N
N	N	N	N	C	C	C	C	S	S	S	S
S	S	S	S	N	N	N	N	C	C	C	C
C	C	N	N	C	C	S	S	S	S	N	N
S	N	C	S	S	N	C	N	C	N	C	S
N	S	S	C	N	S	N	C	N	C	S	C

Briefing the participant

- 1 Thank the participant for their help. Explain:
 - I am trying out this test to see how it works.
 - Some clinical psychologists use it to test people for brain damage after accidents, so I am *not* assessing you and your results will be kept confidential.



- 2 The four stimulus cards are set out as shown above, in front of the participant.
- 3 The 64 cards are shuffled and the pack is turned face up in front of the participant.

- 4 Explain the task to the participant and show them the layout. Read out these instructions:

You have four cards placed face up and a pack of cards to match to them.

I will have a rule for matching the cards and you will need to guess what it is.

Your task is to place the top card from the pack face up in front of the card that you think matches it, according to my secret rule.

I will tell you "correct" or "incorrect".

You continue to guess for the rest of the pack. You will end up with four piles of cards face up in front of the original four.

You can take as long as you like for each decision, but may not change your mind.

You should attempt to get as many right as possible.

From time to time I will change the rule without telling you. You will then need to discover the new rule.

- 5 Answer any questions, but do not suggest how cards can be matched beyond stating that any logical rule can be used.

Carrying out the test

- 1 Allow the participant to make their first choice. Have the *Results sheet* ready.
- 2 Record how their response card matches their stimulus choice by crossing through *any* matching categories. For example, two yellow stars placed against:
 - two blue circles is CNS (for number)
 - one yellow star is CNS (for colour *and* shape)
 - two yellow stars (complete match) would be CNS.
- 3 (a) If there is a match *of any kind* to the rule, place a number **1** in the Correct / incorrect column and clearly state "correct" to the participant.
(b) If there is no match to the rule, place an **X** in the Correct / incorrect column and clearly state "incorrect" to the participant.
- 4 You need to keep a track of runs, i.e. how many correct responses there are in a row. Do this by numbering in the Correct / incorrect column until up to 10 or until an error (**X**) is entered.
- 5 Start again from 1 for a correct response after any error.
- 6 *Whenever 10 correct responses in a row are achieved, move on to the next rule.* Enter the letter for the rule for the next trial in the *Category (rule)* column and cross if off in the *Category sequence* box at the start of the table.
- 7 Stop the test when six sequences of 10 correct responses have been achieved, or after 64 trials if this comes first.
- 8 Thank the participant and arrange to explain the scores when you have worked them out.
- 9 Make a note of any observations you have on what happened during the test.

Scoring

- 1 You can find a description of the scoring system in *Fact sheet: The Wisconsin card sorting test (WCST)*. This also gives some typical scores.
- 2 The most important scores used as measures of executive control are:
 - *categories achieved* - the number of runs of 10 correct
 - *perseverative errors* - the number of errors where the participant has used the same rule for their choice as the previous choice.

The *Results sheet* has a column for you to enter ticks or crosses against trials where a perseverative error has occurred.
- 3 Decide which scores to use and record your findings in a results table.

Write-up /Conclusions

- Using information from *Scoring the WCST* (see *Fact sheet: The Wisconsin card sorting test (WCST)*) to help you, write a short description and some brief conclusions. Discuss the WCST with the participant and comment on the test and the results.
- Describe how the test is carried out and how the results are interpreted.
- Record the results.
- When writing your conclusion, think about these questions
 - What did the results show?
 - Why is this test in common use?
 - How easy was the test to administer?
 - How did the participant feel about the testing procedure?

Results sheet (short 64 / full 128 trials)

Participant name or number
 Category sequence

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(cross out as you use)

Trial number	Category (rule)	Response match	Correct /incorrect 1,2,3... x	Perseverative error?*
1		CNS		
2		CNS		
3		CNS		
4		CNS		
5		CNS		
6		CNS		
7		CNS		
8		CNS		
9		CNS		
10		CNS		
11		CNS		
12		CNS		
13		CNS		
14		CNS		
15		CNS		
16		CNS		
17		CNS		
18		CNS		
19		CNS		
20		CNS		
21		CNS		
22		CNS		
23		CNS		
24		CNS		
25		CNS		
26		CNS		
27		CNS		
28		CNS		
29		CNS		
30		CNS		
31		CNS		
32		CNS		
33		CNS		
34		CNS		
35		CNS		
36		CNS		

Trial number	Category (rule)	Response match	Correct /incorrect 1,2,3... x	Perseverative error?*
37		CNS		
38		CNS		
39		CNS		
40		CNS		
41		CNS		
42		CNS		
43		CNS		
44		CNS		
45		CNS		
46		CNS		
47		CNS		
48		CNS		
49		CNS		
50		CNS		
51		CNS		
52		CNS		
53		CNS		
54		CNS		
55		CNS		
56		CNS		
57		CNS		
58		CNS		
59		CNS		
60		CNS		
61		CNS		
62		CNS		
63		CNS		
64		CNS		
65		CNS		
66		CNS		
67		CNS		
68		CNS		
69		CNS		
70		CNS		
71		CNS		
72		CNS		
73		CNS		
74		CNS		
75		CNS		
76		CNS		
77		CNS		
78		CNS		
79		CNS		

Trial number	Category (rule)	Response match	Correct / Wrong 1,2,3... x	Perseverative error?*
80		CNS		
81		CNS		
82		CNS		
83		CNS		
84		CNS		
85		CNS		
86		CNS		
87		CNS		
88		CNS		
89		CNS		
90		CNS		
91		CNS		
92		CNS		
93		CNS		
94		CNS		
95		CNS		
96		CNS		
97		CNS		
98		CNS		
99		CNS		
100		CNS		
101		CNS		
102		CNS		
103		CNS		
104		CNS		
105		CNS		
106		CNS		
107		CNS		
108		CNS		
109		CNS		
120		CNS		
121		CNS		
122		CNS		
123		CNS		
124		CNS		
125		CNS		
126		CNS		
127		CNS		
128		CNS		

*Fill in the perseverative error column after the test is completed by ticking wrong responses that continue the previous response pattern

Teacher notes

This guidance accompanies the two activity briefs:

- *Activity Brief: Investigating the Wisconsin card sorting test*
- *Activity Brief: Wisconsin card sort test correlational studies*

These activities link to **OCR A2 Unit 13 The mind and the brain**.

Aim

In the specifications, *13.4 Guidance for teachers* has a section *Exploration of the healthy and the damaged brain*. The guidance says:

It is envisaged that, for teaching purposes, this sub-section will be integrated with Subsection 13.2.3 (Methods and ethical issues in brain research). Material here would benefit from conventional delivery, supplemented by material on the CD-ROM, anatomical models, video/DVD and the content of several Internet websites, specified in Sub-section 13.4.3. These websites offer superb Flash and Shockwave animations to help consolidate processes such as the action potential and synaptic transmission. In addition, candidates have the opportunity to develop their familiarity with spreadsheets and statistical packages. When exploring frontal-lobe function, candidates can make their own version of the Wisconsin Card-Sorting Test and explore how it is used in assessing frontal-lobe information processing. Candidates need to be aware of the variety of approaches to explaining disorders such as schizophrenia and need to refer to balanced documents such as review papers from the British Medical Journal.

This activity is intended to introduce students to the use of the Wisconsin Card Sorting Test as a method for measuring aspects of executive control. It can be used to introduce the use of statistical testing, to develop this further or to give students an opportunity to:

present statistical evidence with appropriate complex statistical calculations with full explanation of the rationale behind the test and result gained
(OCR unit assessment criteria)

The activity can also be modified, by providing less guidance, to achieve:

*the design and safe execution of a simple experiment to investigate **one** aspect of cognitive function*

Introduction and teaching strategy

The resources provided allow students to carry out an initial trial of the WCST and then employ it to conduct a correlational study, using a correlation coefficient to analyse their data.

Computerised version

The Wisconsin card sort test has free computerised versions on the internet at <http://java.mdlogix.com/wcst/index.jsp> (a demo version provided by Stanford Cog Psych) and as part of the PEBL test battery (see <http://pebl.sourceforge.net/>)

The PEBL resource includes a folder of images for the 64 cards from the original Berg version of the WCST. These may be used to make sets of cards.

The former is ready to use and user friendly. The PEBL version is more difficult to use but has the advantage of being modifiable (as well as providing a variety of other psychological tests). Both versions have automated scoring systems.

Card version

If computer resources are scarce or unreliable, the WCST is easily replicated in card form or students can design their own version using any three different methods for discriminating the response cards to match them to the stimulus cards. They could try out their own stimulus cards, using different colours and shapes to those originally used by Berg. They might like to use different dimensions, such as borders, size of shape or its orientation. In this case, they will need to amend the *Results sheet* accordingly.

In the standard test, each of four different shapes or symbols has four different colours. Each colour of a shape appears once, twice, three times or four times on a card. This gives a set of 64 different response cards. In addition four stimulus cards are needed, similar to those shown on page 1, which show all the possible "rules".

The WCST is based on 64 cards which normally used in two successive trials to give 128 results. Computerised versions are quick and easy to carry out, but if you are using cards it can take a lot longer. The method given for the card version is therefore for a 64 card trial. There is evidence that the reduced version is as good as the full version (Purdon, S E and Waldie B (2001) *A short form of the Wisconsin Card Sorting Test* J Psych Neurosci. **26**(3) pp 253–256 <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1408295>).

For card versions, a brief demonstration of how to set up the test and use the score sheet would be beneficial. The procedure is easy to master, but the initial instructions are long.

Correlational studies

Once students have mastered the administration of the test, it is a simple matter to obtain data for correlational studies. The study sheets present three different correlational studies. You may prefer to give students the option of designing their own investigation or you may wish all students to follow the same option or to design their own investigation. The task is most easily and rapidly accomplished if students in a class can all act as participants, rather than having to seek volunteers from outside.

To maintain reliability, the original version of the WCST presents the cards in a definite order. For this purpose, the cards are numbered in some sets. However, in this case, a method for altering the category sequence is provided. This is so that students can act as participants and cannot predict what to expect in the test after administering the test themselves. A few may try to count sequences up to ten to predict when the rule will change, but they will normally find this too difficult to persevere. Students may work with friends from outside their class or with partners from their class. They may use a table (Sequence for applying the rules or categories) or an Excel spreadsheet (WCST category sequence, available on the CD ROM) to select the rule sequence. In the latter case, they should swap roles so that both can practise administering the test.

If students follow the same task, use a computerised version and divide the workload, the task can be introduced and sufficient data for analysis obtained in a two hour session. If students design their own version and /or need introducing to the use of *Excel*, and/or the use of statistical tests more time will be necessary. The supporting fact sheets can be used by students in their own time, but are best approached when they can work in small groups

to help each other. If they have the necessary basic skills, the analysis can be completed in a second two hour session, with some time for a class discussion of the outcomes. If formal reporting is necessary, students can be asked to start writing up their report which can be completed in their own time.

Summary of resources for the two related activities:

- *Activity Brief: Investigating the Wisconsin card sort test*
- *Activity Brief: Wisconsin card sort test correlational studies*
- *Fact sheet: The Wisconsin card sorting test (WCST)*
This introduction gives some theoretical background and explains how the test works. It includes a reference to a website article which is hard to follow, but links use of the WCST to fMRI and has some useful images:

Monchi, O *et al* (2001) *Wisconsin Card Sorting Revisited: Distinct Neural Circuits Participating in Different Stages of the Task Identified by Event-Related Functional Magnetic Resonance Imaging* *The Journal of Neuroscience* **21**(19) pp 7733–7741
<http://www.jneurosci.org/cgi/reprint/21/19/7733.pdf> (viewed 29/11/2007)

- *Practical sheet: Using computerised versions of the WCST* (Word document)
This gives a procedure to follow to use a computerised version of the test such as the Stanford Cog Psych demonstration.
- *Practical sheet: Using card versions of the WCST*
This gives a full set of instructions for using a pack of cards and recording the data on the results sheet. Students may need some help to master this and a demonstration of the test and the use of the *Results sheet* is advisable. However, the task is logical and easy to master once it has been tried out. The method uses the shorter 64 card version, but the *Results sheet* (see below) has provision for the full 128 card version if desired.

Requirements

- test materials for any version of the WCST: 64 item card set and four stimulus cards
- *Results sheet* for each test
- *Fact sheet: The Wisconsin card sorting test (WCST)*
- a quiet area where the participants will not be distracted
- at least five participants

If students use their own version, they will need materials to make 64 response cards and four stimulus cards. 128 card trials are conducted by shuffling the pack and starting again. As they will have limited use, 'cards' could be made on paper. Students could be encouraged to use computer packages to design and print out their designs.

- *WCST category sequence (Excel file)* on CD ROM
This generates a random number each time it is loaded to give the column choice in a table of category sequences to be used in the test. This makes it possible for a student who has administered the test to take it themselves, without being able to predict the sequence of changes for the rules. Alternatively, a set of rule sequences is provided for use in the instructions in the Study sheet. Ideally, students should use a random number generator to select which sequence to use. The selected category sequence is entered on the *Results sheet*.

- *WCST Results sheet*

This *Results sheet* is not necessary for self-scoring computerised versions of the WCST. The card version of the WCST *Record Booklet* has four pages to record and calculate scores! This complexity in early versions led to many discrepancies between scorers. Students will **not** need to do a complete analysis. For card versions, the *Results sheet* provides a simple means for recording the main scores. It can be used to record each response, the sequence of rules (categories) that are used and the runs of correct responses. The sheet also includes a column for identifying *perseverative errors*, to be filled in **after** the test is completed. Students will need to check the instructions for each correlational study to decide which scores you they need.

- *Practical sheet: Conducting a correlational study using the WCST.*

This includes instructions for three different correlational studies. Other investigations may be substituted.

If students are to use the work for assessment, they will require additional guidance on how to write up their work. In particular, if they are using statistical tests for the first time, it may be necessary to require them to carry out the calculations, as required by the specifications.

The suggested investigations are:

- *Correlational study 1: Testing for redundancy in the WCST*

Students are asked to choose scores to test for correlation. If two scores show strong association, they are likely to be measures of the same effect and therefore demonstrate redundancy. High correlation has been shown between perseverative errors and perseverative responses and also the number of categories achieved with the total number of errors.

- *Correlational study 2: Testing the reliability of the WCST*

Students are asked to retest to check scores for reliability.

- *Correlational study 3: Finger length and the WCST*

Prenatal exposure to testosterone has been shown to affect the development of areas of the brain associated with spatial and skills and also with the relative lengths of the first and third fingers. Do any WCST or equivalent scores correlate with digit ratios? (As the WCST has been shown to have no gender bias, there should be no correlation found.)

Students may consider other correlational studies, for example comparison with the Stroop test of directed attention (e.g. see <http://www.snre.umich.edu/eplab/demos/st0/stroopdesc.html>) or the Rosenberg self-esteem scale (e.g. see <http://www.atkinson.yorku.ca/~psyctest/rosenbrg.pdf> and <http://www.mhsip.org/reportcard/rosenberg.PDF>)

Five participants will give sufficient plots for a scatter graph, but small samples will reduce the likelihood of obtaining significant correlations, even if they really exist (type 2 error). Note: Pearson's r is often used in the literature, even though the data are not true interval level. *Students may be advised that data approximate to the requirements and either Pearson's or Spearman's correlation coefficients may be used.*

The following fact sheets are also useful:

- *Fact sheet: Background to statistics*
Introduces significance and hypothesis testing.
- *Fact sheet: Using Excel for descriptive statistics*
Describes how *Excel* can be used to calculate measures of central tendency, to plot graphs and calculate confidence intervals.
- *Fact sheet: Using Excel for inferential statistics*
Explains the use of statistical tests to obtain probabilities to test hypotheses and describes the use of correlation coefficients, including the use of *Excel* for Pearson's r .

Further information

Strauss, E *et al* (2006) *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary*, Oxford University Press US